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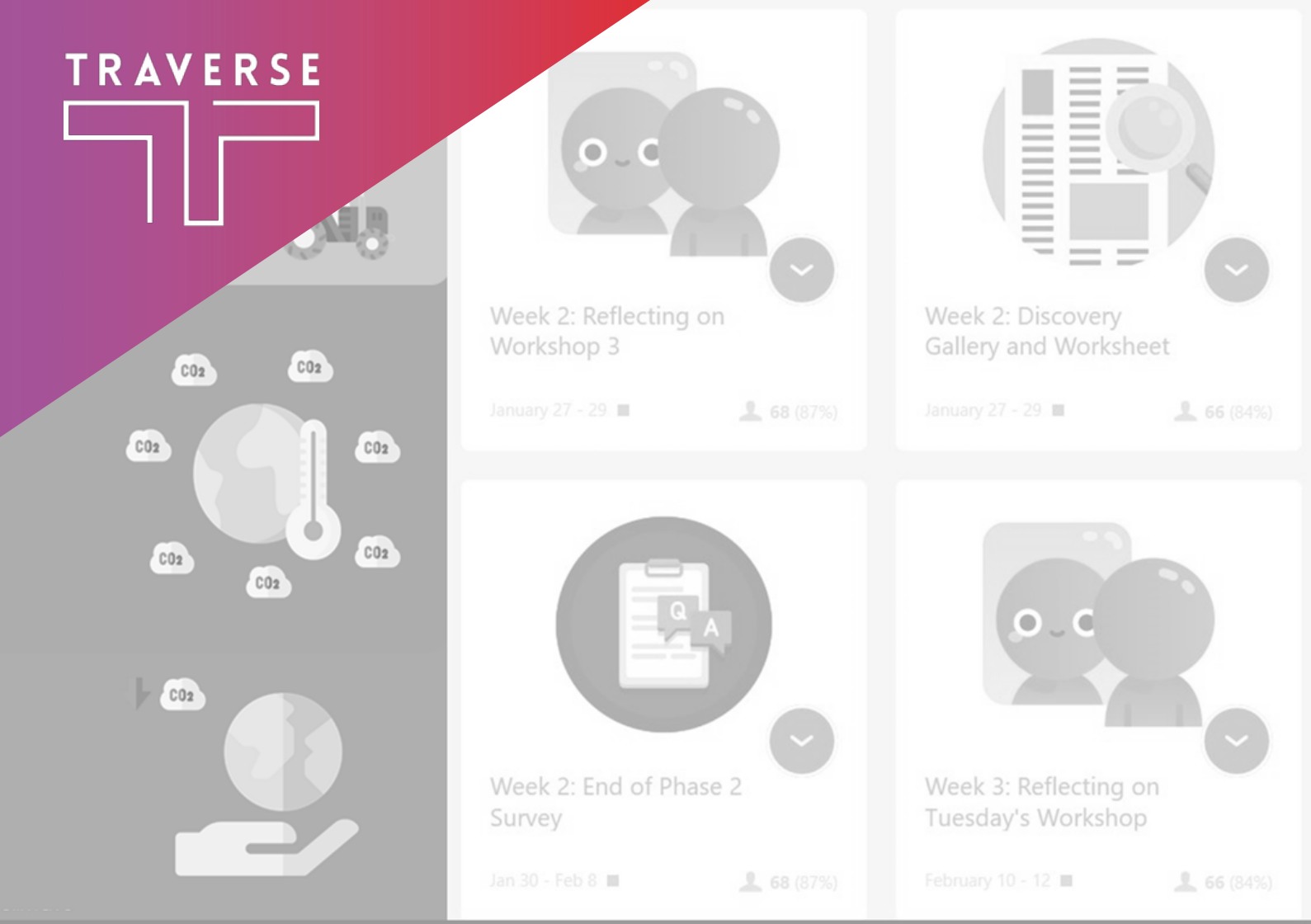

Public dialogue on advanced nuclear technologies

Engagement report

July 2021

Department for Business, Energy & Industrial Strategy

sciencewise

UK Research and Innovation

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Foreword

In 2019, the UK set itself a world leading target to reach net zero emissions by 2050. Since making this commitment, Government have published the Prime Minister's Ten Point Plan for a Green Industrial Revolution and the Energy White Paper. The Energy White Paper presents a vision of how the UK makes the transition to clean energy by 2050. In order to decarbonise the energy system, fossil fuels will need to be replaced with low-carbon energy sources; most likely predominantly renewables complimented by nuclear and carbon capture and storage to ensure the system is resilient.

In his Ten Point Plan, the Prime Minister committed up to £385 million in an Advanced Nuclear Fund to invest further in small and advanced modular reactors. These technologies have a number of potential benefits, including lower capital cost and reduced build time. Some designs also have the potential to provide high temperature heat which can be used for a number of applications beyond electricity production, including hydrogen production, district and industrial heating.

The differences between small and advanced modular reactors and conventional gigawatt-scale nuclear power stations may mean that the UK Government might need different policy approaches in some areas. The Department for Business, Energy and Industrial Strategy, and partners commissioned this public dialogue on advanced nuclear technologies to involve the public at this early stage of policy development.

My team were delighted to see the level of engagement and enthusiasm throughout the dialogue workshops and on the online platform. We even received feedback that some participants would have liked to explore certain related topics (for example, nuclear waste or other energy technologies) in more depth. Due to the limited time and focus on Advanced Nuclear Technologies (ANT), this was not possible, however, we will keep this in mind for future work.

I would like to sincerely thank the members of the public that took part in this public dialogue. Your contributions will inform our future policy development and engagement with the public. I would also like to take this opportunity to thank Traverse for facilitating the dialogue and the members of the Project Board and Oversight Group, and specialists that took part in the workshops.

Following the conclusion of this exciting project, we will continue to engage with the public as we progress policy in support of the development and deployment of advanced nuclear technologies.

Declan Burke

Director Nuclear Projects and Development

Public dialogue on advanced nuclear technologies

Department for Business, Energy & Industrial Strategy

sciencewise

UKRI

BEIS and its partners commissioned a dialogue to explore views on how and where advanced nuclear technologies might be used. The findings will support policy development and inform future engagement.

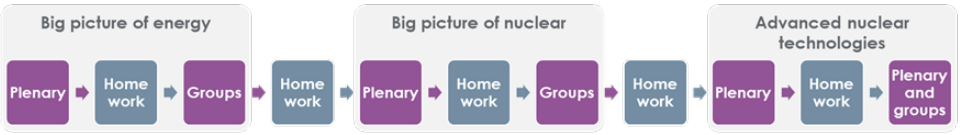
Traverse delivered the dialogue, with oversight from a Project Executive, Project Board, Oversight Group, and 3KQ (independent evaluator).

How was it done?

- 71 participants from 3 locations
- 6 online workshops over 6 weeks
- Activities and discussion on online platform
- 24 specialists answering questions

"The dialogue was easy to understand and delivered in a way that explained a lot. I was comfortable to ask about anything I did not understand."

A journey of discovery and discussion



What did we find?

A majority of participants showed caveated support for the siting and deployment of advanced nuclear to support net zero.

To **deploy** advanced nuclear:

- it must be essential to support renewable technology in achieving net zero targets,
- it should be one of several energy solutions supporting a focus on renewable energy,
- health and safety must be prioritised,
- it should not present long-term risks or leave a negative legacy, and
- there must be robust, independent regulation.

When **siting** advanced nuclear:

- distance from people must ensure health and safety,
- prioritise environmental impacts,
- make the most of existing sites and infrastructure, and
- optimise for benefits and alternative uses.

Participants' views were complex and nuanced

Participants had more questions and concerns than they had hopes

Participants were surprised that nuclear energy is a low-carbon option

Participants considered meaningful public involvement to be essential

Participant support for advanced nuclear grew over the dialogue

Moving forward, more engagement could be done on topics such as:

- waste storage and disposal
- safety
- different uses of the technologies
- different types of technologies
- advanced nuclear and other energy solutions in the pathway to net zero

The findings are not statistically representative of public views and should be considered illustrative.

None of the locations were chosen based on any consideration for future siting and deployment of advanced nuclear technology.

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Executive summary

The Department for Business, Energy & Industrial Strategy (BEIS) and its partners (Sciencewise, UKRI, the Environment Agency, Welsh Government, Office for Nuclear Regulation, National Nuclear Laboratory, Nuclear Innovation and Research Office, and Natural Resources Wales) commissioned a public dialogue to explore public views toward the siting and deployment of advanced nuclear technologies, to support policy development and inform future engagement.

Traverse delivered the public dialogue, which was conducted in line with Sciencewise Guiding Principles. A Project Executive, Project Board, Oversight Group, and independent evaluator (3KQ) oversaw the process.

The dialogue set out to draw conclusions based on an understanding of the following research questions:

- what are participants' perceptions, hopes and concerns about the development and use of advanced nuclear technologies;
- what influences those views of advanced nuclear technologies and, given that, what might make participants more or less open to the use of them; and
- what do participants think is important when considering how advanced nuclear technologies might be sited and how to use advanced nuclear technologies?

Method

The dialogue was initially designed to be held face-to-face, however, the Covid-19 pandemic made this impossible. The dialogue was redesigned to be delivered entirely online, with six Zoom workshops and activities on a digital engagement platform, Recollective, over a period of six weeks.

The dialogue included 71 participants from Porthmadog, Reading and the greater Scunthorpe area. The full sample was designed to broadly reflect the UK population in age, gender, ethnicity, socio-economic group and rural/urban location, with the sample in each location reflecting local demographics. Locations were selected based on their proximity to current nuclear infrastructure and other industries to ensure a broad range of communities were included. None of the locations were chosen based on any consideration for future siting and deployment of advanced nuclear technologies.

The dialogue had three phases, to build toward deliberating advanced nuclear. While this included the wider energy context and nuclear energy more generally, the dialogue remained relatively high-level on these topics.

After each workshop, facilitators reflected on emerging views, which were taken back to the final workshop to refine our understanding. After the final workshop, the Traverse team reflected on the data and emerging themes to develop an analysis approach and early findings to share with participants for review. All qualitative data was thematically coded in our bespoke tool, Magpie, to support robust and neutral analysis.

Understanding limitations

Public dialogues are well respected as an approach for their ability to engage the public with complex policy issues in a meaningful and informed way. However, as with any research method, when interpreting the findings, it is important to bear in mind the potential limitations of the approach.

While the focus of this project was to gain deep, qualitative insight, some quantitative tools were used to support deliberation and complement other data sources. As such, the findings reflect the analysis of all qualitative and quantitative data from discussions and Recollective activities, however, the nuanced qualitative findings should form the basis of the reader's take-aways. The number of participants and deliberative approach, mean that findings are not statistically representative of public views, and should be considered illustrative.

Public engagement on nuclear technology could cover a wide range of related topics, each of which could warrant a separate dialogue due to complexity. This dialogue was among the first in the UK specifically on advanced nuclear technologies, and therefore aimed to explore a broad range of issues to provide insight into priority themes for future engagement. As such, some related topics were not explored in-depth (such as, detailed comparisons with other energy sources, or nuclear waste storage and disposal).

Dialogue findings

Below we present the broader stories coming out of the findings, but we encourage you to take the time to appreciate the detail within them by reading the full report.

Views were complex and nuanced

Participants' views were complex and nuanced, and largely grounded in their perspectives on:

- achieving net zero (in part due to the design of the dialogue, framing nuclear as an approach to support achieving net zero),
- current nuclear energy (as it was more familiar, and advanced nuclear was felt to have many unknowns as a developing technology); and
- the information provided within the dialogue.

As such, there is no one simple take-away – this dialogue provides insight across a wide range of issues related to advanced nuclear, valuably indicating several potential areas for future research and engagement.

Nuclear energy was an unexpected approach to net zero

Participants were generally surprised to learn that nuclear energy was low-carbon. They had not seen it as part of the future energy mix or realised it could play a role in reaching net zero, and therefore this framing played a key role in shaping their views on nuclear energy throughout the dialogue.

Concerns and questions outweighed hopes

While participants' hopes and concerns were often interwoven and shifting, in general, they had greater, more persistent, and more varied concerns for the siting and deployment of advanced nuclear technologies, than hopes.

Participants hopes and concerns were underpinned by a range of perspectives and values, such as fairness and equality, affordability or cost-effectiveness, and responsibility to the environment and society. Some of these values, hopes and concerns were framed by global thinking – where participants expressed views about how the use of nuclear technologies in the UK may lead to impacts elsewhere in the world.

Participants' key concerns related to nuclear waste storage and disposal; health, safety and the regulations in place to reduce the risk of harm; and environmental impacts. Others spanned a range of issues relating to financial costs, cost-effectiveness, the lifespan of the technology, and the size of sites and reactors.

Participants' hopes often centred around the low carbon emissions of nuclear energy, potential creation of job opportunities, and the reliability of nuclear energy. Participants were also interested in other potential benefits of advanced nuclear, such as alternative uses or outputs, the potential for recycling nuclear waste, and a reduction in reactor size.

Caveated support for siting and deployment of advanced nuclear

Overall, the number of participants willing to consider **deploying** advanced nuclear technologies to support reaching net zero by 2050, increased over the dialogue. By the end, a majority were willing to consider it, however this was heavily caveated with nuanced conditions spanning five key themes.

1. **A robust need case must be proven:** Advanced nuclear should only be deployed if it is essential in supporting renewable technologies to achieve net zero targets. The need case should consider consumer costs and the UK economic context.
2. **Renewable energy should be central to achieving net zero:** If a robust need case were proven, advanced nuclear should be one of several energy solutions. The primary focus should be renewables with advanced nuclear helping to meet demand, improve reliability, and/or serving as a stop-gap while renewable technology develops.

3. **Health and safety must be prioritised:** The health and safety of local and international communities, throughout the nuclear lifecycle, must be considered as a priority.
4. **It should not present long-term risks or leave a negative legacy:** Decisions should be led by long-term thinking. Advanced nuclear should not be deployed to achieve short-term goals, if it results in long-term impacts. There must be solutions for nuclear waste storage and disposal before progressing the deployment of advanced nuclear.
5. **Robust and independent regulation is key:** Processes must be transparent and independent from nuclear technology developers. Regulation of the sector must effectively ensure that concerns and considerations are addressed, and deliver effective penalties.

Participants' considerations for **siting** advanced nuclear reactors were also numerous and nuanced, generally spanning four key themes.

1. **Proximity must ensure safety of local communities:** First and foremost, advanced nuclear should be sited far enough away from people to ensure it has no impact on their health and safety.
2. **Prioritise environmental impacts:** Siting advanced nuclear should avoid the use of green space and cause little to no environmental damage.
3. **Make the most of existing sites and infrastructure:** Existing nuclear sites should be used in the first instance to make best use of existing infrastructure and workforces, whilst limiting further environmental and visual impacts.
4. **Optimise for benefits and alternative uses:** Advanced nuclear could be sited closer to where its benefits would be best realised, as long as safeguarding against negative local impact is prioritised and a minimum safe distance from communities established and adhered to.

Public engagement is essential

Some participants' perceptions and experiences of current nuclear, and experiences of public involvement in decision-making generally, led to scepticism of the potential for genuine influence in policy-making and future decisions. Participants considered transparent and meaningful involvement of the public and local communities essential in decisions about the use of advanced nuclear, as well as detailed decisions about where it is placed.

Reflecting on their own pre-existing knowledge of nuclear technologies, some participants felt that educating the public on siting and deployment of advanced nuclear technologies (alongside other energy sources), was important. They emphasised that this should be impartial and balanced, focussed on enabling the public to question proposals for the future of energy in the UK, rather than to increase acceptance.

Participants' experience of the dialogue

Participants noted an overall positive experience, being comfortable in their interactions with the team, specialists, and information provided.

In deliberative engagement participants have the opportunity to learn about and reflect on a topic, hear views different to their own, and are asked to consider what would be best for society, not just for themselves. As such, their views may change through the process, and it can be helpful to consider what might have influenced that. We found that interactions with specialists, particularly those about safety and regulation of nuclear energy, seemed to have the most impact on participants' views.

We observed three general types of participant journey:

- those who started with key concerns, and grew more concerned over the course of the dialogue;
- those with a pragmatic view of nuclear energy and cautious optimism about advanced nuclear technologies, but wanted more information and as such were reluctant to express definite opinions; and
- those who felt more positively about advanced nuclear at the end of their journey as it could contribute to net zero, and trusted specialists with the details of their deployment.

Next steps

Traverse recommends that, given the extent of unknowns around advanced nuclear technologies and the link between views on nuclear energy generally and advanced nuclear, additional in-depth public engagement would be beneficial following further research and development of the technologies. We suggest that this could include engagement initiatives about advanced nuclear technologies' waste storage and disposal; safety of advanced nuclear technologies; different uses of advanced nuclear; and differentiating views on different types of advanced nuclear technologies. Additionally, we would suggest incorporating advanced nuclear technologies into wider deliberative processes about pathways to net zero.

Key terms

This project explored what is referred to in the UK as advanced nuclear technologies. As a developing field, terminology varies worldwide – for example, in other parts of the world advanced nuclear technologies are known broadly as small modular reactors.

In this report we use terms aligned with those commonly used in the UK, so as to make the findings more accessible to different stakeholders.

- **Small modular reactors** when referring to technologies based on current water-cooled reactors, but on a smaller scale. Small modular reactors are smaller scale Generation III reactors.
- **Advanced modular reactors** when referring to reactors which use novel cooling systems or fuels, and may offer new functionalities. Advanced modular reactors are also known as Generation IV reactors.
- **Advanced nuclear technologies** when referring to both small and advanced modular reactors. Modular reactors use components that can be manufactured in factories and be transported to site for assembly.
- **Current nuclear technologies** when referring to large reactors like those that are currently in operation or development. In the UK, reactors in operation are mostly gas-cooled, while those large reactors in development are water-cooled. Current nuclear technologies generally include what is known as Generation II and Generation III reactors.

For the purpose of the dialogue different terms were used to avoid the potential for influencing views. This is described in detail in the report and summarised here for reference.

- Small modular reactors were referred to as **small modular reactors**.
- Advanced modular reactors were referred to as **next generation reactors**.
- Advanced nuclear technologies were referred to as **modular nuclear technologies**.

1. Introduction

1.1. Context

In 2019, the UK Government became the first major economy in the world to pass laws to end its contribution to global warming by 2050. The target requires the UK to bring all greenhouse gas emissions to net zero by 2050.[1]

To meet the target, the Government believes the UK needs low carbon, reliable power such as nuclear energy. Nuclear infrastructure policy to date in the UK has been based on current nuclear technologies. However, more recently, the nuclear sector has been carrying out research and development into advanced nuclear technologies. In winter 2020, the UK Government published the Ten Point Plan for a Green Industrial Revolution, and the Energy White Paper, which outlines its commitment to developing advanced nuclear power as part of reaching net zero by 2050[2,3].

While the UK Government has overall responsibility for energy and nuclear policy, the devolved nations have their own energy policy agendas. The Welsh Government has its own energy policy agenda[4] and publishes a range of documents to help monitor progress on energy generation and emissions issues. In addition, the Welsh Government has powers to approve possible nuclear developments up to a certain size of power generation.

Advanced nuclear technologies could have significant differences to current nuclear technologies, for example, in terms of the size of the nuclear reactors, where they can be sited, or how the nuclear reactors cooling systems work. The Department for Business, Energy, and Industrial Strategy (BEIS) understands that once members of the public have an informed opinion about these technologies, they may hold different views to those they have about current reactor types. BEIS, therefore wanted to gain insight into public opinion at an early stage of policy development. To date, there has been limited specific research into public attitudes of advanced nuclear technologies. The results of BEIS' Public Attitudes Tracker (2019) highlighted that public level of knowledge of advanced nuclear technologies was relatively low[5].

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[1] 'UK becomes first major economy to pass net zero emissions law', 2019, https://www.gov.uk/government/news/uk-becomes-first-major-economy-to-pass-net-zero-emissions-law

[2] The Ten Point Plan, 2020, https://www.gov.uk/government/publications/the-ten-point-plan-for-a-green-industrial-revolution

[3] The Energy White Paper, 2020, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/945899/201216_BEIS_EWP_Command_Paper_Accessible.pdf

[4] Key documents include Prosperity for All: A Low Carbon Wales and Low Carbon Delivery Plan

[5] BEIS Public Attitudes Tracker, 2019, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/844940/BEIS_Public_Attitudes_Tracker_Wave_31_key_findings.pdf

BEIS and its partners (see section 1.4.1) commissioned a public dialogue to explore participants' views on potential benefits of advanced nuclear technologies, how opportunities might be realised, any related concerns, and how any concerns might be mitigated. As part of refining the project objectives and research questions in the early phases of the project, this was amended to focus more specifically on siting and deployment of advanced nuclear technologies.

As the public level of knowledge was assumed to be relatively low, a public dialogue was proposed as the preferred method, as it combines knowledge-building and careful deliberation over time. Following a competitive procurement process, **Traverse** was commissioned as the independent delivery contractor for the dialogue.

1.2. Aims, objectives and scope

The aim was to understand participants' views towards the siting and deployment of advanced nuclear technologies in order to inform and assist policy development.

As part of the project set-up phase, the aim, objectives, and research questions were refined. For more detail on the original objectives and how they were refined, please see Appendix A.

The final agreed objectives were to:

- understand participants' perceptions, hopes and concerns about the development and use of advanced nuclear technologies;
- explore the underlying influences on those views of advanced nuclear technologies, what might make participants more or less open to the use of them; and
- understand participants' priorities when considering how advanced nuclear technologies might be sited and how advanced nuclear technologies could be used.

The findings will potentially be used to:

- inform future policy, guidance, and regulation surrounding small-nuclear; and
- inform and enable future communication and engagement surrounding small-nuclear.

To achieve these project objectives, the dialogue needed to draw clear, coherent conclusions based on an understanding of the following research questions:

- what are participants' perceptions, hopes and concerns about the development and use of advanced nuclear technologies;
- what influences those views of advanced nuclear technologies, and given that what might make participants more or less open to the use of them; and

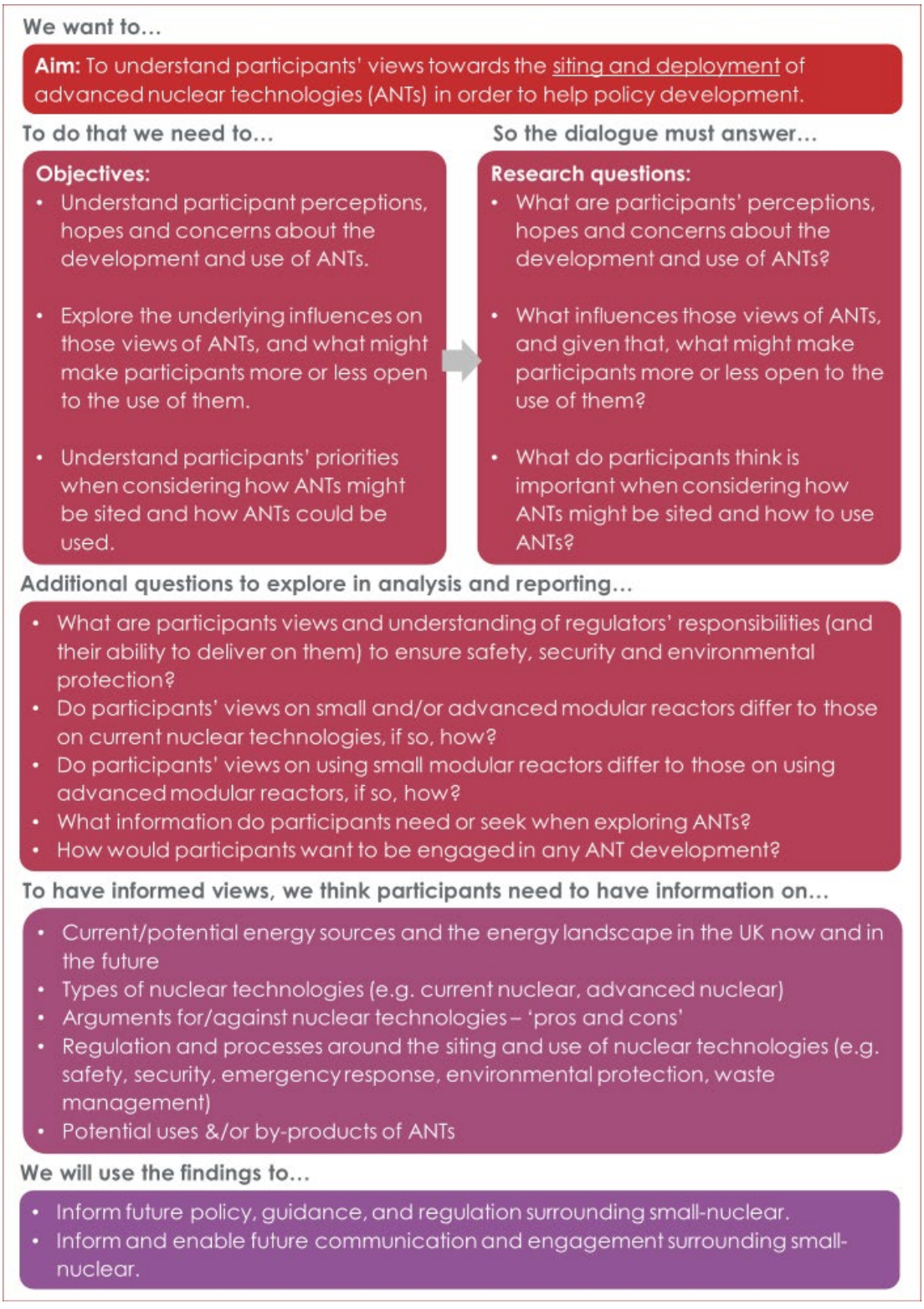
- what do participants think is important when considering how advanced nuclear technologies might be sited and how to use advanced nuclear technologies?

For more detail on the agreed framework for research questions and project objectives, see Figure 1.

In terms of scope, public engagement on nuclear technology could cover a wide range of related topics, each of which could warrant a separate dialogue due to complexity. This dialogue was among the first in the UK on advanced nuclear technologies, and therefore aimed to explore a broad range of issues to provide insight into priority themes for future engagement.

Limited prior knowledge of the energy system and advanced nuclear technologies was anticipated amongst participants. Therefore, a process was designed where participants could first consider information about the UK's energy landscape and net zero, then more generally about nuclear technology, before covering advanced nuclear (Figure 1). Equally, as with most public engagement, the duration of the dialogue posed a barrier to breadth of scope. As such, some related topics were not explored in-depth (such as, detailed comparisons with other energy sources, or nuclear waste storage and disposal). Participant interest in out-of-scope issues can suggest themes for future public engagement or might have been addressed by previous Sciencewise dialogues, such as the New Nuclear Power Stations Dialogue (2015) and the Geological disposal Facility Dialogue (2016).

Figure 1: Outline of agreed framework for research questions and project objectives



1.3. Sciencewise approach

Sciencewise (https://sciencewise.org.uk/) is an internationally recognised public engagement programme which helps to ensure policy is informed by the views and aspirations of the public. The programme is led by UK Research and Innovation (UKRI). Sciencewise supports public dialogue on new and emerging technologies where opportunities exist to support policy-makers to develop socially informed policy.

Sciencewise public dialogues provide in-depth insight into the values, attitudes, concerns and aspirations of a diverse and inclusive sample that reflects the UK population as a whole, or the population in the area where dialogue activities are being held. Dialogues are rooted in evidence, affording participants the opportunity to learn about a topic from a variety of sources over a period of time, enabling them to shape and develop their views as they deliberate with others.

For Sciencewise, public dialogue includes:

- involving specialists and policy-makers in discussion with the public to help explore issues, aspirations and concerns when shaping policy;
- talking with the public about ethical and societal issues related to public policy;
- requiring the instigators of the dialogue, as well as the participants, to be potentially willing and able to change their minds; and
- ensuring that public insights can inform policy involving science and technology issues.[6]

This public dialogue was conducted in line with Sciencewise Guiding Principles[7], including their latest quality framework and considerations for online dialogues, and with input and scrutiny from Sciencewise dialogue and engagement specialists, and social research professionals at UKRI. As with all Sciencewise projects, the design and delivery were also overseen by an independent evaluator, in this instance 3KQ, and an Oversight Group.

1.4. Project governance

Three groups were convened to manage and govern the project: the Project Executive, the Project Board, and the Oversight Group.

1.4.1. Project Executive

The Project Executive was responsible for the day-to-day running of the project. It consisted of the BEIS Project Manager and Project Support, UKRI Project Liaison Manager, independent project evaluator 3KQ, Sciencewise Dialogue and Engagement Specialist, and the Traverse Project Director and Project Manager (see Appendix D for a list of members).

[6] Sciencewise & Department for Business, Energy & Industrial Strategy: The Government's Approach to Public Dialogue on Science and Technology
[7] https://sciencewise.org.uk/about-sciencewise/our-guiding-principles/

The Project Executive met on weekly or fortnightly basis, depending on the project phase.

1.4.2. Project Board

A Project Board was established to oversee the project. The Project Board was led by BEIS and included co-funders (Environment Agency and Welsh Government), partners with a stake in the project outputs (Office for Nuclear Regulation, National Nuclear Laboratory, Nuclear Innovation and Research Office, and Natural Resources Wales), Sciencewise and UKRI (see Appendix C for a list of members). Traverse met with the Project Board during set up, design and delivery stages to discuss project progress. The Project Board provided technical expertise and links to other organisations and public bodies from across the nuclear sector.

1.4.3. Oversight Group

BEIS convened a group of stakeholders from industry, policy, and academia, to provide oversight for the dialogues (see Appendix B for a list of members and Terms of Reference).

The role of the group was advisory, with objectives to oversee the dialogue process and materials and to help ensure that:

- the dialogue material was comprehensive, balanced and accessible; and
- the engagement process was far reaching, accessible and targeted all relevant groups where possible.

The Oversight Group input into and reviewed the topic review, stimulus materials, design of the process, specialist suggestions, outputs and the communications strategy for the outputs.

1.5. Method

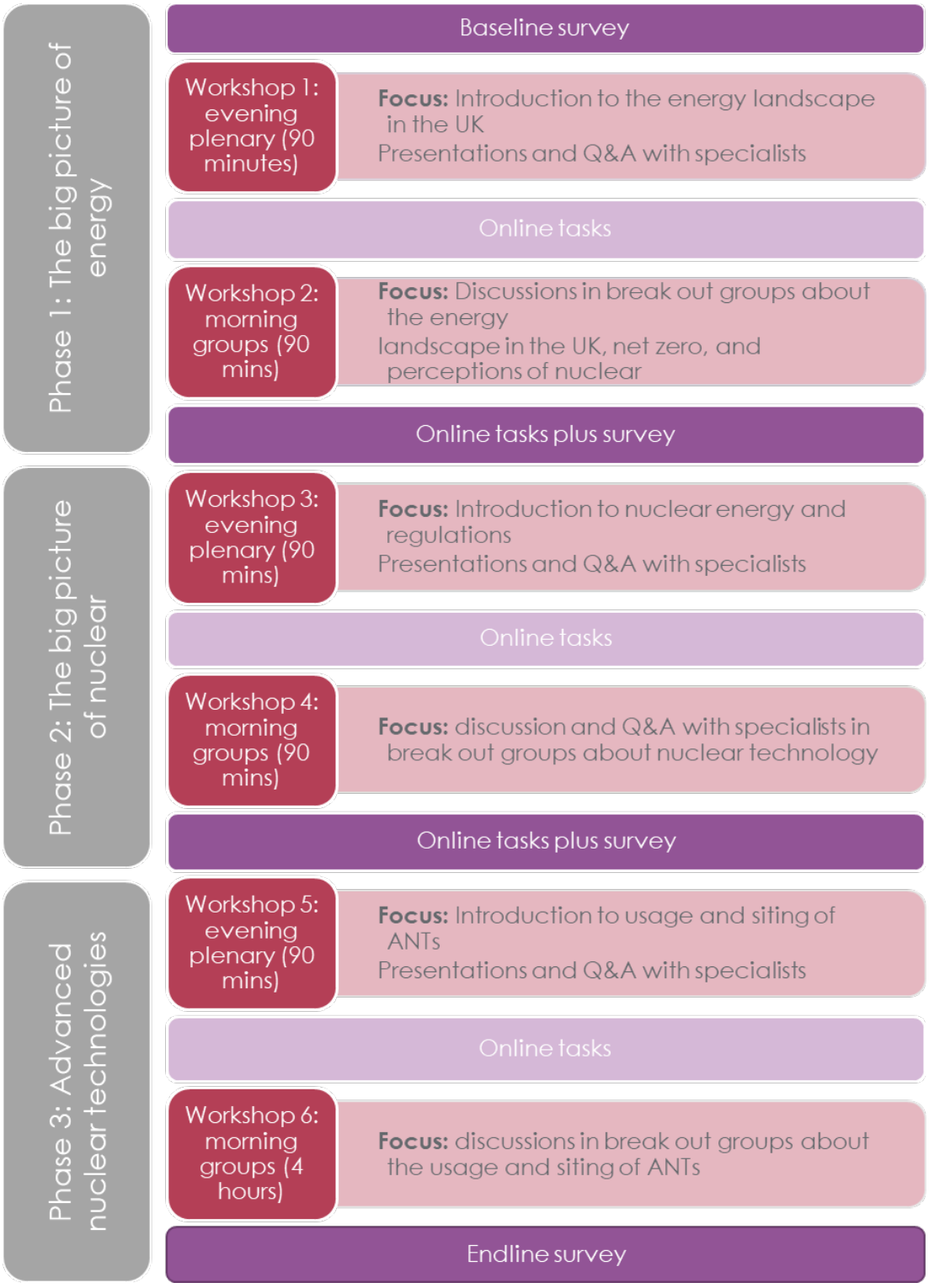
1.5.1. Dialogue structure

The dialogue was initially designed to be held face-to-face. However, the Covid-19 pandemic and associated restrictions made this impossible. In summer 2020, the dialogue was re-scoped to be delivered entirely online. Reflections on learnings and the influence of delivering an online dialogue amid a pandemic, can be found in chapter 5.

The dialogue comprised six online live workshops, and additional activities and discussions on a separate online platform, over the course of six weeks.

Below we set out the key activities of the dialogue (Figure 2). Refer to Appendix A for comprehensive detail on the method and process design. Information about how participant discussion progressed over the dialogue is included in chapter 5.

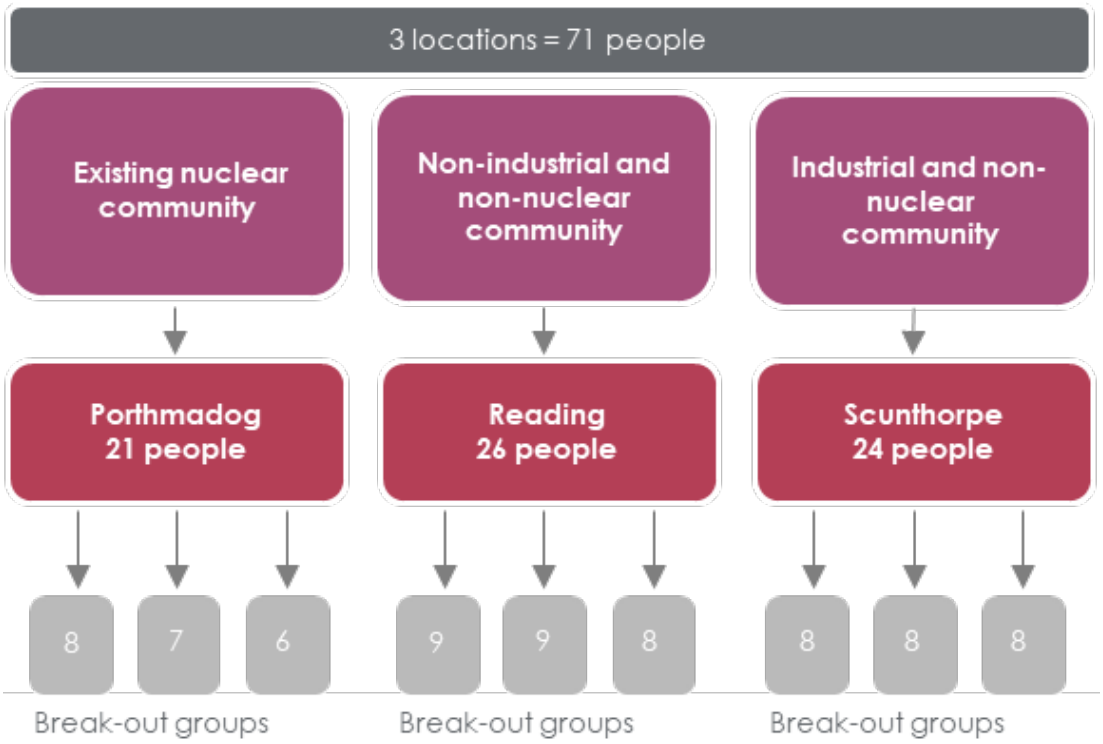
Figure 2: Outline of key dialogue activities



1.5.2. Participant sample

Participants were recruited from three locations: Porthmadog, Reading and the greater Scunthorpe area. Locations were selected based on their proximity to current nuclear infrastructure and other industries to ensure a broad range of communities were included (Figure 3). None of the locations were chosen based on any consideration for future siting and deployment of advanced nuclear technology.

Figure 3: Overview of location and participant numbers



The intended sample was to recruit 84 people, so as to ensure that 72 participants attended (28 for 24 participants in each location). The full sample was designed to broadly reflect the UK population in age, gender, ethnicity, socio-economic group and rural/urban location, with the sample in each location reflecting local demographics.

A total of 71 participants took part substantially in the dialogue (attended more than three workshops and completed most online activities). Refer to Appendix A for further detail on sampling, recruitment, and retention.

1.5.3. Workshops

The dialogue comprised six online workshops, each between 1 hour 30 minutes to 4 hours long. The workshops were hosted on Zoom (see Appendix A for more detail on delivery tools) and saw all participants from across locations come together in one virtual room. The online workshops were organised into plenary and discussion sessions. During plenary sessions, all participants listened to the same presentations and participated collectively in Q&As with specialists. During discussion sessions, participants were organised into smaller, location-based break-out groups led by a facilitator.

For more detail on session structure and materials used in workshops, please see Appendix A and Appendix F.

1.5.4. Online tasks

Throughout the dialogue, participants were asked to complete tasks, review information and watch playbacks of presentations on an online platform hosted by Recollective. While this was separate to the workshops held on Zoom, it was still a key part of the dialogue, and as such forms part of the dialogue data set reported herein.

We set 1-3 small tasks per week for participants to complete. Some of the tasks were aimed at presenting information and to understand if anything remained unclear to participants, while other tasks were aimed at gaining insight on individual reflections.

Some examples of tasks completed are:

- discussions and debates through forums;
- reading and/or writing and sharing stories;
- polls and surveys;
- watching and reviewing film clips;
- commenting on or tagging images (such as maps or models);
- submitting photos, videos or files;
- journaling; and
- ranking or prioritising options.

Participants could also find responses to questions they asked during the workshops in the online platform. Their questions were captured and answered in writing by specialists before being uploaded to Recollective.

For a detailed overview the online tasks, see Appendix A and Appendix F.

1.5.5. Analysis and reporting

After each live discussion session, facilitators reflected on emerging views from their group discussions. Emerging views were taken back to later workshops to test and refine our understanding.

After the final workshop, the Traverse analysis and reporting team met to reflect on the findings and emerging themes and to develop our thematic analysis approach. All qualitative data was thematically coded in our bespoke analysis tool Magpie to support robust and neutral analysis. Early findings were posted on the online platform, for participants to review and comment on.

For a full review of the analysis and reporting process please see Appendix A.

1.6. How to read this report

This report is divided into:

- Executive summary
- Chapter 1: methodology
- Chapters 2 – 4: findings
- Chapter 5: participant journey
- Conclusion
- Appendices are provided in a separate document.

Findings are reported thematically following the key themes that emerged from analysis. Themes are covered in order of frequency they came up in the data. Any key differences in views between locations or nuclear technologies are noted and explored within the relevant thematic area. Where no differences are noted, assume that views were similar.

The data analysed for Chapters 2 - 4 broadly but not wholly, aligns with the journey through phases 1 to 3 respectively, as shown in Figure 2 (above). The report includes analytical commentary on observational data, individual data, and group data. Analytical commentary is not participants' views, but rather Traverse's observations drawing from the dialogue and previous deliberative engagement experience. We have sought to distinguish clearly for the reader between participant views and Traverse observations, by using the active voice. For example:

- "some participants' commented…" is an example of how we report on participants' views; and
- "speculatively, we can infer …" is an example of analytical commentary from Traverse.

When referring to the public dialogue in the text, we refer both to live workshops, and asynchronous activities and discussions on the separate online platform.

Findings and conclusions are reported on as interpreted through the analysis and reporting process.

1.6.1. Quantifiers

We use non-specific quantifiers to give relative weighting to qualitative data, instead of reporting on numbers or percentages of participants, because numeric quantifiers would be misleading given the sample size.

- 'Most' or 'majority' when a clear majority of participants shared a similar view
- 'Some' when a minority of participants shared a similar view
- 'A few' when a small number of participants shared a similar view

To avoid repetition, we sometimes use 'participants' without a quantifier. This should only be the case when used in a paragraph which includes a related sentence which already has a quantifier, and does not imply that all participants shared a specific view.

Where multiple views on an issue are presented, more prominent views are generally reported first. We use terms such as 'consistent', 'frequent' 'commonly held', or 'less common', to show the relative frequency of occurrence of views.

1.6.2. Graphs and quantitative data

While this was a deliberative, qualitative process, some quantitative exercises (such as surveys and polls) were included at various points in the process to understand the audience, support facilitation and iterative design, and complement observational data on shifts in views over time. The quantitative exercises focused on testing participants' views on nuclear energy and advanced nuclear technologies, particularly around participant knowledge, perceptions, siting and usage.

All questions asked as part of the survey can be found in Appendix F.

The focus of this project was to gain depth, deliberative, qualitative insight, as several large-scale quantitative data sources already exist (such as the BEIS Public Attitudes Tracker). As such, we have included only the most relevant and meaningful quantitative data in the main body of the report, and caveated that it must be interpreted in conjunction with the qualitative data.

Additional graphs and data are presented in Appendix G.

1.6.3. Interpreting and extrapolating findings

Public dialogues are well respected as an approach for their ability to engage the public with complex policy issues in a meaningful and informed way. However, as with any research method, when interpreting the findings, it is important to bear in mind the potential limitations of the approach and how these have been mitigated.

- Recruitment processes (Appendix A) can introduce bias, as people interested in a topic are more likely to sign up and attend. During recruitment, we intentionally used a broad description of the dialogue topic, "The future of energy", to try and attract a wider audience and used quotas to reduce bias. Nonetheless, participants may have been more interested in energy than the general public.
- Stimulus materials, specialists and activities influence participant views. This is both a strength and potential limitation of dialogue approaches as it can introduce bias. As professional dialogue specialists, Traverse worked with topic experts to ensure that materials, information and the process were evidence-based and broadly understandable to the wider public. The Oversight Group scrutinised all materials to help

mitigate bias. An independent evaluator (3KQ) was also appointed to evaluate the process.

- Deliberative dialogues have a limited scope and time for participants to engage with the information. Certain topics that are related to advanced nuclear technologies and that were brought up by participants could not be explored in-depth due to limited time, for example, other ways to achieve net zero, the use of renewables, or nuclear waste and geological disposal facilities as a solution.
- The dialogue was a qualitative engagement exercise. The number of participants (71) and deliberative approach, mean that findings should be considered illustrative, and are not statistically representative of public views, as in all Sciencewise dialogues. This is particularly relevant when considering any graphs and quantitative data.
- Any quantitative data in this report came from closed question surveys and polls. All topics of the survey questions were discussed in more depth during live workshops, where it became apparent that participant responses to surveys often came with caveats. Therefore, all quantitative data has been analysed alongside qualitative data. To grasp the complex narrative of the findings it is important to only consider quantitative data in conjunction with qualitative findings.
- Where differences have been identified by location these are noted in the text. Differences between locations should not be interpreted as definite geographical patterns, as they could be attributed to other variables, such as differing local samples, or location specific experiences.
- As with all research, this report is a snapshot in time. People's views may change significantly in the future, particularly given the potential for advancements in relevant technologies.

1.6.4. Finding your way around

Findings are reported thematically, looking at the outputs of the discussions across all locations and across all research questions. Each chapter begins with a high-level summary.

The term advanced nuclear technology is used throughout the report for ease. This was not the term used in the dialogue (for a full discussion of terminology see Spotlight: Language).

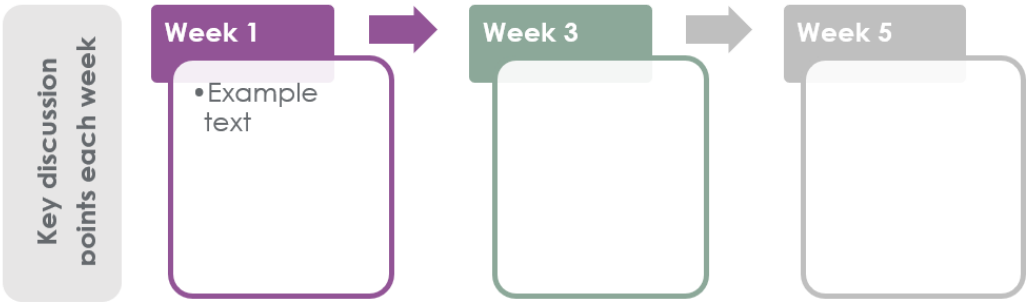
Summaries are presented at the start of chapters 2, 3, 4 and 5, in grey blocks such as this.

- Findings: The big picture of energy page 26
- Findings: Hopes and concerns, page 42
- Findings: Siting and deployment page 68
- Findings: Participant journey, page 79

***Quotes** are used throughout the report to illustrate points, not replace narrative. To ensure quotes are in participants' own words, they have been taken from comments submitted on the online platform Recollective. These are provided verbatim, without changes to spelling or grammar.*

Take away messages are highlighted at the end of sections in purple blocks like these. These present Traverse's interpretation of the key take-aways from the data of each theme.

For each key theme, we will reflect any **change in views over time**, in visuals such as this:



Spotlights

Spotlights are featured throughout the report in blocks such as this. These give more detailed insights on particular cross-cutting themes.

- Spotlight: Global thinking, page 35
- Spotlight: Language, page 82
- Spotlight: Online engagement, page 92

2. Findings: The big picture of energy

This chapter explores the range of views shared throughout the dialogue around the current and future UK energy landscape and the role of nuclear energy and advanced nuclear technologies in it.

Through the dialogue journey, participants were first introduced to the energy landscape of the UK, the commitment to net zero by 2050, and nuclear technology as a whole, before being introduced to details of advanced nuclear technology. As such, their discussions on advanced nuclear were deeply informed by their views on these preceding topics. Placing advanced nuclear technologies within this context was an intentional part of the dialogue design, and it is important to acknowledge it when considering findings.

Participants drew on personal considerations and practicalities when initially considering the future energy landscape of the UK. However, during the course of the dialogue participants became more invested in questioning the broader environmental impact of different technologies.

Most participants acknowledged the complexity of the topic and pathway to net zero. They commonly expressed difficulties in visualising a clear roadmap to net zero by 2050. Most participants did not feel a clear case for nuclear as part of the future energy mix had been communicated, or that they knew enough about alternative pathways (see section 2.2.1).

Indeed, participant views on deploying new nuclear energy to meet net zero by 2050 were complex and nuanced. While most participants accepted that nuclear could provide a low carbon source of energy, helpful to the net zero transition, and appreciated its potential reliability, this support was mostly qualified with concerns and further questions. The majority of participants emphasised using nuclear as a stop-gap to deliver to increasing demand while renewable technologies continue to develop.

As with participant views on nuclear energy in general, cautious optimism about the reliability and low carbon nature of advanced nuclear technologies, was mostly qualified with concerns. Additionally, participants frequently questioned the unknowns of the new and developing technologies. Based on experience from previous public dialogues we can speculate that this contributed to participants' hesitancy to give firm opinions about the technologies.

Most participants preferred resources to be allocated to developing renewable energy technologies and felt that the UK should not rely solely on advanced nuclear technologies to reach net zero, but a mixture of green energy sources, with renewables dominating.

2.1. The UK energy landscape

2.1.1. Making sense of energy and electricity

A majority of participants initially appeared to confuse the concepts of energy and electricity and used the terminology interchangeably when reflecting on net zero, future energy needs and nuclear. Participants used 'energy' to describe various things such as renewable energy, green energy, affordable energy, and nuclear energy and electricity.

Throughout the dialogue, this conflation continued, and most participants continued to consistently refer quite broadly to energy. However, they more clearly differentiated between electricity and energy by reflecting on how various sources of energy (renewables, nuclear, green) would be needed to cater for the increasing demand in electricity.

Yet, even when participants grew more confident in differentiating the concepts, they continued to use the terms interchangeably, arguably indicative of how the public views and uses the term 'energy' as a broad concept, making it difficult for some to use with accuracy.

We can infer, that in the context of advanced nuclear, the public will conflate the concepts of energy and electricity even further, as the energy produced in nuclear reactors could be used for applications other than electricity production. Indeed, some of the potential opportunities of advanced nuclear technologies are specifically around directly using the heat energy produced for other applications, such as heat for industry or hydrogen production. Therefore, even commonly used everyday terms such as energy and electricity, need to be clearly considered and explored in public engagement.

Nonetheless, we did not observe the conflation of terminology to be a barrier to participants sharing their hopes and concerns and, using their lived experience to weigh up different aspects of advanced nuclear technology. As such, we would not see this as a barrier to wider public engagement.

Independent of previous awareness, participants initially confused the concepts of energy and electricity, which is indicative of how these concepts are commonly conflated in society.

Dialogue participants became more confident in clearly differentiating between electricity and energy. However, given the multiple potential outputs of advanced nuclear we would expect the general public, as seen with the participants, to use energy and electricity interchangeably. This will arguably, not provide a barrier to future public engagement on different technology types.

2.1.2. The impact on households versus the impact on environment

At the beginning of the dialogue participants found it easier to talk about energy and future energy in relation to their individual lives, rather than the impact on the environment as a whole. For example, participants commonly referred to the change from petrol to electric vehicles and change of domestic heating systems in the first week of the dialogue. Likewise, participants initially expressed hope that future energy would be affordable to the individual or households.

Some participants were surprised to learn that domestic households are consuming more electricity compared to industry and businesses in the UK. They reflected on the national decline in industry but also the sense of responsibility falling on the individual due to the high household electricity consumption. We believe that for some participants this information stimulated initial discussion on the future energy landscape in relation to their individual lives.

However, as the dialogue continued, participants referred less to individual impacts and more to environmental impacts. For example, while the majority hoped for an affordable energy future, this came with a sense of resignation that relying on green, environmentally friendly energy would potentially come with an added financial cost.

Speculatively, the clear sense of concern for the environment throughout the dialogue could relate to previous awareness of climate change, wider issues of environmental sustainability and existing perceptions of nuclear as non-environmentally friendly. Throughout the dialogue, participants used words such as ‘green’, ‘clean’, ‘sustainable’, ‘environmentally friendly’ and ‘renewables’ to describe their perceptions of future energy. Drawing on frequent themes highlighted in participant discussions, we can interpret that this growing environmental perspective impacted participants’ hopes and concerns about advanced nuclear technologies. For example, while cost continued to feature in discussions, it always came second to the top priority of minimising impacts on the environment.

Most participants’ views about the future of energy in the UK were initially shaped by personal considerations and practicalities but were increasingly influenced by concerns about environmental impacts.

2.1.3. A consistent preference for renewable energy

Coming into the dialogue, some participants were immediately surprised at the proportion of electricity produced by renewable sources in the UK. They learnt about the increase in renewable energy in the last 10 years and that currently 37% percent of UK electricity comes from renewables[8]. Participants reflected that this information instantly made them feel hopeful and optimistic about an energy future dominated by renewable energy.

"I continue to be surprised by the amount of energy produced in the UK which is from a green source. I've always been quite pessimistic and thought that only a very low percentage of our energy came from renewable and green sources (I thought around 10% or less), but following the presentations, I've learned that much more of our energy is renewable." (Porthmadog)

Most participants had a greater pre-existing awareness of renewable energy than nuclear energy. Some participants reflected that they had not covered nuclear energy much in school and did not know to what extent nuclear was used in the UK. Contrastingly, most participants were aware of various renewable energy sources. For example, participants commonly referred to local renewable energy projects such as solar panels and wind farms when discussing their views and perceptions of future energy. The visibility of different energy technologies as part of daily life seemed to play a key part in participants' levels of awareness of renewables but also nuclear technology. For example, some Porthmadog participants had a greater awareness of nuclear technology, with some able to see a nuclear station from their house.

We believe the greater general awareness of renewables, combined with the information presented about the level of renewable energy in the UK electricity generation mix, influenced participants' perceptions of future energy, and their discussion about the need case for advanced nuclear technologies. For example, it may be part of the reason why participants commonly related the concept of future energy to renewable energy at the start of the dialogue.

"Nuclear energy is not something I've been brought up learning about it. I've heard hardly anything about it. You hear lots about renewables. I didn't think there were many nuclear power stations generating power in the UK." (Porthmadog)

[8]Digest of UK Energy Statistics (DUKES) 2020, Chapter 5: Electricity. https://www.gov.uk/government/statistics/electricity-chapter-5-digest-of-united-kingdom-energy-statistics-dukes

Participants generally preferred renewable energy to nuclear energy throughout the dialogue, both in discussion and in individual feedback through the online platform. This aligns with the evidence from the UK Climate Assembly, where participants strongly agreed that renewables should be the dominant source of electricity generation[9].

The majority of participants questioned why the UK is not aiming to rely only on renewable energy in the future. Some participants reflected that their interest in this was influenced by what they learned during the dialogue about low-carbon and renewable energy sources, predicted increases in electricity demand, the need for low-carbon energy, and the reliability and efficiency of different energy technologies.

Some participants felt strongly that investment should be put into the research and development of renewable energy, rather than additional nuclear technologies. They noted technologies that would improve the reliability and consistency of solar and wind (such as battery storage) and expressed an interest in renewable technology that is less common in the UK, such as hydro- and tidal-power. However, in discussions some participants became more inclined to consider the use of nuclear energy to reach net zero, upon being reminded that some renewable energy technologies are dependent on weather conditions, and discovering that nuclear energy is considered more reliable and low-carbon.

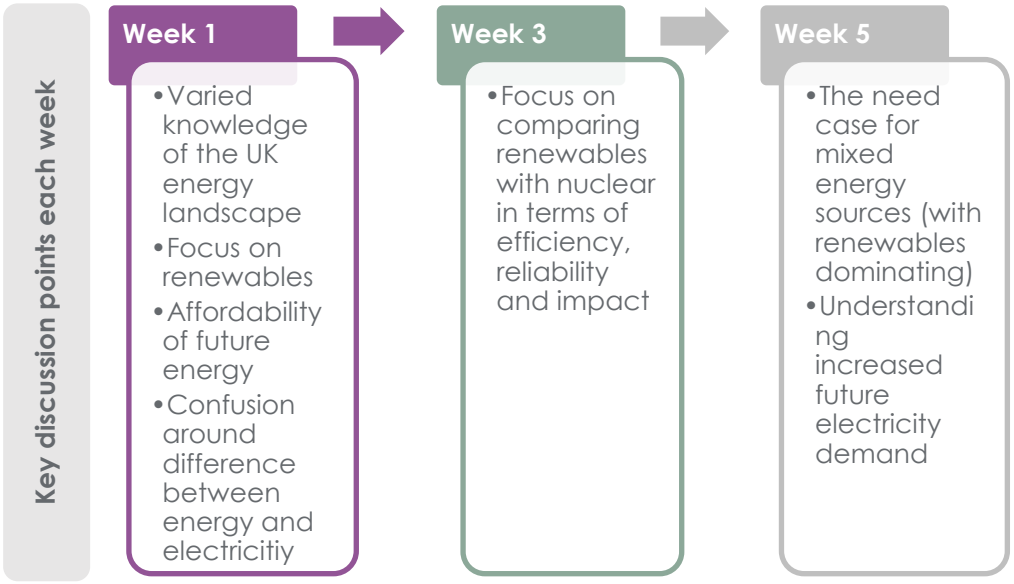
Most participants felt that Government should focus on increasing the use of renewable energy ahead of new nuclear energy. This was a key influencer on views about the siting and deployment of advanced nuclear technologies.

2.1.4. How did views on the energy landscape in the UK change during the dialogue?

Participants entered the first workshop with varied pre-existing views on the future UK energy landscape. Where some participants were familiar with how energy is produced and what energy sources are currently used in the UK prior to the dialogue, others reflected that it was something they had rarely considered before. Participants were initially hoping for future energy sources to be environmentally friendly and sustainable when entering the workshop. This view grew over the workshops, as they reflected on how combatting climate change relies on a reliable, low carbon energy system.

The diagram below shows key points highlighted in each workshop (in no particular order), when participants discussed future energy in the UK. It also shows the main activities or information sources that influenced opinions according to our analysis ('what we think shaped these changes').

[9] UK Climate Assembly, 2020, https://www.involve.org.uk/sites/default/files/field/attachemnt/Climate%20Assembly%20UK%20Executive%20Summary.pdf



What we think shaped these changes	Presentation on UK energy landscape Online activities	Specialist Q&A Online activities Presentation on nuclear energy	Presentation on advanced nuclear technologies

At the first workshop participants listened to a presentation about the energy landscape in the UK. This presentation introduced participants to current energy use, energy sources, and how these will have to change in the future to achieve net zero. Throughout the dialogue, participants frequently reflected that much of the information given in this initial presentation was new to them. Some participants described this presentation as an 'eye opener' to their understanding of the big picture of energy, both relating to the current and future energy landscape. Participants mentioned the change in dominant energy sources to produce electricity over recent years, and the proportion of electricity consumed by households in the UK, as particularly surprising information.

Renewables continued to feature in discussions throughout the dialogue. Participants used a lot of their specialist Q&A time (refer to Appendix A for more detail) to ask about the development of renewable energy and compare it to nuclear.

Increased understanding of future electricity demand and supply impacted participants' views of the need for a diverse mix of electricity sources. Participants accepted the assessment presented by specialists that a mix of energy sources should be used in the UK, to respond to the increasing demand for electricity.

2.2. Net zero targets and ambitions

2.2.1. The complexity of net zero and a roadmap to 2050

Most participants had heard of net zero and the UK 2050 target prior to the dialogue. They expressed optimism when they were given more information about the UK working toward net zero carbon emissions. Some participants had heard less about net zero and were unaware of the UK 2050 target. They too, were mostly positively surprised to hear about the target date for net zero emissions in the UK. Regardless of previous awareness, most participants reflected that prior to the dialogue they did not necessarily reflect much on what such a target meant for them individually and, more so, for the UK energy system.

Participants had varied views on the achievability of the UK 2050 target. While some saw it as realistic, others only saw it as a hopeful rather than realistic ambition. Some participants wanted an even more ambitious target while a few did not care much about the actual date set.

However realistic the target did or did not seem; most participants consistently highlighted the complexity of the pathway to net zero throughout the dialogue. Some participants wondered if there were alternative pathways to net zero not including nuclear. They did not feel that enough clarity had been provided around alternative, non-nuclear pathways. This led them to feel there was not a clear case for the need for nuclear in achieving this target.

> *"I would like to see a clear plan to obtaining net zero carbon emissions by 2050. I don't feel like it has been showed how this can be achieved and particularly the specific impact of nuclear energy on this." (Scunthorpe)*

For many participants, this was a key milestone in their participant journey (see section 5.3). As noted in chapter 1, the dialogue scope focussed on enabling participants to deliberate on advanced nuclear, rather than alternative pathways to net zero. Whilst participants heard information about future energy scenarios, detailed information about the future development of other technologies was not given (Figure 7).

Most participants highlighted the complexity of the pathway to net zero and, reflected that they had not thought of the implications for themselves or the public. They commonly expressed difficulties in visualising a clear roadmap to net zero by 2050 and did not feel a clear case had been made for nuclear as a solution in achieving this target.

2.2.2. Net zero as a global issue

Arriving at the dialogue, participants initially discussed net zero from an individual behaviour change perspective referring to, for example, how it would require fewer holidays abroad and abandoning petrol cars. However, some participants immediately spoke about net zero as a global issue. Participants commonly questioned if the UK 2050 net zero target mattered in the context of the global picture.

Although the dialogue focused on understanding participants' views towards the siting and deployment of advanced nuclear technologies in order to help policy development in the UK, we continued to see participants take a global perspective on net zero as the dialogue progressed (see Spotlight: Global thinking). Some participants were consistently concerned that if other countries did not reduce emissions, it would not make a difference if the UK does or does not reach net zero by 2050. Some made specific references to other countries they perceived to be the big emitters today, for example China. They argued that climate change will not be alleviated based on the success of one country only and as such felt unsure it was the UK's responsibility to lead in the development of this new technology. Information and discussion around the UK's historical contribution to carbon emissions, and a comparison of global emissions was outside the scope of the dialogue and so this view was not consistently challenged.

Speculatively, participants' global perspective on net zero affected their feelings towards the development of advanced nuclear technologies. Some participants felt that a decision to deploy advanced nuclear technologies in the UK should not only be driven by their potential role in achieving net zero nationally, but also internationally. They worried that the UK would end up spending a lot of time and resources on developing a technology with many unknowns, rather than using and further developing tried and tested renewable technology. Renewable energy was viewed by some as potentially bringing more immediate national and global benefits to the environment as much of this technology is already in place in the UK as well as other countries.

"At least it has been recognised that we need to reduce emissions and if we achieve the [UK net zero] target then even if there is a small threat from nuclear power stations at least we will have reduced pollution and hopefully no global warming. Although having said that, we are a tiny island and we need all the other countries to do the same and I am not sure that they will. So actually I still feel pretty hopeless about it all." (Scunthorpe)

Most participants envisioned net zero as an issue that needs to be tackled globally. They worried that the UK would potentially risk spending a lot of time and resources to invest in research and development of a new technology, that in the end would not particularly mitigate climate change if other countries did not achieve net zero. Some saw renewables as having less unknowns and bringing more immediate benefits.

2.2.3. How did views on net zero targets and ambitions change during the dialogue?

Participants continuously expressed concerns about the lack of clarity on the pathway to achieving net zero, with or without nuclear. However, net zero as a concept featured less in discussions after the first week of the dialogue. Instead, participants more commonly spoke about 'protecting the environment' when discussing the need case for nuclear and other energy sources. We believe this was both due to net zero featuring less as a concept in later presentations and participants' growing concerns around the impact of nuclear on the environment. These will be explored further in chapter 3.

Participants reflected on how presentations and engagement with specialists somewhat clarified how nuclear is a low carbon, reliable energy source.

However, participants continued to question how using nuclear to reach net zero compared to not using nuclear to reach net zero.

	Week 1	Week 3	Week 5
Key discussion points each week	• Varied level of understanding of net zero and the UK target • Net zero as a global issue • Learning that nuclear is a low carbon energy source • Confusion around the road map to net zero (and the role of nuclear)	• Nuclear perceived as a reliable energy source • Questions to specialists on 2050 UK target being dependent on other countries and possibilities to reach it without nuclear • Net zero as a global issue	• 2050 UK target viewed as important • Confusion around the road map to net zero • Net zero as a global issue
What we think shaped these changes	Presentation on UK energy landscape Online activities	Specialist Q&A Online activities Presentation on nuclear energy	Presentation on advanced nuclear technologies

Spotlight: Global thinking

This public dialogue focused on understanding participants' views towards the siting and deployment of advanced nuclear technologies in order to help policy development in the UK. However, early in the dialogue most participants took on a global perspective in their reasoning and discussion. This perspective continued to feature frequently as participants journeyed through the dialogue. Noting our typical experience in dialogues being that people comment from personal or family/community perspective more than global perspective or ethical considerations / concerns for communities abroad, we were surprised by the extent of global thinking that many participants applied. While we expected participants to somewhat draw on international comparisons around climate change and nuclear accidents, some of them went beyond climate change and previous nuclear accidents and picked up quite heavily on comparisons with other nations' energy systems, the environmental and ethical concerns for uranium mining in communities abroad, and exporting impacts to potentially ill-equipped, poorly regulated countries.

As outlined in section 2.2.2, most participants instantly perceived the challenge of combatting climate change as an issue that needed to be tackled globally. Similarly, they immediately applied global thinking to the need case for nuclear energy. Some participants questioned and compared the UK's attitude and approach to new nuclear energy with other countries. They frequently asked specialists to clarify why some countries relied heavily on nuclear energy and others not at all. Speculatively, these types of international comparisons could have added to some participants' frequent interest in pathways to net zero that exclude the use of advanced nuclear technologies.

Participants' global thinking also highlighted varied attitudes to global leadership and how comfortable they felt about the UK taking on this role in reference to advanced nuclear. While some participants saw the development of advanced nuclear as an opportunity for the UK to be a world leader in a new technology field, they emphasised the responsibility and accountability that comes with such a role. For example, some discussed how uranium mining could result in unfair working practices in less wealthy countries, often to the benefit of wealthier ones. Others feared that developing advanced nuclear came with responsibilities around ensuring the technology would not end up in the hands of unstable political regimes. This arguably shows how underlying concerns around global power dynamics and values of equality and fairness influenced discussions.

Among some participants, these conversations further highlighted a fear of being dependent on others and a preference for being self-sufficient. They worried that any foreign dependency on resources, workforce and funding could be taken advantage of. This type of concern arguably

highlights some participants' mistrust in international relations, potentially heightened by the current global pandemic and vaccine dependency.

2.3. The need case for nuclear energy

2.3.1. Nuclear energy and its role of achieving net zero

Most participants had limited knowledge of nuclear power stepping into the dialogue. Some participants initially perceived it as dangerous and questioned its safety and impact on the environment, commonly referring to international accidents such as those in Chernobyl or Fukushima. Others mentioned how their knowledge was limited to watching cartoons and TV shows, such as The Simpsons and Chernobyl.

As Figure 4 shows, arriving at the dialogue about half of the group were commonly undecided as to what extent they supported the use of nuclear energy for generating electricity. Participants commonly felt that their limited knowledge of nuclear prior to the dialogue made it difficult to express an opinion on the extent to which they supported or opposed its use.

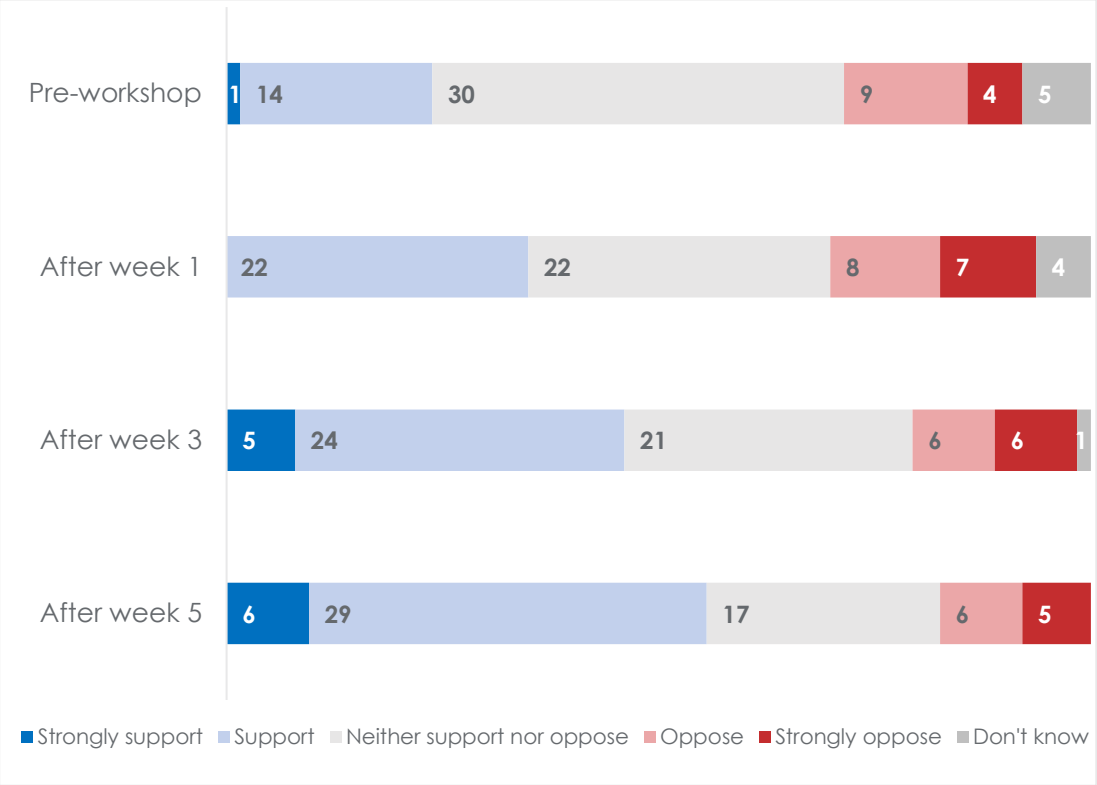
"Although I watch news programmes regularly, and read national newspapers, I am surprised to discover how little I know about nuclear energy." (Scunthorpe)

Data from the survey on the online platform (Figure 4) shows how support for using nuclear for generating electricity in the UK, grew among participants over the course of the dialogue. Prior to the dialogue, about a quarter indicated support, while at the end of the dialogue, about half of the participants who responded to the survey indicated some sort of support.

Similarly, in the survey most participants tended to agree that nuclear energy will help combat climate change in the UK, by the end of the dialogue (see Appendix G, section 7.1.3, Figure 6).

However, while the survey data shows quantified support of using nuclear for generating electricity and agreement that it will help combat climate change in the UK, the qualitative data shows that this was mostly qualified with questions or concerns. Some participants who grew more supportive of the use of nuclear energy over the course of the dialogue reflected on the need case for low carbon energy to efficiently meet increasing electricity demands and help meet the 2050 net zero target. Others commented on the potential benefits to the local economy and job opportunities, and whether advanced nuclear technologies could make the UK a leader in new low carbon technology. However, few participants fully supported the use of nuclear without questioning the approach, comparing it to renewable energy or expressing concerns around safety and long-term impacts. The varied levels of support for the use of nuclear are explored further below and in following chapters.

Figure 4: Graph of survey data from before the dialogue and the end of each phase, for the question 'From what you know, or have heard about using nuclear energy for generating electricity in the UK, do you support or oppose its use?', reflecting those participants who completed all three surveys (n=63).



Participants' initial perceptions of how nuclear energy could play a role to the future energy landscape of the UK varied slightly. While some felt it appeared 'futuristic' (mainly referring to the way nuclear energy is created), others claimed it was something of the past – 'clunky' and old.

Specialists gave information which included National Grid's 'Future Energy Scenarios', all of which included an element of nuclear energy in 2050 (Figure 7). Specialists were regularly asked to clarify if the UK 2050 net zero target could be met without using nuclear energy. Speculatively, the commonly held perceptions that future energy should be renewable, together with limited base knowledge of current and future nuclear technology could mean that participants initially felt confused and conflicted about the focus on nuclear as a future energy source.

"My feelings towards modular nuclear technology at the beginning was that it was a dirty way of producing energy, but after listening I feel that the way things are going and heading towards it will become more clean and if every person follows then the world will become net-zero by 2050 but then again I do have doubts on reaching this, and if it is not reached then where will that leave the whole world?" (Porthmadog)

Most participants were surprised when they learnt that nuclear power is a low-carbon energy source. Participants widely accepted the evidence on nuclear as a low carbon source presented by specialists. They used this information frequently throughout the dialogue when reasoning about nuclear and its role in achieving net zero. In addition, after participants found out more about the reliability of nuclear energy, they were more inclined to consider it as a future energy source.

Some participants frequently spoke about the use of nuclear as a 'stop-gap' and a temporary alternative to diversifying energy sources. While they could see the need for reliable electricity production to cater for increasing demands in the immediate future, they also believed that technology and research around renewables would catch up over time. These participants felt that nuclear might not necessarily be a long-term solution, but rather an interim until renewable technologies had been further developed and could provide for all energy needs in the UK.

Most participant views on deploying new nuclear energy to meet net zero by 2050, were complex and nuanced. Indeed, most were surprised to learn that nuclear energy is low carbon.

While most participants understood the presented need case for a low-carbon energy source to meet net zero, support for nuclear was always qualified with concerns and questions. Some participants emphasised using nuclear as a stop-gap to deliver to increasing demand while renewable technologies are still advancing.

2.3.2. Using advanced nuclear technologies to achieve net zero

The majority of participants had not heard of advanced nuclear technologies prior to the dialogue. Most participants felt slightly more inclined to consider using advanced nuclear technologies in achieving net zero as the dialogue proceeded. By the end of the dialogue some participants reported that they felt cautiously optimistic about advanced nuclear technologies. They could better visualise the benefits of advanced nuclear technology and its role in ensuring a reliable, low carbon future energy supply to cater for an increasing electricity demand. They particularly referred to nuclear being a reliable source of energy as a key factor for their cautious optimism.

"When the process started I was perhaps I person who's glass was half full / half empty I could take it or leave nuclear energy perhaps believing technology would catch up making better wind turbines, solar cells, storage batteries and perhaps tidal power, then we wouldn't need nuclear. After the last few weeks and listening to specialist I now believe we need nuclear as a piece of the energy jigsaw in the big picture to achieve zero carbon, if we are to give the future generations a chance." (Porthmadog)

Quantitative data indicated that about three quarters of participants completing the online survey acknowledged that advanced nuclear technology has a role to play in the UK reaching net zero (see Appendix G, section 7.1.4, Figure 7).

However, like the survey data about nuclear energy, positive views about advanced nuclear technologies, were mostly qualified by concerns and questions. Indeed, workshop discussions highlighted that most participants felt uncertain about providing strong opinions regarding what extent advanced nuclear technologies would help to combat climate change and should be used to achieve net zero. Most participants could see the benefits of a reliable, low carbon energy supply. However, they felt there were plenty of unknowns that needed to be clarified before they could more firmly express a view for or against, particularly around the long-term impact of advanced nuclear technologies on the environment (these are explored further in the following chapters). Drawing on past experiences of public dialogues, this highlights the complexity and nuance that often appear in participant views as they journey through a dialogue.

Some participants were against the use of advanced nuclear technologies to reach net zero. They felt that time, energy, and resources going into research and development of advanced nuclear technologies would be better placed developing renewable energy sources. They also remained conscious of various concerns, which are discussed in chapter 3.

There was a level of optimism and support, although complexity and nuance often surfaced with many participants questioning whether a focus on advanced nuclear technologies could remove focus from renewables.

"I think we need to think about whether we actually need to use nuclear power or whether all the money we would have paid into research, development, building, paying interest on money invested and running the stations could be invested in researching and paying for storage of renewable produced energy when we have more than we need, for times when we don't, other forms of renewable that are reliable." (Scunthorpe)

Although some participants felt cautiously optimistic towards using advanced nuclear technologies in achieving net zero, it was emphasised that this energy source should just be one of many or as a stop gap or last resort. Most participants felt that the UK should not rely solely on advanced nuclear technologies to reach net zero, but a mixture of green, low-carbon energy sources, where renewables should feature as the dominant energy source.

"I have learnt a lot more since attending the meetings on Zoom and listening to experts, but I still cannot subscribe to the idea of using nuclear energy to meet the zero carbon initiative as I feel there are greener and cleaner methods of generating electricity that should perhaps be better funded. Nuclear energy should be used as a last resort, and definitely newer, unproven technology should not make its way into highly populated areas where it can pose a risk to the life, health and livelihood of the people in the event of any untoward incidents." (Reading)

Like with nuclear energy in general, cautious optimism about the reliability and low carbon nature of advanced nuclear technologies, was often qualified with questions and concerns. Additionally, many participants heavily questioned the unknowns of the new and developing technologies, and we can speculate that this underpinned a reported hesitancy to give firm opinions.

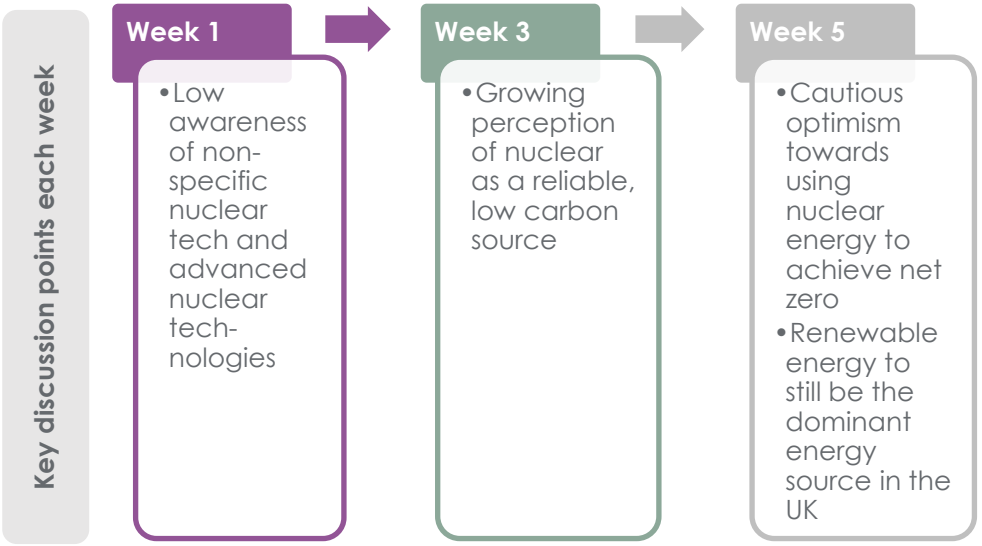
Most participants preferred resources to be allocated to developing renewable energy technologies and felt that the UK should not rely solely on advanced nuclear technologies to reach net zero, but a mixture of low carbon energy sources, with renewables dominating.

2.3.3. How did views on the need case for nuclear energy change during the dialogue?

Participants entered the first workshop with limited pre-existing views on nuclear technology and its role helping the UK to achieve net zero. Most participants had never heard of advanced nuclear technologies before stepping into the dialogue (this aligns with results from the most recent BEIS Public Attitudes Tracker[10]).

While quantitative data showed support for the use of nuclear energy increasing over time (Figure 4, and Appendix G, Figure 6 and 7), qualitative data showed that most participants' views on the need case for nuclear energy did not change significantly. Throughout the dialogue, participant views about using nuclear energy to achieve net zero remained complex and nuanced. A shift in views about the need case for nuclear energy took place from week 3 and onwards. At this point specialists explained current and advanced nuclear technologies in more detail, and participants felt that they could, to some extent, give more informed views.

[10] BEIS Public Attitudes Tracker, 2019 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/844940/BEIS_Public_Attitudes_Tracker_Wave_31_key_findings.pdf



What we think shaped these changes	Interaction with specialists	Specialist Q&A Online activities Presentation on nuclear energy	Online activities Interaction with specialists Presentation on advanced nuclear technologies

Participants pre-existing views of nuclear were often more negative than positive. Some participant views were influenced by media such as TV shows and animations.

Presentations and engaging with specialists clarified some issues and alleviated some pre-existing concerns (for example, safety concerns).

For most participants, the more they learned, the more questions they had, and it was clear they felt that in-depth, specialist knowledge was necessary to shape fully formed opinions. While most participants therefore drew on their interactions with specialists as part of their opinion-forming process, some felt that they needed a much more detailed picture of the UK (and sometimes global) energy landscape and energy options in order to be able to reach a conclusion. As such, the focus on nuclear and advanced nuclear left them feeling that while they had developed some views on one part of the issue, there was much more to discover about alternative pathways to net zero, which may then further influence their views.

3. Findings: Hopes and concerns

This chapter explores the hopes and concerns participants shared about nuclear energy as a whole, and advanced nuclear technologies in principle, throughout the dialogue process.

Participants were guided through a range of topics regarding nuclear energy and advanced nuclear technologies, including the fundamentals of nuclear technology, environmental considerations, regulation, nuclear waste, and eventually siting, deployment and policy-making. As the participants discussed nuclear energy as a whole, before covering advanced nuclear technologies, views about the principles of different technology types are very interwoven in this chapter. Chapter 4 provides more detail about how participants started to differentiate their views on different technology types when considering siting and deployment.

As most participants arrived at the dialogue with little to no prior knowledge of nuclear technology as a whole, hopes and concerns were initially formed of preconceived ideas about nuclear power, then influenced by the big picture of energy as discussed in chapter 2. Hopes and concerns were underpinned throughout the dialogue by a firm preference for prioritising renewable forms of energy. Views also shifted significantly over time, and became more intertwined, as participants used one another's hopes and concerns as springboards to other possibilities.

Key amongst participant concerns were nuclear waste storage and disposal, safety and the regulations in place to reduce the risk of harm, from both normal operations and potential accidents. Other themes which emerged included environmental impacts, and the transparency and fairness of decision-making around nuclear energy development. Values of fairness and cost-effectiveness underpinned a range of hopes and concerns about cost, local benefits, international relations, site size, and reactor size.

For some, these concerns were enough to entirely oppose the development of nuclear energy in the UK, and some of these views remained throughout the dialogue. Nuclear waste became a major sticking point for most participants, who went from knowing little about it, to having concerns centring around a perceived lack of solutions, and long-term impacts on future generations. The majority of participants cited concerns about safety in particular in initial conversations, though most of these participants were reassured by interacting with specialists who laid out the regulations in place in the industry.

Hopes that participants held often centred around the low carbon emissions of nuclear energy, job opportunities, and the reliability of nuclear energy supply. These emerged over the course of the dialogue, though were often held in a fine balance with questions and concerns. Some participants, for example, felt that the environmental benefits of low

carbon energy generation might be outweighed by other environmental impacts.

Although some participants' concerns lessened over the course of the dialogue, some participants retained or developed serious reservations, including some who expressed mistrust in decision-making processes and frustration at the scope of this dialogue. These are explained in further depth in the chapter to follow.

3.1. Impacts of nuclear waste storage and disposal

3.1.1. Hopes and concerns about impacts of nuclear waste storage and disposal

The impacts of waste storage and disposal were a concern for most participants throughout the dialogue. The topic was often raised and discussed in depth with specialists and in groups. Concerns about waste were evident in discussions, but also clear in survey data collected after the six workshops (Appendix G, section 7.1.9, Figure 13). In initial discussions of nuclear energy, almost all participants said that at the start of the dialogue, they had not been aware of challenges around the permanent disposal of nuclear waste in the UK.

The storage of nuclear waste was not the central focus of this dialogue, and the planned use of geological disposal facilities is a complex topic, itself subject to public dialogue processes[11]. This process briefly detailed the production of nuclear waste and its storage and disposal in workshop three. However, in workshop four, which largely consisted of Q&A sessions with specialists, participant questions and arguably the presence of specialists with expertise in waste, meant that waste became a significant focus of conversation and questions.

Most participants shared questions and concerns about various impacts of nuclear waste storage and disposal. The most significant of these were about potential impacts on the environment (particularly near storage and disposal sites), related costs and logistics, and the safety of the facilities, including potential health impacts on those in the local area.

Some participants asked specialists for more detail about the costs of the waste management process, questioning whether it was cost-effective. Information shared about related costs seemed to contribute to some participants' wider perception of nuclear energy as expensive.

Some participants also asked specialists for clarification about the logistics and safety of transporting waste. These conversations were usually brief and did not form persistent concerns. Nonetheless, this indicated that participants

[11] Sciencewise Report to Department for Energy and Climate Change, 'Evaluation of Public Dialogue on Community Involvement in Siting a Geological Disposal Facility', 2016

https://sciencewise.org.uk/wp-content/uploads/2019/05/Geological-Disposal-Dialogue-report-2.pdf'

were curious about the whole process of waste management, which was unfamiliar to most of them.

Some participants raised concerns about potential impacts on environments near nuclear waste storage and disposal sites. These concerns focused on potential harm to local wildlife and ecosystems. A few participants specifically mentioned a perceived risk of waste contaminating waterways and the water supply.

"I am still worried about the waste disposal aspect. Even in sealed containers I don't like the thought of nuclear waste being underground. If the fuel rods can be reused great." (Reading)

A few participants also mentioned concerns about the safety and regulation of storage and disposal sites, expressing concern that the health of people living or working nearby or at sites might be compromised (this is explored in more detail in section 3.2.1). Safety was a clear priority for almost all participants (see section 4.2).

Discussions revealed that almost all participants were not aware of the need for a permanent solution for disposing of existing nuclear waste in the UK, until it was covered in week three. In workshop four, specialists explained the amount of nuclear waste currently stored in the UK, the ways in which it is stored, and the size and form of the waste expected to be created by various nuclear reactor types. They also explained the ongoing approach to finding a geological disposal facility for the long-term disposal of nuclear waste.

It was at this stage that the topic of waste became a deeply felt concern and sticking point for a majority of participants. While a geological disposal facility was explained as the solution being pursued in the UK, this generally did not lessen concerns, as a site had not yet been agreed and some participants were not sure that communities would be willing to host one. Most participants felt it was important to have a waste disposal solution in place before investing in further nuclear energy.

Future impacts and long-term thinking were a key factor in considering nuclear waste storage and disposal. Some participants considered nuclear waste to be a long-term environmental issue comparable to carbon emissions and, expressed a preference for long-term thinking to underpin decision-making. In these conversations, some participants offered strategic recommendations unprompted, urging decision-makers to prioritise future generations and not to make hasty decisions without planning for the long-term future. Some participants expressed concern that current generations might be causing problems for generations to come, which seemed to tie in with core values for most participants around our responsibilities to future generations.

Most participants were uncomfortable accepting perceived safety and environmental risks, due to uncertainty around waste disposal. This was reinforced when some participants suggested potential future waste management challenges, such as running out of space in storage and disposal facilities, or unexpected consequences due to the duration of nuclear waste radioactivity. The more participants explored various factors around waste management, the more firmly they seemed to hold their concerns.

"I think that, like others, I see deep geological disposal as an unavoidable lesser evil rather than a preferred option. However, this isn't really relevant to the arguments for or against future nuclear development, as high level waste disposal is a problem that exists now. Adding to the stockpile doesn't really change the fundamental question: what is the safest means of disposal?" (Reading)

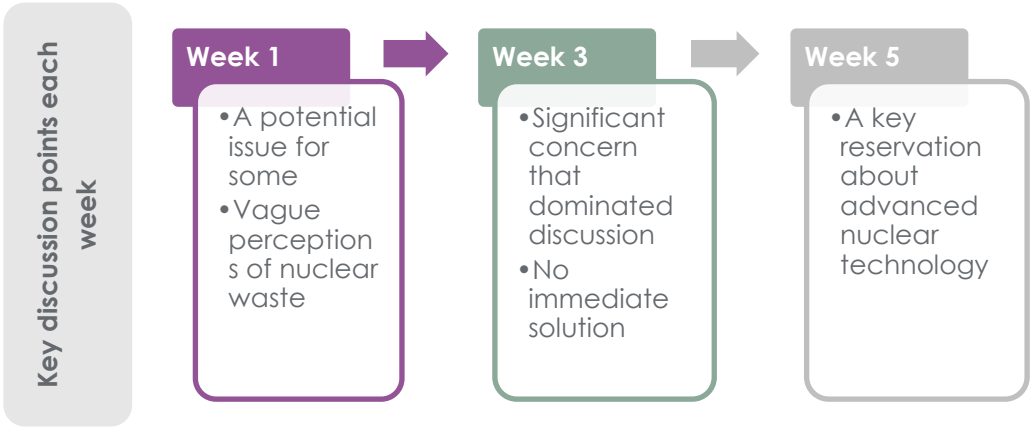
Some participants were hopeful that new technologies being developed might address these and other concerns. They responded positively to the possibility of nuclear waste being reused within advanced nuclear processes, although were concerned by the idea that re-using nuclear waste would still create more waste.

A few participants, who arrived at the dialogue with a greater pre-existing knowledge or interest in nuclear energy, hoped that new forms of nuclear power (such as fusion) might develop, in which waste would not be produced in the same way. This did not form a part of the larger dialogue, but was raised a few times, and formed a kind of 'outside the box' thinking approach in some groups.

Concerns about waste centred around immediate and long-term impacts of nuclear waste storage and disposal, in particular environmental and health impacts on local areas and people.

Most participants were concerned that a permanent disposal solution was not yet in place, and were worried about potential impacts for future generations. They felt this should be addressed before investing further in nuclear energy production.

3.1.2. How did views on nuclear waste storage and disposal change during the dialogue?



What we think shaped these changes	Popular culture reference points	Specialist Q&A Presentations	Interactions with specialists Siting activity

Early in the dialogue, some participants shared their preconceptions of nuclear waste, describing 'green bars' or 'goo', and referring to popular cartoon *The Simpsons* as a source for their initial understandings of nuclear waste.

In week 3, specialists took part in a Q&A in which participants asked many questions about waste. Although some participants were reassured by information shared by specialists at this point about the form and size of nuclear waste, others reacted with concern to the difficulties of finding appropriate disposal sites for existing and future nuclear waste, and the need to secure local agreement for hosting those sites.

3.2. Safety and security of nuclear sites and materials

3.2.1. Concerns about the safety and security of nuclear sites and materials

Most participants raised questions and concerns about safety in several contexts throughout the dialogue, and characterised those as some of the most important to them, which was not unexpected. Safety concerns were clearly a priority in discussion, but this was also noticeable in survey data after the series of workshops had ended (Appendix G, section 7.1.9, Figure 13).

"Safety will always be a concern for me and I will always worry that we can't mitigate every risk and with the best intentions there is always room for human error." (Scunthorpe)

Safety concerns largely centred around the possibility of accidents, and the impacts these might have on local people and environments. Most participants considered the potential impacts of accidents to be very severe and potentially catastrophic.

This perceived risk of accidents was raised in many discussions and was underpinned by what participants knew about historical accidents such as events at Chernobyl and Fukushima. These concerns were of key importance to a majority of participants and seemed to be underpinned by values of responsibility to the general public, and a compulsion to work to prevent large-scale harm to the population.

Most participants expressed concerns about various ways in which safety systems might be accidentally breached, such as in the event of an earthquake, subsidence, or human error, and asked specialists about procedures in place to avoid breaches. The concept of human error was raised several times, with some participants seeming to consider it more difficult to predict or safeguard against than other possible safety breaches.

Some participants also regularly raised concerns about security, and potential deliberate breaches of protocols, such as the risk of theft, or acts of terrorism. They connected these security concerns to a risk to public safety, but also to the possibility of the nation's energy supply being compromised, and the significant knock-on effects this might have. Some participants were concerned about possible implications of making international partnerships in nuclear technology, and what might happen if international relations broke down.

Some participants raised concerns about possible negative impacts on the health of residents in the areas surrounding nuclear sites (either a reactor or waste management facility). Some participants expressed concern that living near or working in a nuclear site might increase risks of cancer. They related these concerns to international nuclear accidents or what they had heard in the media, whilst a few participants from Porthmadog drew on local experience and knowledge of workers at Trawsfynydd. When specialists stated that health statistics did not suggest any increased risk of cancer to those living or working near nuclear sites, some of these participants were not reassured, expressing doubts about the transparency of that information.

"My main concern is the correlation between the radiation put out by nuclear power stations and a surge of cancer cases over time in the local area surrounding said power station." (Porthmadog)

A few participants also asked and expressed concern about possible risks associated with the supply chain of nuclear energy, particularly the mining of uranium in other countries. The safety of working practices in sourcing those materials, and the impact of those mining processes on local environments and populations was very important to some participants. These participants were concerned about unfair working practices in less wealthy countries, often to the benefit of wealthier ones, and it was very important to them that the UK should not be part of exploiting or mistreating labourers or communities abroad.

"I also began to think about the hazards of mining the stuff. Even though in Australia, there is a strong code of practice, I have read there is a lot of negligence in this area and that the workers are still affected by radon gas, resulting in a higher susceptibility to lung cancer. I certainly wouldn't want to do the job. Apparently, the risk of long term occupational exposure is significantly higher than generally accepted." (Scunthorpe)

Safety was very important to most participants throughout the dialogue, as expected. Concerns often centred around the possibility of large-scale accidents causing major harm and disruption to people and the environment. Some participants also raised concerns about safety risks they associated with the supply chain of nuclear energy, and a few worried that those living or working near nuclear sites might be at risk of adverse health impacts.

3.2.2. Regulation of nuclear industry and sites

When speaking with specialists, participants asked many questions about regulation in the nuclear industry as a whole, and the regulation of nuclear sites was discussed at length, in terms of ensuring safety for local communities, but also protecting natural environments.

At the beginning of the dialogue most participants had not heard of the Office for Nuclear Regulation (Appendix G, section 7.2., Figure 15). Similarly, at the outset of the dialogue most participants said they knew 'nothing' or 'hardly anything' about how nuclear power stations are regulated (Appendix G, section 7.2, Figure 17).

Some participants doubted that the penalties for breaking regulations would be strict enough, and held the view that financial penalties for very large corporations could not prevent unsafe practices. They were worried that even very large financial penalties would barely affect some corporations, and also that the costs of those fines would be passed on to consumers. These conversations revealed a distrust of private companies working in nuclear energy, and a perception that such companies are difficult to appropriately regulate.

A few participants expressed curiosity about the fines and penalties that regulatory bodies have given in recent years, and were keen that penalty processes be transparent to the public. Several participants raised an example of safety breaches at Sellafield as a cause for concern, particularly the detail of some nuclear waste being improperly stored in plastic bottles.

Some participants also wanted to know who forms the regulatory bodies, and who funds them. Regulation specialists explained that licence fees are paid by site owners to the regulator, and this prompted concern for a few participants who felt that the regulators might not be independent enough if they were funded by the nuclear industry.

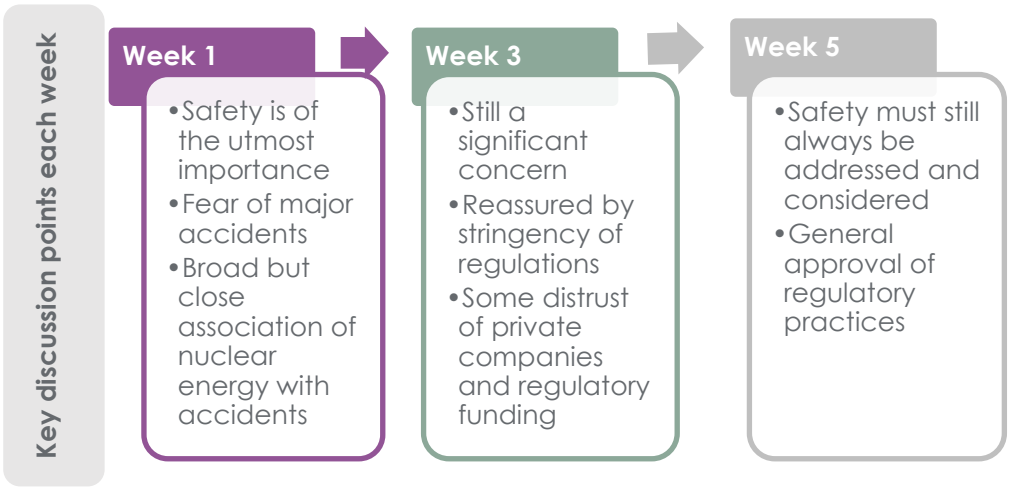
Despite some participants' serious concerns about the independence of the regulators, most participants ultimately described their conversations with regulation specialists and the information they were given as reassuring. They explained that they felt more positive about nuclear energy as a whole following those sessions.

It seemed that for most participants, mitigating safety concerns was a fundamental condition for approval of the development of nuclear technologies. For some however, safety concerns remained an insurmountable issue, as they weren't satisfied that regulation could effectively mitigate the risks.

"I didn't think there were would be so many regulations to pass before the production of building a nuclear site could happen. Also, the safety precautions taken seem really intensive." (Scunthorpe)

Discussions about regulation in week 3 lessened many of the concerns raised by participants, but safety remained a priority for almost all participants throughout, and some weren't confident that regulation would, or could, be effective enough.

3.2.3. How did views on the safety and security of nuclear sites and materials change during the dialogue?



What we think shaped these changes	Historical reference points Cultural reference points	Specialist Q&A Specialist presentations	Interactions with specialists

Most participants entered the dialogue with more perceptions about the safety and security of nuclear sites and materials than other elements of nuclear technology. Most participants cited cultural and historical reference points for these perceptions. The most often mentioned were the use of nuclear weapons in World War II, major incidents in Chernobyl and Fukushima, the television series *Chernobyl* and the cartoon series *The Simpsons*.

Discussions about regulation seemed to be a turning point for some participants in their thoughts on safety and security. The opportunity to speak directly with specialists in regulation significantly impacted some participants, whose safety concerns lessened over the course of the dialogue as a result of interactions with specialists.

3.3. Impacts on local environments

3.3.1. Hopes and concerns about impacts on local environments

This section explores participants' hopes and concerns about impacts of nuclear energy on local environments. Most participants regularly raised these from a number of perspectives, in regard to their own local areas and others. Questions and concerns largely centred around potential damage (caused by any element of the nuclear energy supply chain) to waterways, ecosystems and wildlife – three key strands in environmental discussions. These ranged from environmental disturbance caused by construction (which was perceived to be lengthy and disruptive), to contamination from nuclear reactors, to storage or improper handling of waste.

A few participants also raised concerns about the environmental impacts of mining for materials like uranium abroad in terms of causing earthquakes or subsidence, and asked specialists to clarify what those impacts might look like and how likely they might be. These views seemed to be founded in participants' values about our societal responsibility to protect the environment, and a belief and concern, that humankind on a wider scale is enacting significant harm on its surroundings.

> *"I am still concerned about nuclear power. I don't know how mining for uranium affects the environment and I feel that the building and running of huge nuclear power plants must also affect the environment." (Scunthorpe)*

Some participants also raised concerns about a loss of countryside, rural areas and green space, alongside a hope that new nuclear facilities could be built on existing brownfield sites. Some were concerned about the visual impact of nuclear sites on the landscape. They hoped that new structures could be underground, less visible, or designed in a more visually appealing way, describing current sites like Sellafield as 'ugly', or 'eyesores'. Some of these discussions arose as part of activities and discussions designed to explore siting, which is covered in more depth in chapter 4.

Although a majority of participants had questions and concerns about potential environmental impacts, some were reassured by a presentation detailing the involvement of various organisations in monitoring and regulation. These organisations included Natural Resources Wales, the Northern Ireland Environmental Agency, the Scottish Environment Protection Agency, and the Environment Agency. A few participants expressed reservations about the efficacy of penalty fines issued by regulatory bodies. They expressed an expectation that these wouldn't act as a deterrent, and that the costs would be passed on to the consumer, as in discussions about regulating for safety.

Over the course of the dialogue participants became increasingly hopeful about the benefits of nuclear energy being low-carbon, and this seemed to improve the overall perception of nuclear energy for some. However, a few participants were also concerned that there might be other as yet unknown pollutants produced by nuclear energy. These concerns connected again to the values some participants held around a responsibility to safeguard the environment for future generations. These conversations also seemed to connect to wider participant perceptions of nuclear energy as either 'clean' or 'dirty', both words used frequently in early exercises where participants were asked to list words they associated with nuclear energy.

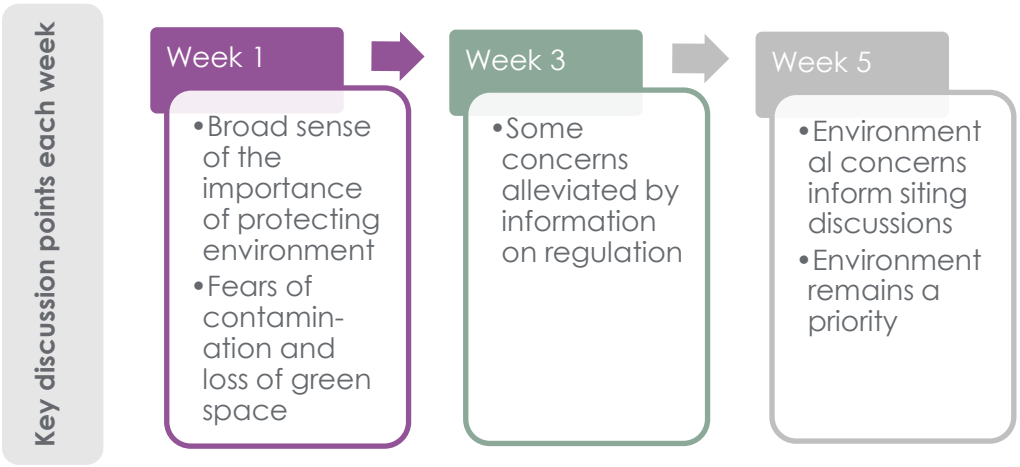
"I have become more pro nuclear energy since the start of the dialogue. It's clear that for the future benefit of our planet we need to take action to ensure we have reliable clean energy for future generations. We need to act now to reverse the damage done to the planet and to protect it for future generations." (Reading)

For some participants, the hope for lower carbon emissions did not outweigh other environmental concerns raised about nuclear power generation. A few commented that it would be counterproductive to prioritise nuclear development to protect the environment by reducing carbon emissions if doing so meant damaging it in other ways. This connected to ongoing conversations about waste management, and contributed to a sense of unknown factors or quantities giving some participants consistent cause for concern.

Environmental hopes and concerns were raised in many discussions throughout the dialogue. Most participants were concerned that nuclear sites or waste management facilities might damage local environments, harming or contaminating wildlife, ecosystems, and waterways.

The involvement of environmental agencies in the regulation of nuclear sites reassured some participants, and some were hopeful that nuclear energy development would lead to lower carbon emissions. However, this did not ease concerns for all.

3.3.2. How did views on impacts on local environments change during the dialogue?



Conversations about impacts on local environments occurred throughout the dialogue, and were often interwoven with ideas about safety and regulation. Although protecting the environment was important to most participants throughout the process, concerns were lessened for some by information shared by specialists on regulation.

When asked for their initial perceptions of nuclear energy at the start of the process, some participants used words relating to danger, pollution and toxicity. Later in the dialogue general perceptions of nuclear energy were more broadly 'green' (a term most participants used to mean low-carbon), yet they maintained concern about environmental impacts.

3.4. The economics of new reactors and sites

3.4.1. Funding of new reactors and sites

The question of where funding for new reactors and sites would come from came up regularly throughout the dialogue and was of key interest and concern for most participants.

Most participants wanted to know where funding was coming from for current nuclear sites, as well as where it might come from for new or advanced nuclear sites and technologies.

Some participants also asked about who owns existing nuclear sites, and whether and how the UK Government holds stakes in nuclear sites. These questions suggested that participants felt significant investment was necessary to move forward with the development of advanced nuclear technologies, and that they expected key investors to hold sway in future decision-making. Although participants were not given estimates of the costs of developing advanced nuclear technologies, they assumed significant investment would be needed.

A regular concern some participants raised, was whether an increased nuclear power supply would have an impact on costs to the consumer. Some participants seemed to expect that any major investment in nuclear power would eventually result in a cost increase for the public, whether in the form of taxes or energy bills.

Some participants also raised concerns that they might be expected to invest in changes to their homes to be able to adapt to new technology. This included conversations about the replacement of gas boilers as the UK's energy system moves towards greater electricity usage. These participants wanted to avoid being expected to contribute financially to the development of more nuclear energy in the UK.

This reluctance to pay for nuclear energy development seemed to be founded in ideas about fairness, and a lack of trust towards private companies. It seemed as if these participants felt that private companies should not be profiting from energy development while consumers foot the bill, and that costs should be transparent and shared by all parties.

"Finally, a major factor for me is how it impacts me as a consumer. Will my energy prices go up or down. Will I need to rip out my heating system for something new. Will I be forced to buy an electric car and install a charging point in my garage. If the shift to nuclear is going to cost me significantly more in the long run and cause me other types of financial burden it would be difficult to get behind - even if it's the right thing to do." (Reading)

Concerns around who would fund new reactors and sites were raised regularly throughout the dialogue. Some participants were concerned that those who funded the industry would hold the most sway in decision-making, while some focused on possible costs to the consumer, which they felt should be minimal.

3.4.2. Costs of nuclear energy

Conversations about the costs of nuclear energy revealed that some participants perceived nuclear energy overall, to be an expensive form of energy. They sometimes compared it to renewables, which was perceived to be cheaper, as the natural resources required are free.

The perception of nuclear energy as expensive was held about all stages of the nuclear life cycle, from construction, to ongoing waste management, to decommissioning. However, participants did identify the initial costs of setting up a new reactor or site, as a particularly expensive part of the process.

A few participants thought that this initial need for investment might be a problem for future nuclear projects, and questioned how likely it would be that nuclear projects would be adequately funded to begin construction. This possibly reflected perceptions of the current economic landscape of the UK, especially in the aftermath of the Covid-19 pandemic.

A few participants also raised concerns about perceived increasing costs associated with existing nuclear construction site Hinkley Point C, and delayed timeline at that site, taking that as a sign that nuclear construction generally does not run to time or budget.

"I had read that £20 billion funding for nuclear plant had been pulled and the project scrapped. I felt like this was a shame that money/bureaucracy was impeding our strive for cleaner energy." (Scunthorpe)

Some participants also compared the cost of nuclear energy per unit produced, to other energy sources, including renewables, and this was a source of concern for some. Most participants expressed a preference for the provision of affordable energy to all, regardless of the source.

Further conversations about the perceived cost-efficiency of nuclear energy are covered in more detail in section 3.5.1, as participants held their

understanding of financial costs in balance with the amount and reliability of the energy delivered.

Some discussions about affordable energy prices revealed a general distrust in private energy companies among some participants. Some participants associated the UK's privatised energy system, with a prioritisation of profit, over affordability for the consumer. These ideas echoed the distrust raised in discussions about effective regulation of private companies, and with the values of fairness raised in earlier discussions about who pays for and profits from developing technology.

Conversations about the financial costs of nuclear energy revealed that some participants considered it to be expensive in comparison to other forms such as renewables. A few discussed the impact high costs might have on the development process. Some expressed distrust in private energy companies in these discussions.

3.4.3. Nuclear energy and international relations

Some participants raised questions about the impacts of nuclear industry on the UK's international position throughout the dialogue and in various ways. Some expressed hope that if the UK were to commit to investing resources in nuclear energy, the nation might be able to take the lead internationally in advanced nuclear, and so improve its trading position. These participants spoke to possible benefits of globally connected technology development.

However, some participants raised concerns consistently about the influence of foreign investors in the energy and economic landscape of the UK. Some participants expressed concern that new nuclear reactors and sites might be partially funded by foreign investors, and that this might lead to the UK's energy supply or security being overly reliant on international relations.

Minimising reliance on other countries was a frequent theme across conversations for some participants, not only when discussing economic considerations. Some participants felt strongly that decision-making needed to consider how developing advanced nuclear technologies might result in dependency on other countries, and what impacts such dependency could have. They referred to the current situation of countries being vulnerable due to dependency on foreign vaccine export and import and could see how this could happen in the future with any kind of resource, such as uranium.

These participants expressed a clear preference for a self-reliant energy system in the UK, and a perception of self-sufficiency as more secure than the interconnected models discussed above.

This range of perspectives demonstrates a split in participant values around international relations. The strength of feeling demonstrated in these discussions seemed to be influenced by the many ongoing debates about international relations in other contexts, including Brexit and the Covid-19 pandemic.

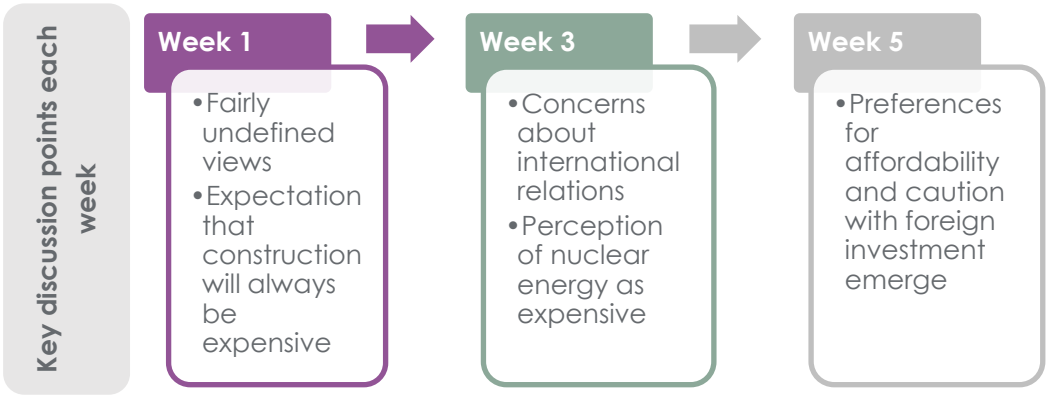
"I am now concerned that there is a very limited supply of raw material. Saying one has years supply is good but once reliant on this form of energy other countries will have considerable control. We have just seen with the vaccine people who are meant to be our friends quickly turn." (Reading)

Other concerns centred around the impacts of supply chains in other countries, in terms of ethical and fair trade with countries providing materials for nuclear reactors (such as uranium mines) and security and ethical concerns if reactors were sold to countries experiencing political upheaval, and then used to cause harm.

Some participants were unsure that the UK would have the right skills to deliver advanced nuclear technologies. They felt worried that the UK would end up relying on workforce and skills from abroad. Some participants referred to Brexit and connected it to a need for the UK to become self-reliant. This shows how the current policy climate, with ongoing debate around import and export of goods and workforce, affected the discussion.

Economic considerations of nuclear energy and international relations were raised in a variety of ways. Some participants expressed a desire for self-sufficiency in the UK, while some hoped the UK might be able to lead the way in developing this technology.

3.4.4. How did views on the economics of new reactors and sites change during the dialogue?



What we think shaped these changes	Existing perceptions of large-scale construction	Interactions with specialists Specialist presentations	News and media Online activities Interaction with specialists

As the dialogue went on, participants asked increasingly specific questions about the funding structures behind the nuclear industry, and developed varying priorities and perceptions about costs, funding, and economic implications.

3.5. Efficiency and reliability of nuclear energy

3.5.1. Hopes and concerns about the efficiency and reliability of nuclear energy

Most participants discussed hopes and concerns about the efficiency and reliability of nuclear energy balanced against the financial investment they assumed would be necessary. These conversations were often complex and weighed up multiple factors to determine whether nuclear energy was a sensible and suitable approach to the future of energy in the UK. Most participants placed a high value on cost-effectiveness for the future of energy.

The factors these participants considered were diverse and detailed, including the level of financial investment required and various risks, against the lifespan of a reactor, and the number and size of advanced nuclear sites required to generate power for different parts of the country.

Some participants expressed frustration later in the dialogue that they did not have a clearer picture of exactly how many modular nuclear sites might be needed to power a specific area. They felt the lack of this information held them back from fully exploring ideas around the siting and deployment of nuclear sites (covered in more detail in chapter 4).

Generally, most participants were hopeful that advanced nuclear technologies, once operational, would quickly produce a significant amount of energy, but held reservations as to how achievable this might actually be. They also expressed hope at the reliability of the production of nuclear energy, in comparison to older forms of energy production like coal, or weather-dependent renewable technologies, like wind and solar power.

"I don't have an real concerns about modular nuclear technologies . It's probably about convincing people we require it. People quickly forget the coal strikes when we had power cuts etc. Imagine if phone masts weren't working people would soon vote for nuclear." (Porthmadog)

Some participants also expressed hope at the possibility of making use of by-products of advanced nuclear technologies (such as using heat produced to power nearby industry) and wanted to know more about these possibilities. It appeared that participants considered making use of all elements of the nuclear energy production process to be a real benefit. This demonstrates a hope some participants held that there might be opportunities in the future to make the most of new nuclear technology and thereby minimise wastage.

"I found it really interesting hearing about all the additional uses that nuclear can have past the production of electricity. For example, using the excess heat and waste materials in different ways." (Reading)

Similarly, some participants expressed hope at the idea of recycling nuclear waste into new nuclear fuel using new technology, although there were questions raised about how much waste this process could create. These conversations demonstrated a hope for sustainability in energy production processes, including in advanced nuclear technologies.

However, some participants considered the operational lifespan of nuclear reactors to be too short, particularly in comparison to the length of the construction and decommissioning processes. Another concern a few participants raised was that as technology moves forward, better forms of energy production might be found before the benefits of nuclear investment arrive, and nuclear technology and investment might become obsolete. This showed an awareness of the fast pace of technology development and global innovation, and a desire not to be left behind, or stuck with outdated technology.

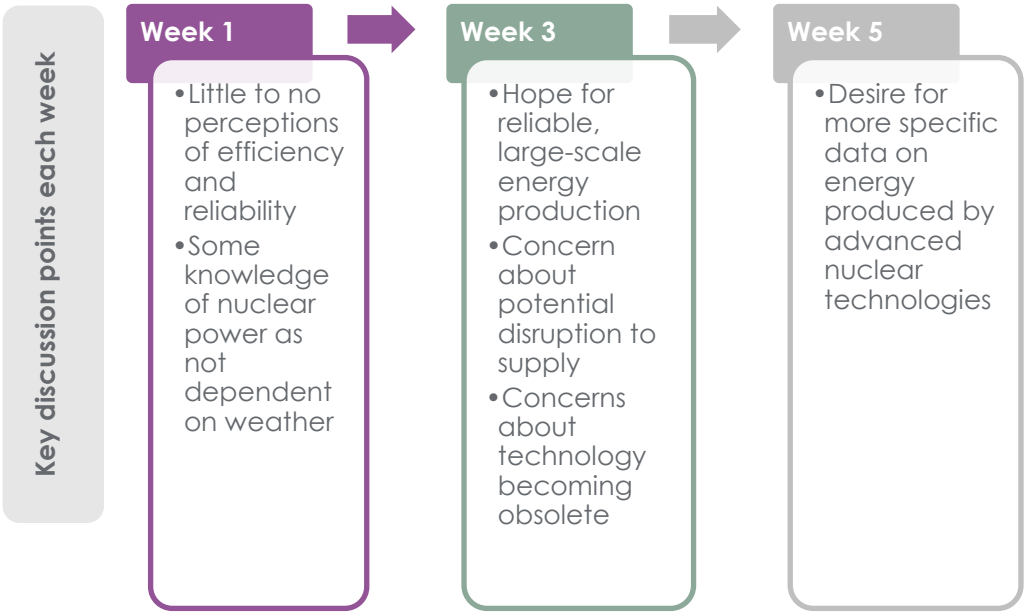
"The only concerns that I do have, is that these new technologies are going to cost huge amount of money, and there could be a better way in the end?" (Porthmadog)

A few participants also raised concerns about the use of uranium, and considered the use of uranium in nuclear energy production to be inefficient and wasteful. Some worried that relying too much on nuclear might result in more dependence on foreign resources, companies and workers, as detailed in section 3.4.3.

Most participants thought of nuclear energy as relatively efficient, and some participants were hopeful that other applications of advanced nuclear technology would be useful.

However, some held a range of concerns about efficiency and reliability, such as the short operational lifespan of nuclear reactors, or new technology making nuclear investment obsolete.

3.5.2. How did views on the efficiency and reliability of nuclear energy change during the dialogue?



What we think shaped these changes	Presentations on big picture of energy	Interactions with specialists	Siting activity Online activities

Participants entered the dialogue with few perceptions of the efficiency and reliability of nuclear energy, and over the course of the process developed much more in-depth, nuanced views and preferences.

3.6. Reactor and site size

3.6.1. Hopes and concerns about reactor and site size

Reactor and site size were a key consideration for some participants in the dialogue, and were often raised by participants based near a current nuclear site, in Porthmadog.

Some participants expressed concern that nuclear reactors would be too big. Some asked specialists for further detail, and a few referred to existing sites such as Trawsfynydd in North Wales as a scale of comparison. Some participants in Porthmadog were surprised by the idea that sites for future development of conventional reactors might need to be larger than Trawsfynydd, as they considered it to be a large site and area of land.

"What really surprised me is the size of the new/modern reactors. I was of the opinion that they were much smaller but learnt today for example that they could not be fitted in Trawsfynydd which I always thought was a big site." (Porthmadog)

Some participants who were concerned about the size of reactors and sites explained that concern was about wanting to protect visual landscapes and

also about a larger impact on the local environment. They were keen to see green spaces protected, and reluctant to accept new reactors or sites which took up too much countryside.

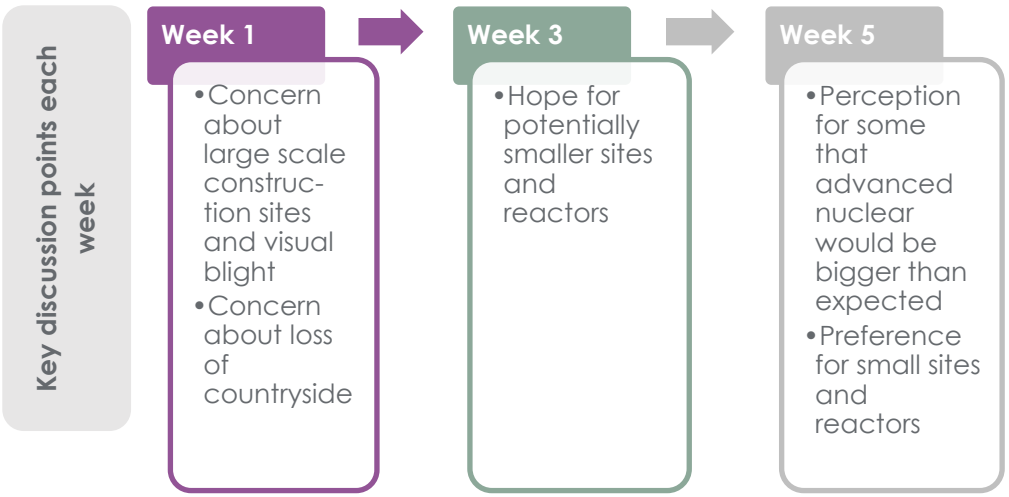
They expressed reluctance to see sites of similar or larger size than existing sites (like Trawsfynydd) constructed near their own homes, due to disruption, visual blight and local pollution. This concern demonstrates a persistent underlying value for some participants that natural environments and countryside are important and must be protected.

A few participants commented that advanced nuclear reactors and sites, while expected to be smaller than current nuclear technology allows, would still be bigger than they had expected. However, some participants expressed hope that advanced modular reactors might be able to be much smaller, and therefore have less impact on the visual landscape and local environment. A firm preference for smaller reactors was clear, although this came with reservations about how much energy they could supply.

Some participants asked for clarity about how changes in reactor size impacted the amount of energy produced, and therefore the number of reactors and sites needed to meet energy demands. They suggested that it wouldn't be worth investing time, money and resources into developing smaller reactors if the energy yield was too low.

The key concern most participants had about size was that nuclear reactors and sites would be too big. They were clear that future nuclear sites should not take up too much green space or countryside. Some balanced this with the idea that the technology should still produce enough electricity to be worthwhile pursuing.

3.6.2. How did views on reactor and site size change during the dialogue?



What we think shaped these changes	Initial presentations Existing ideas about construction processes	Interactions with specialists Online activities	Specialist presentations Siting activity and deployment discussions

Some participants reflected that when advanced nuclear technology was first described to them early in the dialogue, they had expected much smaller sized reactors and sites, and were concerned when in later sessions, more detailed descriptions were given.

Size of reactors and sites remained a consideration throughout the dialogue, and views on this didn't shift much. Most participants expressed a clear preference for smaller sites and reactors in order to lessen visual and environmental impact, but were also concerned that smaller sites and reactors might not deliver the same amount of energy.

3.7. Creating and delivering job opportunities

3.7.1. Hopes and concerns about creating and delivering job opportunities

Most participants shared hope and excitement relating to the possibility of nuclear sites offering jobs, training, and investment in local people, and connected conversations about siting and policy-making to these hopes.

Most participants expressed a strong preference for local people to be given first access to any jobs and training opportunities that come from the establishment of a nuclear site. In addition, some suggested that providing job opportunities should be part of choosing appropriate locations for new nuclear sites, hoping that areas with higher rates of unemployment might be able to benefit from work and training opportunities.

Values of fairness seemed to underpin these preferences. Most participants seemed to consider that local communities which took on the expected disruption of building reactors and sites should also benefit from the opportunities such sites could bring. The suggestion that choosing nuclear sites for development should be informed by which areas might benefit from those opportunities, also seemed to be influenced by this idea of fairness, and by a desire to support struggling communities with lower employment levels.

"If it possible, modular installations could all be constructed in one or two sites in the UK then delivered to their destinations. This would enable a major plant to be operating (under strict regulations) in areas chosen for their high unemployment." (Scunthorpe)

In contrast, a few participants mentioned potential benefits of skilled workforce (from outside the local area but not foreign), which could help local areas and communities to prosper.

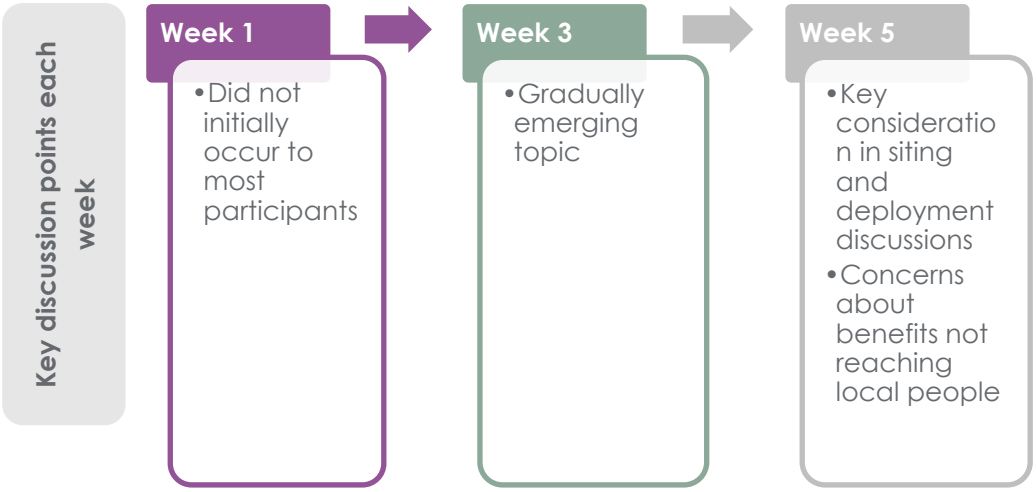
There were also concerns raised about the real extent of the opportunities on offer, particularly if advanced nuclear reactors are smaller and manufactured offsite. Some participants in Porthmadog referred to the Wylfa B nuclear power plant project as an example of a planned power station for which proposed plans were not carried out, and spoke about the negative impact of this on the local population.

Another concern raised by a few participants was whether the local infrastructure and accommodation needed to support a new workforce would be in place. They worried about what impact it might have on some areas if new residential areas needed to be built or amenities became overstretched.

Discussions clearly highlighted local economic benefits and opportunities as important. These discussions sometimes built on a sense of distrust that local benefits and opportunities would be maximised when it came to decision-making.

Most participants were hopeful that new job opportunities would be available to areas with high levels of unemployment as a result of nuclear development. Some were concerned that those opportunities would not actually be delivered, either because opportunities would be enjoyed elsewhere, or because plans would not be followed through.

3.7.2. How did views on creating and delivering job opportunities change during the dialogue?



What we think shaped these changes	Unfamiliarity with subject	Specialist Q&A	Siting activity News and media

Participants did not raise job or training opportunities initially when the dialogue began. As the process went on, it became a more frequently raised subject and a source of optimism about nuclear development in the UK and in participants' local areas, in all three locations.

3.8. Decision-making and public engagement

3.8.1. Communication and public engagement

Towards the end of the dialogue there was lots of discussion about the importance of communication and engagement with the public, which several participants framed as 'education'.

Drawing on their own experience in the dialogue, most participants reflected that they knew very little about nuclear energy and about the wider energy landscape when it began. They felt it was likely the population as a whole would share the perceptions of nuclear energy that they had held early in the dialogue.

They saw a need for experts and decision-makers in nuclear technology to communicate the various options and implications of the future nuclear strategy in the UK. Most participants referred to this both in terms of the wider energy picture and when discussing specifics about siting and deployment (see chapter 4).

Some participants related these conversations to their own changes in view over the course of the dialogue, mostly explaining that nuclear technology had become more acceptable to them over time. A few noted that while they were still generally opposed to nuclear technology, they now believed there was a need for its use. Most participants largely attributed these changes in their views to understanding more about the challenges of the

nation's energy needs and the industry regulations in place.

Most participants were firm in recommending transparency in all planning and engagement processes. Some expressed a preference for future engagements to have broader scopes, and include more information about other technologies. Some said that they would have liked to hear more from organisations and experts that oppose nuclear power during this process. These conversations are covered in more detail in section 5.1.

Some participants also emphasised the importance of public acceptability of advanced nuclear technologies, and expressed concern about the likelihood of achieving it. A few suggested that disruption could be caused by a backlash against advanced nuclear technologies from local communities and media.

"I'm worried about how the media and the public will react to the newer technologies. When a nuclear plant is set to be built somewhere, there are usually a lot of backlash and protests. Since the modular technologies are smaller, more plants will be built resulting in more plant areas, which could possibly result in more protests." (Porthmadog)

Although participants were not asked to think about ways to involve the wider public in decisions about advanced nuclear technologies, some offered suggestions, which centred around transparency and thorough public engagement and consultation processes.

Most participants talked about the importance of communicating with the public about nuclear energy development. Most expressed a firm preference for being involved in decisions about their communities from the beginning of discussions. Most also wanted information about nuclear technologies to be presented alongside alternative energy sources, and in balance with opposing views.

3.8.2. Decision-making around nuclear technologies

A majority of participants expressed concern about the decision-making processes that would happen in the development of advanced nuclear technologies. Some were very concerned that decisions would be made by those with power or money, and without considering the views or priorities of the public.

Discussions about this concern led to a sense of hopelessness among some participants, about taking part in dialogues like this one. Some participants, particularly those in Reading, held firm beliefs that local and national governments would make decisions regardless of local objections. A few attributed these concerns to actions taken by Reading's local government structures in recent years.

These fears and views seemed to stem from negative experiences with governmental decision-making. Some participants seemed to hold these views as given, expecting that public opinion would not matter to decision-makers.

However, some participants were reassured by a presentation about the local experience of hosting a nuclear site, given by Councillor David Moore from Copeland Borough Council. The Councillor explained how his local area had been involved in discussions about the construction and operation of Sellafield, and this eased some participants' fears of decisions being made without the local community's consent.

"Councillor David Moore put many minds at ease by telling the group exactly how nuclear power stations are first presented to the community that the proposed site will be built and that the community has their say every step of the way which for many is very reassuring." (Scunthorpe)

As discussions about siting took place, and particularly about siting at existing or decommissioned sites, some participants, particularly from Porthmadog, worried that a decision had already been made. It was explained to participants that none of the locations were chosen based on any consideration for future siting and deployment of advanced nuclear technology. However, some expressed concern that reactors would be deployed in existing nuclear communities on a continuous basis.

Some participants also expressed doubt about how balanced the dialogue itself was in presenting advanced nuclear alongside other technologies. The dialogue began with discussions of the big picture of energy, but then focused closely on nuclear energy and advanced nuclear technologies. As such, most participants developed a keen interest in understanding and exploring other energy forms early in the dialogue and were frustrated that these lay outside the main scope.

This limitation of the scope alongside doubts about the need case and concerns, particularly about nuclear safety and waste management, arguably led to some being concerned that they had not heard enough counter-information, and some distrust in the dialogue process. We can speculate that participants would have used more detail and debate about the need case for nuclear energy, and role of other technologies, when initially considering the energy system and pathway to net zero.

Some also drew on their own limited knowledge of nuclear energy development at the start of the process, which they felt was evidence that there is not enough transparency about nuclear technology development in the UK. This suggests that participants feel more able to develop views on specific technologies, when they feel confident in their understanding of all alternatives.

Some participants expressed a suspicion that a decision on focusing, developing, and researching advanced nuclear technologies had already been made, without the involvement of members of the public. Therefore, they wanted to see how decision-making processes and policy development would be scrutinised.

> *"Even if the whole of Britain was totally against it (and let's face it, the majority of the public don't know and don't care), it's going to happen anyway. I am actually quite upset and depressed by the whole thing as it just feels like the government decides what happens and then the public deal with the fallout when it results in less than ideal outcomes. All i get is a tiny vote that doesn't even count as we don't have proportional representation." (Scunthorpe)*

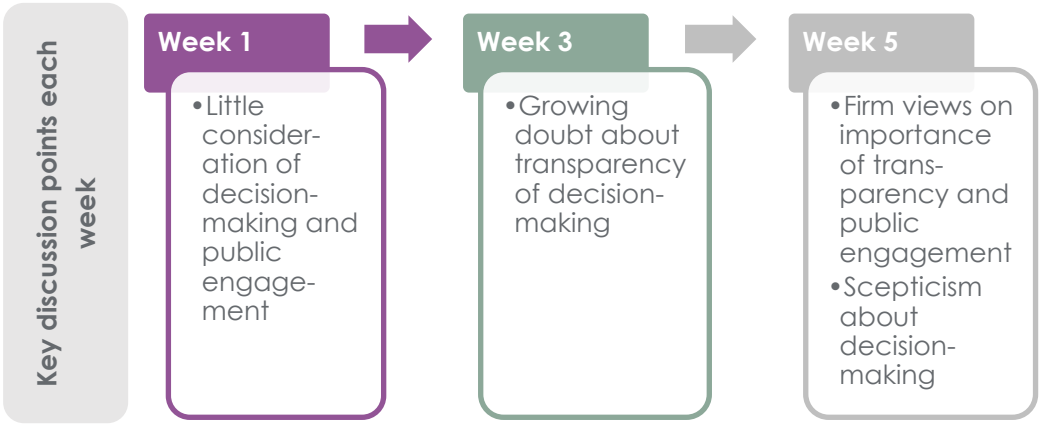
Some participants at times asked about who might profit from various stages of the nuclear development process and suggested that those who stood to gain from the development of advanced nuclear technologies would influence decisions.

Some participants from Porthmadog worried that they had been chosen to participate in the dialogue to increase the acceptability of restarting the nuclear station in their own local area. This demonstrates the importance of building any public engagement process on trust from the outset.

Most participants were clear that they did not want to be consulted when decisions have already been made, and that they want to be included in decision-making from the very start.

Most participants were keen to understand the decision-making processes behind nuclear development, and expressed concern about how they might work, and who might have influence in them. Some participants worried that decisions had already been made, and that public opinions would not be truly taken into account.

3.8.3. How did views on decision-making and public engagement change during the dialogue?



What we think shaped these changes	Unfamiliarity with subject	Specialist Q&A Presentations	Siting activity Interaction with specialists Personal research and experiences

Decision-making and public engagement emerged as a key theme towards the end of the dialogue, as participants gathered more information about advanced nuclear technologies as a whole and began to take part in depth in conversations about future policy.

Although we saw the importance of transparency to participants raised throughout the dialogue, most participants began to apply those values to public engagement and decision-making later in the process.

4. Findings: Siting and deployment

This chapter explores the range of views shared on considerations for siting and deployment of advanced nuclear technologies. Siting and deployment were mainly discussed towards the final stages of the dialogue, but considerations built significantly on participants' views of the energy landscape of the UK and the commitment to net zero in 2050 (chapter 2), and their hopes and concerns (chapter 3). As a result, this chapter touches on many previously mentioned themes, and how these were prioritised and balanced against each other. To avoid repetition, we have not commented on how views on siting and deployment align with hopes and concerns about nuclear more generally and advanced nuclear in principle. Rather we have focussed our commentary on any variety and evolution of views relating to different types of technology.

As in previous chapters, participants' views on siting and deployment of advanced nuclear technologies were often nuanced and complex. While ensuring safety and minimising environmental impacts were often non-negotiable key considerations, the discussions on siting and deployment also demonstrate how participants weighed and balanced other considerations such as affordability, dependency on others, local economy, and public involvement, in forming their views.

Building on the strong preference for renewable energy over nuclear energy expressed throughout discussions, most participants felt that the UK should first and foremost increase renewable energy sources in the UK, before considering the siting and deployment of advanced nuclear technologies.

Safety and minimising environmental impact remained paramount in the discussions on siting and deployment of advanced nuclear technologies. The majority of participants found it difficult to trade off either of them against other potential benefits of advanced nuclear technologies. They favoured long-term thinking around risks, and a prompt solution to the existing issue of waste management, ahead of looking at the deployment of advanced nuclear and its potential short-term benefits.

Discussions on siting advanced nuclear were multifaceted. Most participants considered how siting at existing or decommissioned sites could minimise disruption and community impact. Some participants could see how siting in proximity of residential areas and industry could bring local benefits and opportunities, as well as make use of different potential outputs of advanced nuclear. However, these considerations remained heavily caveated by concerns over safety and local community impact.

The majority of participants felt strongly that rigorous public communication and engagement was key to any future decision-making on siting and deployment of advanced nuclear. They wanted any public communication and engagement to be inclusive, transparent, balanced,

and truly demonstrate impact on policy-making as a result.

4.1. Nuclear as part of a mixed energy system, with renewables dominating

Participants regularly weighed up the costs and benefits of nuclear energy against renewable forms of electricity production. In this comparison, most participants responded positively to the amount of energy produced by nuclear reactors in principle, and to the reliability of supply that nuclear energy can offer (as discussed in chapter 2). Despite this, most participants emphasised that any siting and deployment of advanced nuclear technologies should only be considered once the potential for increasing uptake and wider development of renewable energy technologies had been fully investigated. Moreover, most participants wanted to see more clarity on the cost of producing energy from using nuclear, compared to other renewable sources of energy. This highlights the lack of clarity some participants arguably felt around other potential ways to reach net zero, without the deployment of advanced nuclear technologies.

Most participants wanted any need case for deploying advanced nuclear technologies to be based on clear evidence of how nuclear energy delivers on low carbon promises compared to other energy sources. At the same time, participants argued that such evidence should not compromise on long-term risks, for example safety and environmental impacts.

"It will reduce global warming and has one of the smallest carbon footprints, but it can also be very dangerous." (Reading)

Most participants felt there should be a limit to the proportion of nuclear power in the energy mix, even if a clear case could be made for the use of advanced nuclear technologies in achieving net zero. They wanted to be reassured that research and innovation around renewables, would also be encouraged: as nuclear technology might develop, so should other energy sources.

Most participants viewed renewable energy sources as less risky in the long term – in terms of safety and environmental impacts, but also when considering cost and dependency on other countries' resources. Minimising reliance on other countries was a frequent theme in conversations on siting and deployment of advanced nuclear technologies. Some participants felt strongly that decision-making needed to consider the extent to which deployment of advanced nuclear technologies would result in dependency on other countries, and what impacts such dependency could have.

Similarly, a few participants highlighted that any decision-making needed to consider whether deployment of advanced nuclear technologies will be competitive with other technologies developed, both inside and outside of the UK. They wanted to see how all financial risks around investing in this new

technology, compared to other renewable energy sources, had been considered.

"The fact that we have a finite source of uranium so surely with that in mind and the dangers and the need to dispose of radioactive waste, why not just concentrate on renewables and reduction in use of electricity through behaviour and developing new technologies." (Scunthorpe)

Most participants felt strongly that the UK should consider and explore other options for lower-carbon energy (such as solar, wind and wave energy) in depth, before committing to deployment of advanced nuclear technologies.

4.2. Prioritising safety in the UK and abroad

In the majority of discussions on siting and deployment of advanced nuclear technologies, most participants questioned safety and any potential risk of impacts on workers, surrounding communities and even the global world order. They wanted reassurance that advanced nuclear technologies would be safe to use, today and long term. Building on these views, most participants emphasised that safety should always be prioritised. This was of fundamental importance throughout the dialogue and something all participants did not want to compromise on.

The majority of participants highlighted that safety for surrounding communities should always be prioritised in any decision-making. Participants wanted any long-term health impacts on people living in proximity of a nuclear site, and any impact of faults, damage or accidents to be considered. Similarly, some participants urged for rigorous safety regulations to be applied across any future sites, to ensure maximum safety for workers. They wanted reassurance that all actors would comply with safety regulations.

"The health and safety of the community should always come first when even considering nuclear power as an option." (Porthmadog)

A few participants discussed how any safety regulations for any future deployment of advanced nuclear technologies, not only needed to be applied domestically in the UK, but also abroad. They highlighted the huge responsibility that comes with developing this type of technology, and the possible danger if it ends up in the wrong hands. Drawing on the frequency of participant discussions that touched on global risks of nuclear, we can speculate that this reflects the current destabilised global context. The dialogue took place during a time of global economic instability, and in which the UK is entering a new era of international relations as it exits the European Union. There were clear references to vaccine nationalism and

other leaders in the energy field globally, such as oil nations, and how being a leader comes with great risks.

The dialogue demonstrated a clear tension for participants between balancing safety and still looking to maximise benefits from nuclear, particularly in conversations on siting. Independent of reactor type, most participants tended to consider safety impacts first and foremost when discussing where advanced nuclear could be sited for future use. For example, some participants commonly referred to siting as far away from airports or residents as possible, to avoid any disastrous consequences if there were an accident, while siting in mountainous, underground or offshore areas was suggested to possibly feel safer. However, for small modular reactors and advanced modular reactors, where additional uses (such as heat and medical) would make it increasingly useful to site in proximity of industry and residential areas, most participants struggled to feel confident in their views. They could see the potential of siting to maximise benefits but were worried this would compromise on safety.

Out of the three reactor types (current, small modular reactors and advanced modular reactors) participants felt that advanced modular reactors would potentially be safer. Participants did not give clear examples on why they felt advanced modular reactors felt safer, but mainly referred to interactions with specialists, who often spoke about them as being potentially safer. This meant most participants were more open to explore various siting options for advanced modular reactors, compared to current and small modular reactors.

Safety was paramount and majority of participants found it difficult to balance safety against other potential benefits of advanced nuclear technologies. Independent of reactor type, most participants agreed that all safety risks needed to be considered prior to any decision-making on deployment and siting of advanced nuclear technology.

4.3. Minimising environmental impacts

Minimising environmental impacts was a key theme throughout the dialogue. Most participants wanted reassurance that deployment and siting of advanced nuclear technologies would cause little to no environmental damage. Independent of reactor type, most participants insisted that local environmental impacts should be considered and prioritised in any siting decisions. At no point throughout the dialogue did participants suggest or discuss siting in areas of outstanding natural beauty, rural countryside or agricultural farmland. Most participants were extremely hesitant to cause any damage to rural countryside and wildlife.

Some participants discussed cost to the consumer in relation to environmental impact. While they wanted to be reassured energy production from advanced nuclear technologies would not increase the

overall cost to the consumer, they also emphasised that any argument of nuclear energy being affordable should not be used to override any potential negative impacts on the environment.

"The cost and environmental effect of building, furnishing and running a station and then decommissioning and removing it after the end of its life compared to other forms of energy production. I can't see how this wouldn't be a higher cost both moneywise and environmentally than such things as wave power, wind power, solar power farms, etc. (Scunthorpe)

Most participants wanted to be reassured that siting and deployment of advanced nuclear technology would have little to no negative impact on the environment. They agreed that minimising impact on environment was a key consideration that could not be traded off.

4.4. Prioritising waste management planning and geological disposal facilities

Most participants commonly weighed the potential short-term benefits of using more low carbon energy from nuclear, against any longer-term impacts of advanced nuclear technologies on health of the environment, wildlife, and the population. Nuclear waste was a central part of this conversation.

"A 'clean' method of obtaining reliable energy - with the additional benefit of potential to provide vital resources for the health industry. On the other hand- a secure and reliable method of storing the waste must be achievable." (Scunthorpe)

Most participants highlighted a perceived lack of, and the immediate need for, long-term planning around waste management and geological disposal facilities. Participants urged all decision-making on deployment of advanced nuclear technologies to consider any harmful long-term impacts of waste on both health of the environment, wildlife and the public.

Most participants felt that the often-unknown risks and long-term impacts of nuclear waste and the still unidentified siting for geological disposal facilities, was a matter of urgency that needed to be dealt with now, not later.

"An increased generation of nuclear power to meet the Zero Carbon initiative will also mean massive increases in nuclear-waste generated, no matter how compact the new reactors may be. The decision-makers must first identify suitable sites for Geological Disposal Facilities before planning an increased the nuclear energy output. I understand it's been well over 40 years that no suitable site has been identified!" (Reading)

Most participants want to be sure that nuclear waste storage and disposal poses no long-term risks, before any decision-making on siting and deployment of advanced nuclear technologies is progressed. Most participants favoured thinking long-term around risks instead of looking at immediate benefits.

4.5. Maximising local benefits and opportunities

Most participants felt strongly that any decision-making around deployment and siting of advanced nuclear technologies needs to consider how local benefits and opportunities could be maximised. Participants insisted that local contexts should be fully investigated and considered before any decisions in siting. They wanted deployment or siting decisions to be based on clear evidence of how advanced nuclear technologies would complement the local context and maximise opportunities, and not bring any negative impacts to residents, such as devalued property prices.

Some participants felt that it was important to consider how local communities could benefit from siting nuclear reactors by looking at existing industry in the area. For example, they discussed how negative impacts on the local carbon footprint caused by industry emissions and dirty energy production such as coal should be considered when siting. When discussing siting and deployment of small modular reactors and advanced modular reactors, some participants believed that siting near industry could help bring down overall carbon footprint of industrial areas by using nuclear energy to heat industries, while removing reliance on fossil fuels. Lowering carbon emissions from industry, would in turn benefit surrounding local areas.

Some participants suggested that siting should consider areas in need of investment. If siting of advanced nuclear technologies could bring technological investment, potential for innovation and training for young people in engineering, then those areas in need of such investment across the country should be prioritised. Some participants more specifically referred to possibilities of increased employment opportunities locally. In doing so, they commented that it would be essential to consider how siting and deployment of advanced nuclear technologies could provide additional job opportunities and viewed it as a potential opportunity to upskill local workforce. A few participants highlighted how any job opportunities should be considered for those at risk of losing their current jobs due to deployment of advanced nuclear technologies (for example deployment of advanced nuclear resulting in closing of current nuclear stations, or industry).

Most participants emphasised that any decision-making on siting and deployment of advanced nuclear technologies needed to fully investigate local contexts to ensure maximised local benefits and opportunities.

4.6. Siting on existing or decommissioned nuclear sites versus new sites

Most participants believed that the less disruption caused by siting and deployment of advanced nuclear technologies, the better the outcome would be for the local population, environment and overall cost. This perception led most participants to suggest siting at existing sites, or nearby solar and wind farms, as infrastructure transmitting electricity would already be in place.

"The new SMR s seem the most popular choice, I am hoping they will be sited on current industrial/ nuclear plant sites. This would be most cost effective plus Easier for the environment and public as they would be in an already established place." (Reading)

Siting at existing or decommissioned sites was particularly referred to when discussing current reactors and small modular reactors, and commonly came with fewer trade-offs. Most participants felt that existing or decommissioned sites would arguably be more convenient as much of the necessary infrastructure would already be in place. Some participants also referred to the potential benefit of an existing workforce with transferable skills if siting at existing or decommissioned sites.

Some participants wanted to explore whether decommissioned sites could be used for something else, such as farming or residential, but sensed that this would not be the case in the short term. Therefore, they argued that existing and decommissioned sites would be more suitable compared to other locations, as they would potentially not be used for much else.

Some participants drew on perceptions of general public acceptability around siting and deployment of current and advanced nuclear, which they deemed to be low. They speculated that the public would potentially be less resistant to siting a reactor where there was already one in place.

When considering location alone, most participants expressed less hesitation to create new sites for small modular reactors and advanced modular reactors compared to current reactors. This was mainly due to their comparatively smaller size, which participants felt would cause less disruption and impact on local environment. However, participant discussions on siting in new areas remained complex and circled back to their concerns, including those about size, and trade-offs. This is explored further below.

Most participants were more prone to consider siting new nuclear technology at existing or decommissioned sites due to convenience, minimised disruption and minimised impact on communities.

Some participants valued the opportunity to make use of existing workforce and maintain use of sites which may not be suitable for other activities.

4.7. Proximity to residential areas and industry

The idea of siting advanced nuclear technologies in proximity to residential areas and industries generated complex discussions and often came with caveats around balancing proximity against disruption and potential benefits, as well as balancing outputs and number of reactors needed. All whilst ensuring complete safety and minimal impact on the local environment.

Very few participants felt that current nuclear reactors would be suitable for siting in proximity of residential areas and industries. However, some were slightly less hesitant to consider such siting for small modular reactors and advanced modular reactors, particularly for siting in proximity to existing industrial sites. Some participants argued that siting in proximity to other industry could potentially be considered if exploring other uses such as hydrogen, medical radioisotope and heat production. Participants also argued that siting in proximity to industrial areas would come with less impact on the visual landscape.

Although a few participants felt that it could potentially be appropriate to site advanced modular reactors in proximity to residential areas to better utilise outputs, it often came with more caveats compared to siting in proximity to industry. For example, while some participants argued that disruption from increased traffic to and from sites could be minimised by siting close to where outputs would be needed or where workers might live, they were still hesitant to site too close to residential areas due to concerns around safety and impact on local communities. Others discussed that while they understood that advanced modular reactors ideally needed to be placed in proximity to where outputs would be best used (to for example generate heat for homes), they still did not want a nuclear reactor around the corner from their property or community.

Some participants felt that potentially having to site multiple small modular reactors or advanced modular reactors together, possibly positioning them near urban areas, was particularly worrying. To avoid numerous reactors being sited in the same area, they wanted to be reassured that advanced nuclear technologies would only be sited in proximity to residential and industry areas if there was a clear need case for it, for example where there was an obvious lack of other energy sources.

A few participants reflected on their general preference of siting closer to towns and residential areas compared to remote rural areas and areas of outstanding natural beauty. This highlighted participants' underlying hesitation to cause any damage to environment, but also how new uses of advanced nuclear technologies were frequently considered in siting.

However, although as above, a few participants felt that siting in proximity to residential areas could arguably be considered, albeit heavily caveated, it was clear that some sort of distance should always remain, and that siting should always avoid densely populated areas.

Discussions on siting and deployment of advanced nuclear technology in proximity of residential areas and industry were particularly complex. When considering how to maximise use of potential new outputs from advanced nuclear technologies, some participants could see the benefits. However, these were often outweighed by concerns around safety and local impact.

A few participants were less hesitant to explore siting of small modular reactors and advanced modular reactors in proximity of residential areas and industry compared to untouched rural areas and countryside. However, participants felt strongly that some sort of distance to residential areas should remain and densely populated areas should be avoided.

4.8. Maximising additional opportunities and new uses

The potential new uses of advanced modular reactors played a key role in some participant discussions on siting and deploying advanced nuclear in new areas. Participants frequently referred to medical radioisotope, heat, hydrogen and synthetic fuels production when discussing potential new uses.

Some participants felt that siting should consider how outputs could best be utilised. This was particularly discussed for advanced modular reactors, due to an understanding that they would be comparatively smaller in size and come with more uses such as heat and hydrogen production. On this basis, some participants felt it would make sense for these reactor types to be sited where the outputs could be best utilised. In doing so, however, they pointed to the importance of incentivising local communities through, for example, offering free heating and use of hydrogen to replace natural gas boilers.

When discussing siting and deployment from a national perspective, some participants frequently discussed how siting and deployment of advanced nuclear technologies should consider areas of the country currently vulnerable to electricity shortages due to distance from other energy sources.

From engaging in question-and-answer sessions with specialists, some participants understood that distance mattered for how well outputs could be utilised for advanced modular reactors, as they are expected to produce less energy per reactor compared to current reactors. This information was key to how they considered siting in terms of proximity to residential areas and industries. A few participants further reflected on cost implications of siting further away from where outputs could be best utilised. For example, they discussed how longer transport distances of hydrogen (and energy) could result in more costs to the consumer. However, in these types of discussions participants found it difficult to balance the benefits of proximity with concerns around siting too close to communities.

Wider uses of advanced modular reactors, such as heat, medical radioisotope and hydrogen production, played a key role in some participant discussions on siting and deployment in new areas.

Some participants balanced benefits of increased use of outputs, with concerns around siting too close to communities. They rarely felt like a clear trade off could be made.

4.9. Public communication and engagement

A majority of participants felt strongly that rigorous public communication and engagement was key to any future decision-making on siting and deployment of advanced nuclear technologies. There was a strong message across groups and locations around truly involving the public in decision-making.

Some participants referred to the importance of educating the public on siting and deployment of advanced nuclear technologies. However, it was strongly emphasised that any education and information giving should be impartial and balanced, informing the public of a range of views and disclosing any conflicts of interest. Some participants mentioned the need for an open and honest conversation. They feared that engagement and communication with the public was yet another tick-box exercise and would not affect policy-making. They wanted clear and transparent communication from both the industry and policy-makers to feel reassured their voices had truly been heard.

"I hadn't realized the UK government was planning an increase in production of nuclear energy till I attended these sessions. The UK Government White Paper of Dec 2020 signals a major rise in priority for nuclear energy in the UK ... would our dialogue make any difference to the government's decision?" (Reading)

Most participants expected backlash from members of the public around siting and deployment of advanced nuclear technologies. They felt strongly that no siting could be done without public consent. Participants argued that education and information giving on siting and deployment of advanced nuclear technologies, as well as other energy sources, were essential. They elaborated that this should not necessarily be to increase public acceptance of advanced nuclear technologies, but to ensure members of the public were given the ability to question decision-making about the future energy landscape in the UK.

Most participants urged for decision-making to be inclusive. This involved ensuring that engagement and communication would happen in all areas of the community. Participants drew on their own local experiences, such as Reading being a multicultural town with groups who are normally left out of decision-making, or considering Welsh language in Porthmadog.

"I believe its also important to think of the site and area which a nuclear power plant will be placed, depending of the environment, the present infrastructure and industries of the area, and the communities which live there. It's important to listen to the needs of the areas residents, since a good relationship and transparency is key for a successful partnership." (Porthmadog)

A majority of participants felt strongly that rigorous public communication and engagement was key to any future decision-making on siting and deployment of advanced nuclear technologies. They wanted any communication and engagement with the public to be inclusive, transparent, balanced, and truly demonstrate impact on policy-making as a result.

5. Findings: Participant journey

Deliberative engagement is different to other forms of research. It is unlike a focus group, where participants give top-of-mind responses, without necessarily any knowledge of the subject, and provide their opinions as an individual. In deliberative engagement participants are given the opportunity to learn about and reflect on a topic, hear views that are different to their own, and importantly, are asked to respond as citizens – considering what would be best for society, not just for themselves.

As such, participants' views may change through the journey of a deliberative process. Therefore, the purpose of this chapter is to consider what might have shaped participants' views – what information, or conversations, proved particularly compelling for them – or indeed, if it is a subject where underlying beliefs and values are so strong that additional information and discussion does not change attitudes or behaviours.

This chapter will explore the participant journey focusing on:

- 5.1 Learning and understanding
- Spotlight: Language
- 5.2 Changes in participants' views over time
- 5.3 Key milestones
- Interaction with specialists
- Spotlight: Online engagement
- 5.5 Additional influences

In this dialogue we found that participants' learning experience was generally positive. Some participants focused their learning on understanding the details of the technology, while others used the process to assess how much they could trust the institutions, the information and the experts. Interactions with specialists and conversations about safety and regulation of nuclear energy seemed to have the most impact on participants' views.

There was not one dominant journey among the group of participants. We observed three general types of journey:

- participants who started their journey with key concerns about nuclear energy (safety, nuclear waste), and grew more concerned about the same or other aspects of advanced nuclear over the course of the dialogue;
- participants who had a pragmatic view of nuclear energy and felt cautiously optimistic about advanced nuclear technologies, but requested more detailed information and were reluctant to express definite opinions; and

- participants who felt more positively about advanced nuclear at the end of their journey as it would contribute to net zero, and trusted the experts with the details.

Key milestones included participants' first contact with the topic, which made them interested in exploring options other than nuclear, to achieve net zero. During mid-dialogue engagement, participants felt reassured by the experts' comments, particularly about the safety of nuclear energy. Their interaction with detailed information towards the end of the process helped them shape their opinions about advanced nuclear, but also made them aware of the many uncertainties.

Participants were also influenced by external information. In some cases, representation of nuclear energy in the media and popular culture contributed to a negative view of nuclear energy. In other cases, positive personal experiences were linked to participants being more open to the use of nuclear energy.

The dialogue also made certain participants feel more empowered as citizens, more confident in group discussions and sharing their opinions, and encouraged them to learn more about energy and get involved in policy.

5.1. Learning and understanding

Learning and interacting with new information is an important part of a deliberative dialogue. Survey data suggests that by the end of their journey most participants knew more about all the themes discussed. Participants' comments and facilitators' observations suggest that presentations, online activities, and group discussions were stimulating and useful for participants to learn more about the subject.

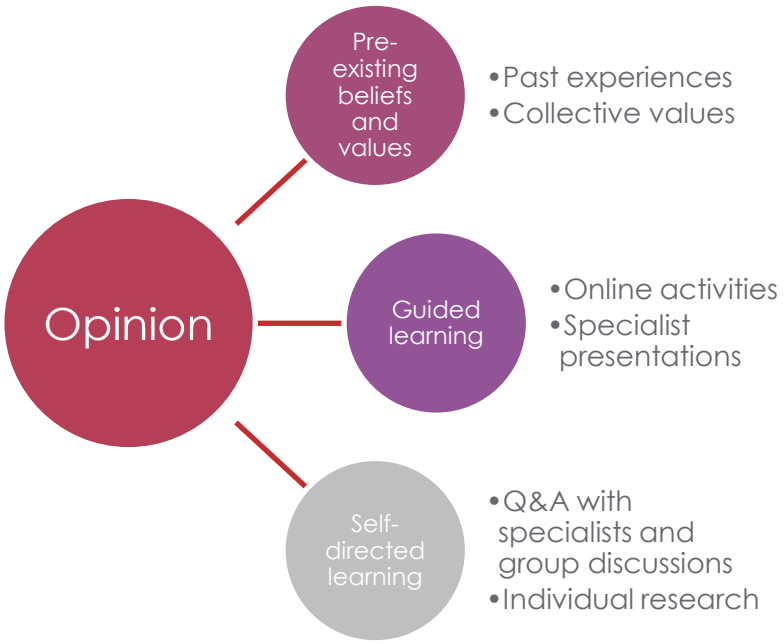
"Joining a group not knowing anything about the subject was quite scary but I was put at ease immediately by the welcoming approachable manner of everyone at Traverse. The dialogue was easy to understand and delivered in a way that explained a lot. I was comfortable to ask about anything I did not understand. I felt the timings were just right, not too much overload." (Reading)

Some participants felt that there was too much information during the sessions. They felt overwhelmed by the number of presentations and activities, and the duration of the live sessions. They suggested that it would have been easier to engage in shorter sessions to allow time to process the information. Other participants thought that the topic was too complex. As discussed in section 2.1 some participants struggled with the differences between concepts and technology types. Other participants felt that the topic was too complicated for the public to understand, and that they would have to trust experts and the government to make the right decisions.

A few participants felt that policy around nuclear was predetermined. They were distrustful of the process and defensive in their opinions. These impressions seemed to be linked to what they saw as a lack of balance in the information. These participants often commented that they would have liked to have heard about other technologies to achieve net zero, and other perspectives on nuclear energy, including anti-nuclear arguments. Their learning experience was less focused on understanding the details of advanced nuclear technologies and more on assessing whether they could trust the information, the institutions, and the experts.

In general, we believe that for some participants the learning process focused more on **understanding** the technology. They sought detailed information about advanced nuclear as it helped them understand how different elements of this technology aligned with their values and previous opinions. Some other participants were more focused on **trusting**. They used the process to assess whether they could trust the information presented, the institutions involved, or the experts' opinions.

Figure 5: How participants formed their opinions

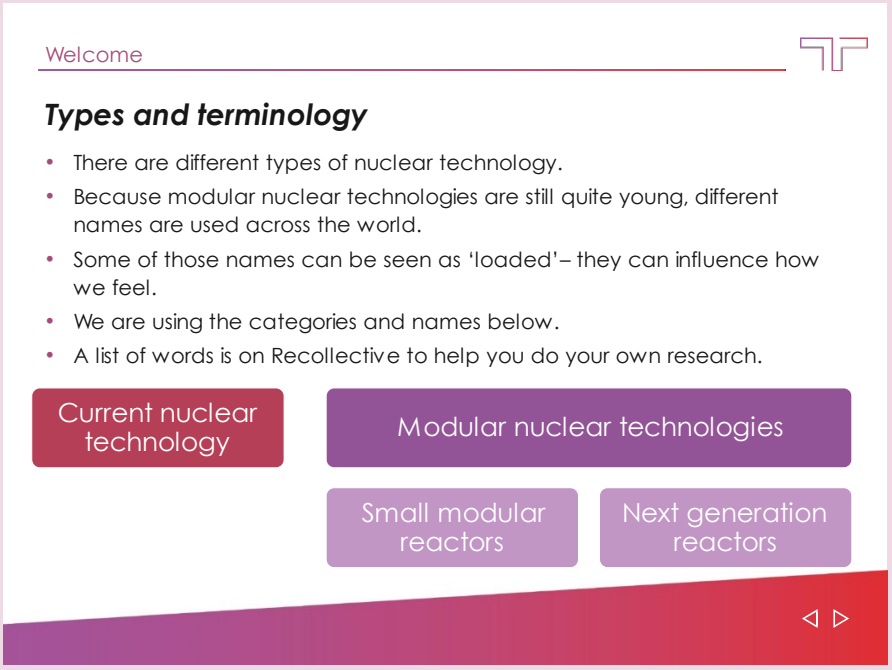


Spotlight: Language

The dialogue promoted a transparent discussion about how language might influence participants' views. The project team was aware that words such as "advanced", "future", and "new" could carry positive meanings and so avoided using them throughout the dialogue. Instead, the phrase "modular nuclear technologies" was used to talk about small modular reactors and advanced modular reactors as a group. In addition, the term "next generation reactors" was used to refer to advanced modular reactors specifically.

Traverse also wanted participants to reflect on the influence of language on their views, so we addressed this transparently during the third session of the dialogue.

Figure 6: Slide from Workshop 3, presenting the complexities of terminology and language when discussing advanced nuclear technologies



5.1.1. Interaction with stimuli

Figure 7 describes the main stimuli participants engaged with throughout the dialogue. Activities were grouped in three phases which developed over the course of two weeks each. More detailed descriptions of the materials can be found in the appendices and have been referenced in the table.

Figure 7: Main stimuli with which participants interacted during the dialogue

Phase 1 (the big picture of energy)

1. **Workshop 1 (Appendix F, section 6.1.1)**
   - Presentation about energy consumption by fuel in the UK, electricity production and use, electricity mix and electricity usage.
   - Presentation including topics such as the concept of net zero, UK policy to achieve net zero, future electricity demand, and scenarios for the electricity supply mix in 2050.
2. **Online task 1 (Appendix F, section 6.3.2)**
   - Discussion board to help participants build relationships with their peers.
3. **Workshop 2**
   - Facilitated group reflection and Q&A with specialists focused on energy and electricity in the UK, decarbonisation and net zero.
4. **Online task 2 (Appendix F, section 6.3.3)**
   - Participants explored a series of posters and completed a short quiz. The information presented in the posters and the questions in the quiz were related to energy fuels, electricity generation, nuclear energy, and net zero.

Phase 2 (the big picture of nuclear)

5. **Workshop 3 (Appendix F, section 6.1.2)**
   - Presentation covering definition of nuclear energy, evolution of nuclear energy, functioning of a nuclear reactor and details of nuclear energy production. Information focussed predominantly on current technologies.
   - Presentation about the role of the Office for Nuclear Regulation, environmental regulation of nuclear sites in the UK, the role of regulators in nuclear sites and the regulatory and planning process for new nuclear stations.
6. **Online task 3 (Appendix F, section 6.3.4)**
   - Participants were asked to complete a reflection journal and explore a new set of posters. The information presented in the posters was related to functioning of a nuclear reactor, different types of nuclear reactors (including current, small modular and advanced modular), and governance and regulation of the nuclear industry in the UK.
7. **Workshop 4**
   - Facilitated group reflection and Q&A with specialists focused on nuclear energy technology and its regulation.
8. **Online task 4 (Appendix F, section 6.3.5)**
   - Participants reflected on the different types of nuclear technology through a journal activity.

Phase 3 (advanced nuclear technologies)

9. **Workshop 5 (Appendix F, section 6.1.3)**

   - Presentation about the evolution of nuclear reactors, the definition of advanced nuclear technologies, the main differences between current and advanced nuclear, and advance nuclear development outside the UK.
   - Presentation about other potential uses of advanced nuclear other than electricity production, and the opportunities and unknowns of advanced nuclear technologies.

10. **Online task 5 (Appendix F, section 6.3.6)**

    - Participants completed a journaling activity and reviewed flashcards about potential opportunities of advanced nuclear technologies.

11. **Workshop 6 (Appendix F, section 6.1.4)**

    - Siting activity (Appendix F, section 6.2). Participants sited different types of nuclear reactors in an imaginary island to understand their views about siting and deployment. Stimuli for the activity included a map of the imaginary island, visual of different types of nuclear reactors, and maps showing the current siting of different types of energy technologies in the UK.
    - Group activity 'Messages for policy-makers'. Participants were asked to come up with messages for policy-makers based on a series of prompts.

Sections 5.1.2, 5.1.3 and 5.1.4 will explore participants' interactions with stimuli in more detail during phases 1, 2 and 3, respectively.

5.1.2. Phase 1 (the big picture of energy)

The slides and presentations of phase 1 (Appendix F, section 6.1) framed the conversation about advanced nuclear in the context of achieving net zero. For example, slide 33 during Workshop 1 and the poster "How to achieve net zero" (Appendix F, section 6.3.3) from the online tasks, showed participants different initiatives than can help achieve net zero. We believe that this reinforced some participants' interest in knowing more about other ways of supporting net zero, other than nuclear energy, particularly renewables. Participants' comments during this phase also suggest that most of them associated the terms "low carbon", "clean" or "green" much more with renewables than with nuclear energy at this stage.

During the first presentation on Workshop 1, the slides showed graphs which detailed changes in UK's electricity generation mix over the years. As mentioned in chapter 2, some participants were surprised to discover what proportion of the electricity mix in the UK was already sourced from renewables (section 2.1.3). This suggests that these participants had a different, pre-conceived notion of the energy landscape. When the

presentations challenged their long-term existing views, participants reflected and formed new opinions.

During Workshop 1, both specialists relied on graphs to present the information about energy and electricity in the UK. We believe this is the reason why a few participants felt that the presentations were too data-driven and hard to understand. A few other participants also confused key concepts, such as energy and electricity (section 2.1.1).

In general, the quality of the group discussions suggests that most participants felt positively about their interaction with the information and the materials at this point.

5.1.3. Phase 2 (the big picture of nuclear)

The online activities between Workshop 3 and Workshop 4 were based around posters that introduced participants to the different types of advanced nuclear technology (Appendix F, section 6.3.4). We expected that this introductory activity would not lead most participants to start to differentiate their views between different technology types, until the topic was addressed in more depth in Phase 3. The data shows that the difference between current and advanced nuclear technologies was not clear for some participants at this stage. Participants who were engaging with nuclear energy for the first time were inclined to group together all three types of technology (current nuclear, small modular reactors, and advanced modular reactors) when they expressed their opinions. As they interacted with the concepts more, particularly during the third phase, they developed more specific thoughts about each type of technology.

Most participants appreciated their interactions with visual stimuli. They commented positively on the illustration of the nuclear planning process and the diagrams explaining the functioning of a nuclear reactor in the slides of Workshop 3 (Appendix F, section 6.1).

Facilitator and survey feedback indicate that most participants found it useful to engage in the question-and-answer sessions, which were the primary focus of Workshop 4. Participants who were more confident in their knowledge and keener to learn about advanced nuclear wanted to focus more on asking questions to specialists, while less confident participants preferred more time to reflect. Whilst Workshop 4 was primarily a chance for participants to question specialists, it is possible that having a specialist present, impacted on group reflection. The process was amended during the dialogue to allow more time without specialists for reflection in Phase 3.

Interaction with specialists was the most important stimuli for the engagement during the second phase and it is discussed in more detail in section 5.4.

5.1.4. Phase 3 (advanced nuclear technologies)

During phase three, participants explored the siting of current and advanced nuclear technologies through an interactive activity. Participants had to site different types of nuclear reactors on a fictional island, by adding pins to a map (see Appendix F, section 6.2). Facilitators and participants reported that the siting activity was very stimulating. The level of detail in the map, which included towns, airports and other sources of energy, motivated participants to consider siting creatively.

Overall, the siting activity encouraged participants to ask questions and reflect on their views. The data shows that across groups, participants interacted with all the elements that were added to the fictional map. Facilitators also reported that participants interacted more with each other during this activity. This can be linked to the interactive design of the activity, but also to participants' increased confidence and knowledge to speak about the topic.

Some participants' comments suggest that the details on the map led them to think in terms of their own community. These participants also found it more difficult to site their reactors on the map, as they were more interested in developing a sense of scale and distance between the elements on the island. In a similar way, a few participants wanted a clearer understanding of the output of each type of reactor to be able to site them. Facilitators' comments suggest that the level of detail in the map helped a few participants to think in terms of the road layout and the impact of the stations on the electricity grid.

In the final activity of the dialogue, participants worked together to develop recommendations for policy makers about deployment and siting. Groups typically found it easy to agree on the key priorities (such as ensuring safety, and considering the environmental impact). There was less consensus on how important some of the other points were, as they seemed more related to individuals' specific views and experiences.

5.2. Changes in participants' views over time

Participants' journeys were very diverse in the way views changed over the course of the dialogue. While it is important to highlight the complexity of each individual journey, we consider that participants' experiences could be largely grouped in three types of journeys.

5.2.1. Participants who had concerns about nuclear and grew more concerned when they learned about advanced nuclear

A few participants grew slightly more concerned, the more they learned about advanced nuclear. Participants with this type of journey often had strong previous notions of nuclear energy linked to past experiences and had more intense emotional responses to their concerns about it.

They seemed to have an underlying belief that nuclear energy was unsafe and that there were high risks associated with its use. They might have heard negative comments about nuclear from close friends and family, or they felt strongly about historical events, such as nuclear accidents or the use of nuclear weapons. Participants in this group were generally environmentally conscious, and aware of the importance of achieving the net zero target. They were already uncomfortable with the risks related to producing nuclear energy. Speculatively, they associated advanced nuclear technologies with a larger number of nuclear stations and therefore an increase in risks, accidents, or nuclear waste. These participants also had lower levels of trust in government; they were generally more sceptical of the information and inclined to question the purpose of the dialogue activities.

Sample participant journey: Participant A

At first concerned about the safety of nuclear, but now more concerned about nuclear waste

Participant A joined the dialogue with a general understanding of nuclear energy. They identified nuclear energy as a reliable source of electricity, but they were concerned about safety. They preferred to focus on other initiatives to achieve net zero, particularly renewables.

As the dialogue progressed, conversations with specialists and information about the regulation of the nuclear industry in the UK reassured them that there has been progress in terms of safety standards, but they still did not feel comfortable with the potential risks of using nuclear energy. They expressed that past negative comments about the safety of nuclear energy still had an influence in how they perceived this technology.

"Even though I am learning more, the safety of the plants still concerns me. I am still concerned of the massive damage the reactor can have if there is an issue. This has obviously been ingrained in me over years of stories. As there are risks with all industry."

During the discussion of advanced nuclear technologies, Participant A was interested in their potential to help achieve net zero but grew more concerned about the disposal of nuclear waste. They were concerned that, being smaller, modular reactors would proliferate and produce more waste, and that it was not clear how nuclear waste would be disposed of. They also felt that although some of the advanced modular reactors could be safer, the potential consequences of a nuclear accident were concerning.

"My main concern now is the safety both for people and the environment regarding the disposal of the nuclear waste. Nothing I have heard so far has helped me feel better about the disposal. If anything, I am more concerned. I now have a better understanding of how this is a more sustainable source of energy then gas or coal, but I am concerned about the mining of uranium. I also understand it is a more reliable source of

energy than renewables but if it was up to me, I would rather put money into those advancements than the advancement of nuclear power at this point."

5.2.2. Participants who felt cautiously optimistic, but requested more detailed information

Some participants in this group had previous personal experiences about nuclear energy (they grew up near an existing power station or had a family member who worked in one). They had a pragmatic view of energy and nuclear technology, and seemed to recognise some potential in them, but by the end of the dialogue, preferred not to take a definitive view on advanced nuclear until more information was available. These participants felt that they had a general knowledge of the themes discussed in the dialogue, and often played an active role in the group sessions. Their journey focused on asking in more detail about nuclear and advanced nuclear technologies.

Although their views did not shift much throughout the dialogue, slight shifts in their opinion were linked to individual research prompted by discussions in the dialogue sessions. They ended their journey feeling that they needed more information. We infer that a sense of uncertainty played an important role in how they formed their views. They seemed optimistic about the potential of advanced nuclear, but were cautious in how they expressed their opinions about it.

Sample participant journey: Participant B

A more positive view of advanced nuclear, but aware of uncertainties

Participant B joined the dialogue with a general understanding of energy, carbon emissions, and current nuclear technology. They felt that renewable energy and restoration of wetland and forests were slightly more important to achieve net zero than nuclear energy. They were also concerned about the disposal of nuclear waste. When asked about siting of nuclear facilities, ***Participant B*** identified environmental and visual impact, and safety as the most important criteria. They had not heard much about advanced nuclear technologies before and did not know what role these technologies could play in achieving net zero by 2050.

As the dialogue progressed, ***Participant B*** felt more positive about the role of nuclear energy in achieving net zero. They expressed that the information shared during the dialogue, and their individual research, led them to feel more positively towards nuclear energy. They still had questions about nuclear energy's environmental impact and the safety in nuclear sites, as well as concerns about disposal of nuclear waste.

As they learnt about advanced nuclear technologies specifically, they shifted from a neutral stance to a more positive view of nuclear energy. They still felt there were many uncertainties as to how advanced nuclear technologies would be deployed. Reflecting after the second-to-last week of dialogue activities, they commented:

"(…) I have moved from firmly neutral to fairly pro over the course of this research. I have not heard anything during the project and read anything when researching online that concerns me too much although I am taking this view based on where new technology could take us more than where we are currently at."

5.2.3. Participants who had a more positive view of advanced nuclear and trusted the experts with the details.

Some participants had a journey focused on discovering new information. They often started the dialogue with a neutral position. Their views shifted more prominently when they engaged with new knowledge about issues that mattered to them. For example, receiving information about regulation of nuclear energy addressed many participants' concerns about the safety of nuclear technologies, and made them more open to their use. These participants did not feel they needed all the details about advanced nuclear to develop a sentiment towards the technologies, as most of them trusted the government and the experts to make the right decisions. In general, participants with this type of journey felt they had a slightly more positive view of advanced nuclear technology after the dialogue.

Sample participant journey: Participant C

Greener energy is a positive, but would trust the experts to get it right

At the start of the dialogue, ***Participant C*** felt unclear of the role nuclear energy could play in combatting climate change. As they discovered that nuclear energy was low carbon, they started to express that it could play a role in achieving net zero but were concerned that electricity from nuclear energy would be more expensive than energy from renewables to both the government and consumer. Participant C was also concerned about nuclear waste.

As the dialogue progressed, ***Participant C*** was more supportive of nuclear as a source of low carbon energy. Information shared by specialists made them feel more comfortable about its use and they expressed hope that the government and experts would address some of the main concerns.

Participant C clearly expressed that they did not understand everything about advanced nuclear, but that they had a positive view of them as it would help produce 'greener' energy. They highlighted that they trusted scientists and the government to guarantee a safe use of advanced

nuclear technologies. Towards the end of the dialogue, they commented:

"The phrase modular nuclear technology was alienating to me at the beginning. However, after reading the information provided in the focus groups and taking part in the discussions, I believe we are in good hands, it's going to be greener and safer. It can't get any better than this."

5.3. Key milestones

There were three particular points during the discussion that influenced participants views and represent key milestones in the collective dialogue journey.

- During phase 1, a conversation about the scope of the dialogue and the relevance of other ways to achieve net zero had an important influence on certain participants' perception of balance in the dialogue.
- A discussion about the regulation of the nuclear industry during phase 2 was important in reassuring participants who had concerns about safety, and supported a more informed discussion during the following session about advanced nuclear.
- During phase 3, the conversation about the uncertainties around advanced nuclear prompted participants' numerous requests for more information and led some participants to have more cautious views about deployment and siting.

5.3.1. Nuclear energy as an option for net zero

The dialogue presented advanced nuclear as an option that could help achieve net zero by 2050. This resulted in the majority of participants expressing an active interest in exploring other options.

For some participants, this had a considerable influence on how they interacted with the topic, for example:

- they felt disappointed, as they wanted an exploration of other technologies to form part of the dialogue;
- they felt the discussions were unbalanced, as there was not enough debate about renewables, or enough presence of nuclear sceptic specialists;
- they felt that they could not form an opinion about advanced nuclear until they knew more about the other technologies; and
- they felt confused as to why the government sought public views on nuclear energy specifically or assumed that the use of nuclear was already decided.

5.3.2. Discussion with specialists about regulation

Some participants' comments and facilitator feedback suggest that during the sessions exploring nuclear energy as a whole (second phase), the question-and-answer session with specialists had a considerable influence on participants' views. Some participants felt reassured that nuclear energy was safer than they previously thought. Data from surveys suggests that this was linked to having limited previous knowledge of nuclear industry regulation. Learning how the nuclear industry is regulated made some participants feel less concerned about safety. In addition, interaction with experts made participants develop a level of trust in the people responsible for safety. Based on participants' comments, they had a previous impression that the nuclear industry was not transparent about safety, which presumably created distrust.

"I didn't think there would be so many regulations to pass before the production of building a nuclear site could happen. Also, the safety precautions taken seem really intensive." (Scunthorpe)

5.3.3. Receiving more detailed information about advanced nuclear

Some participants had reservations about current nuclear technology due to the size of the reactors and sites, and perceived costs. After learning more details about advanced nuclear technologies they became more open to their use to produce energy. They felt that advanced nuclear addressed some of their main concerns regarding current nuclear power stations.

Some participants were genuinely engaged by the topic of advanced nuclear, as they saw opportunities in the technology they had not considered before. The contrast between current and advanced nuclear made them curious about the technologies' potential to recycle waste, produce heat for industrial uses, or support the production of hydrogen.

"Throughout the workshops, as we came to learn more about modular technologies, I'm optimistic about their future. They seem to have everything that the traditional plants lacked, such as smaller sizes, more flexibility, faster construction and lower upfront costs." (Porthmadog)

Participants wanted to engage with more detailed information on advanced nuclear technologies to better understand how they felt about it. Even though some participants had a clear sentiment about the technologies, they were conscious of the many uncertainties about their use and were less comfortable expressing opinions about aspects of advanced nuclear that are still in development.

Spotlight: Online engagement

The deliberative dialogue on advanced nuclear technology occurred fully within the restrictions imposed by the Covid-19 pandemic. As a result, the dialogue had to be rescoped to be delivered fully online to comply with COVID-19 restrictions.

Recruiting participants fully online proved challenging as Covid-19 cases increased and new restrictions were put in place, but once recruited most participants remained engaged and completed the majority of the dialogue activities.

A fully online deliberative dialogue gave participants access to a greater number and diversity of experts, as specialists could join from any location. Participants also interacted with specialists in more flexible ways, as experts could easily rotate between groups, answer questions in the chat, and share online resources with participants. In addition, most of the team at BEIS was able to attend the online sessions and gain first-hand insights into the process directly from participants. Additionally, chat logs and polls from Zoom and comments from the online platform complemented the data from session notes and surveys, supporting the overall quality of the data.

However, some aspects of online engagement proved challenging. Participants would occasionally require technical support before and during the sessions causing small delays and interruptions. Participants also find it more difficult to interact with each other in virtual groups, compared to face-to-face-groups. Some participants felt uncomfortable having their cameras on or interacting with others whose cameras were off. Sometimes participants were distracted by happenings in their surroundings or had to drop off momentarily to tend to domestic situations.

Participating in the dialogue during the pandemic might have provided participants with a social space at a time when they needed one. It allowed them to safely interact with new people and hear from others outside of their household and close social circle. These circumstances meant that the dialogue was perceived as a positive experience by participants, despite being held online, thus resulting in purposeful engagement and good quality data. However, we cannot assume this experience would be felt as positively if conducted during a time when face-to-face interactions and socialising were possible.

5.4. Interaction with specialists

Overall, participants enjoyed engaging with specialists. Most participants felt reassured to discuss their concerns with experts in the field. We believe that having specialists available to answers participants' questions greatly supported engagement, by allowing a more self-directed learning process and promoting an open and transparent discussion. Participant comments suggest that interaction with specialist inspired trust in the institutions responsible for regulating nuclear energy. A few participants also appreciated being able to contrast the information they had researched individually with the specialists' opinions.

Some participants preferred interactions with specialists who did not represent the nuclear industry. As most of the experts on the topic tend to have a positive view of nuclear energy, participants felt that nuclear industry outsiders added balance to the dialogue. For example, some participants highlighted their interactions with a councillor or a communications expert. We believe that this preference is also linked to the specialists' communication style, as participants' comments suggest that they preferred less data-driven conversation.

Interactions with specific specialists left a particularly lasting impression on some participants. Their comments about interactions with specific specialists suggest that they appreciated:

- a balanced approach between benefits and risks;
- an emphasis on the fact that participants have a choice on whether and how advanced nuclear technologies are used; and
- a communication style focused on encouraging reflection, rather than giving information.

In the specific case of the Porthmadog group, language played a role in participant's interaction with specialists. A few participants felt that specialists and facilitators who communicated in Welsh had a bigger influence on their views. In addition, other participants felt that local experts understood them better, as they had a more knowledge of their community.

5.5. Additional influences

Some participants were clearly influenced by external information. Previous nuclear accidents, and their representation in the media, contributed to a negative view of nuclear energy amongst them. A few participants also felt that the public opinion on nuclear was negative, as they had not seen positive accounts of nuclear energy on television and in the news. These comments tell us that external information not only shaped their views, but also their impression of public opinion about nuclear technology.

Some participants mentioned that their experience with nuclear energy made them more open to its use. Their family might have worked in nuclear facilities, or in the energy sector, and they had a more positive opinion of nuclear because of it. Other participants felt they trusted the nuclear industry more because they had heard positive comments about it as an employer. Participants seemed aware that these experiences had an influence on their views and were open to discussing them, suggesting that their engagement with the topic was beyond superficial and emotional reactions.

Another influence on a few participants' views was their lived-experience or knowledge of other countries. Experiencing energy policy abroad gave these participants a reference point to challenge the information they were receiving and encouraged discussion with specialists. They also added an additional, international layer to the debate which other participants benefited from.

5.6. Wider impact on participants

Most participants had an overall positive experience of the dialogue. Participants generally interacted comfortably with facilitators and appreciated that everyone had an opportunity to express their views throughout the process, regardless of their level of knowledge. They felt that they had opportunities to discuss the issues that mattered to them, particularly in the format of small groups. They enjoyed the casual but respectful tone of the dialogue sessions and were comfortable to ask questions.

Some participants commented that the dialogue was relevant in the current UK context of achieving net zero. Their participation motivated them to think about the future and what actions they could take to help achieve the net zero target. Other participants reported feeling more empowered as citizens and encouraged to become more involved in politics. They appreciated being consulted on issues that mattered to them. In some cases, participants seemed reassured that decisions were being made by experts and that the public was being consulted at each stage.

Some participants commented that they felt encouraged to learn more about energy and nuclear technology and that they were more comfortable discussing the topic. Other participants were inspired to learn about, and be involved in other policy issues, such as energy, climate change and net zero.

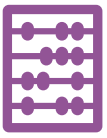
A few participants commented that dialogue had helped interact better with digital information and video-conferencing technology, while a few others mentioned that the dialogue had helped them feel more comfortable with group discussions, more confident in expressing their opinions in public and to consider other people's perspectives when forming their own opinions.

6. Conclusions

In general, participants had greater, more varied **concerns** for the development and use of advanced nuclear technologies than **hopes**. Key concerns were nuclear waste storage and management, health and safety, environmental impacts, and the transparency and fairness of decision-making; while hopes centred around the reduced carbon emissions, job opportunities, and the reliability of nuclear energy.

Participant views were largely **influenced** by the information provided through the dialogue, and participants' own perceptions, knowledge, and experience of current nuclear technologies.

Overall, the number of participants who were willing to consider the **deployment** of advanced nuclear technologies to support reaching net zero by 2050 targets increased throughout the events. By the end there was a majority who were willing to consider it, however this support was heavily caveated. While the conditions were numerous and nuanced, our analysis identified five key themes.



1. A robust need case must be proven: Advanced nuclear should only be deployed if it is essential in supporting renewable technologies to achieve net zero targets. The need case should consider cost to consumer and the economic context of the UK.

2. Renewable energy should be central to achieving net zero: If a robust need case were proven, advanced nuclear should be one of several energy solutions. The primary focus should be renewables with advanced nuclear helping to meet demand, improve reliability, and/or serving as a stop-gap while renewable technology develops.

3. Health and safety must be prioritised: The health and safety of local and international communities and workers throughout the nuclear lifecycle (from uranium mining through to waste management) must be considered as a priority.

4. It should not present long-term risks or leave a negative legacy: Decisions should be led by long-term thinking. Advanced nuclear should not be deployed to achieve net zero in the short-term if it results in long-term impacts on the environment and future generations, in the UK and abroad. There must be solutions in place for nuclear waste storage and disposal before progressing the deployment of advanced nuclear.

5. Robust and independent regulation is key

Processes must be transparent and independent from nuclear technology developers. Regulation of the sector must effectively ensure that concerns and considerations are addressed, and deliver effective penalties.

Participants' considerations for **siting** advanced nuclear reactors were numerous and nuanced, our analysis identified four key themes.

1. Proximity must ensure safety of local communities: First and foremost, advanced nuclear should be sited far enough away from people to ensure it has no impact on their health and safety.

2. Prioritise environmental impacts: Siting advanced nuclear should avoid the use of green space and cause little to no environmental damage, including to rural countryside, waterways, and wildlife.

3. Make the most of existing sites and infrastructure: Existing nuclear sites should be used in the first instance to make best use of existing infrastructure and workforces, whilst limiting further environmental and visual impacts.

4. Optimise for benefits and alternative uses: Advanced nuclear could be sited closer to where its benefits would be best realised, as long as safeguarding against negative local impact is prioritised and a minimum safe distance from communities established and adhered to.

Participants' perceptions and experiences of current nuclear, and experiences of public involvement in decision-making, led to scepticism of the potential for genuine influence in policy-making and future decisions. **Transparent and meaningful involvement** of the public and local communities was seen as essential in decisions about the use of advanced nuclear, as well as more detailed decisions about where it is placed.

Traverse's recommended next steps

The extent of unknowns around advanced nuclear technologies limited participants' confidence in committing to specific stand-points, and (as can be expected) their views on advanced nuclear were largely rooted in views on nuclear energy more generally. As such, Traverse recommends that additional in-depth public engagement following further research and development of advanced nuclear technologies, would be beneficial.

We suggest that this could include engagement initiatives about advanced nuclear technologies' waste storage and disposal; safety of advanced nuclear technologies; different uses of advanced nuclear; and differentiating views on different types of advanced nuclear technologies. Additionally, we suggest that nuclear energy and advanced nuclear technologies should be included in wider public deliberative processes about pathways to net zero, particularly as part of a suite of options in energy and electricity.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