



CENTRE FOR RESEARCH INTO ENERGY DEMAND SOLUTIONS

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# Improving Data Sharing in Energy Consortia: Summary of Workshop Outputs

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**November 2023**

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Cultivate Innovation Ltd.

This workshop was a joint event organised by CREDS and UKERC

Sarah Higginson, Catherine Jones, Kate Kwok, Marina Topouzi, Mike Fell, Gesche Huebner

The organisers would like to thank the workshop participants for their time and expertise without which the recommendations wouldn't have been identified.

## Recommendations

- The data sharing experience of others is important – we need to secure better access to data for sharing, and make the methods, tools and guidance on how to do this more available. Energy consortia have a role in setting expectations and developing/pointing to resources.
- Providing metadata and good quality data indicators takes time. Managing data across multiple institutes, ethics teams and collaboration agreements can be complex. The different disciplinary domains common to energy consortia may have different standards that need to be met. All of these require expertise, attention and resourcing.
- Creating better data sets requires them to be more highly valued. Institutions need to take the value of data more seriously, funding activities effectively, rewarding individuals for taking an active role, and recognising the importance of workload management. Energy consortia should help to set this framework as part of their culture.
- Data Management Plans are an essential starting point and should be in place at the beginning of projects. However, to make most effective use of them, they should also be flexible, with appropriate mechanisms in place to reflect and learn as change occur.
- For large energy research centres in particular, proposals need to budget for a data manager, recognising that this is an important role requiring appropriate remuneration to secure quality personnel.
- Not all data are equal. The skills of the data manager should provide guidance and support to help discriminate between the value of different data sets and prioritise management effort accordingly.
- Skills and knowledge in the area of data management vary widely across the energy community, partly because of the involvement of so many different domains. Training is required to improve researcher awareness of the value of data sharing and to improve their data management skills. Energy consortia can provide/ host this training and have a role to play here, emphasizing the domain aspects of data management.
- A peer network for data managers and data stewards would be useful to enable sharing of best practice and identify areas to work on together to embed FAIR data and Open Research practices within researcher's activities. Building on existing Energy Consortia collaboration activities, such as the Cross-Consortium Engagement Meeting (CCEM) would get this process started.
- The energy community is a large producer and user of models in a wide variety of areas and common standards for what to archive to enable FAIR data and reproducibility have not yet been agreed. Such protocols would be helpful to discuss. The energy research specific issues for sharing the outputs of energy models should continue to be highlighted.

## 1 Introduction

Sharing energy research data is good practice for responsible research (though there are particular data sharing challenges in this sector) and many funders now require it as a condition to receive grant funding. However, it is still often seen as a burden and many projects fail to fully deliver on FAIR (findable, accessible, interoperable, reusable) data sharing commitments. This workshop brought together key stakeholders in the whole research lifecycle to develop recommendations for improving the level and quality of data sharing within the energy community. (*\*from pre-workshop briefing note by Catherine Jones and Sarah Higginson*).

[\*A 'Data sharing workshop briefing note' was circulated to all participants beforehand, which included workshop aims and intended outputs, information on the importance of data sharing, energy research data sharing challenges, experiences from CREDS and UKERC and shared challenges with lessons learnt – see Appendix 1.]

This report summarises the outputs of an online workshop, jointly organised by CREDS and UKERC, held on 19 October 2023. The organising committee consisted of Sarah Higginson (CREDS), Catherine Jones (UKERC), Marina Topouzi (Oxford), Michael Fell (UCL) and Gesche Huebner (UCL), any of whom can be contacted for more information on the contents of this report.

The workshop brought together a range of stakeholders from the energy research lifecycle including consortium leads, data managers, researchers, publishers and funders.

Outputs include:

- A summary of key lessons (captured in this report)
- A set of recommendations (to be shared with participants)
- A blog (to be shared with the wider research community via the CREDS and UKERC websites and newsletters)

This workshop explored lessons relating to data sharing in the energy research domain from the perspective of different stakeholders and used these lessons to develop recommendations.

The workshop included three short talks/presentations. The first was from UKRI to set the context, and then from both CREDS and UKERC outlining their experience of research data sharing and management.

In breakout groups, participants were asked to:

- Reflect on the experiences of CREDS & UKERC and capture lessons learned from broader experience
- Consider what is needed to deliver effective data sharing
- Identify the main barriers to sharing energy research data
- Explore potential solutions and the means to take them forward
- Develop and prioritise recommendations

A visual tool (Mural) was used to capture responses from participants during the group discussions. A FAIR (findable, accessible, interoperable, reusable) data sharing framing was used for this process. This created a complex mapping of responses, which were subsequently analysed and arranged under four new headings: 'Resources', 'People', 'Methods and Technologies'. These are presented in the Stakeholder Responses section of this report. In each case, the workshop sought to capture lessons learned, key barriers to data sharing, and views on the pre-requisites for effective data sharing.

The Appendices to this report provide a detailed account of the workshop and participant responses.

## 2 UKRI, CREDS & UKERC Experience – Talks/ Presentations

### 2.1 Rachel Bruce – UKRI context setting

As Head of Open Research at UKRI and lead for the Pan UK research policy for open access, Rachel set the context for developing research data strategy and policy within UKRI. She emphasised her interest in hearing about different approaches to research data management and in identifying specific challenges and opportunities. UKRI wish to invest in and support best practice with availability of research outputs as a key cross-cutting aim.

In this context, the main drivers for UKRI, when it was established in 2018, were:

- Open access to publications
- Research data policy and practice to enhance trust and transparency (with a common principle to be as open as possible, as closed as necessary).

UKRI is working for best practice in innovation in a UK context, but also globally with partners and funders around the world. Part of their corporate plan includes updating their [research data joint principles](#), and then each Council has its own policy. Global collaboration is important, as is data sharing across sectors. Open research is a key aim with support from best policy and practice across all disciplines.

UKRI has invested in more cross-disciplinary research and has enhanced the focus on reproducibility. They are currently working on reforming the [research assessment](#) to incentivise data sharing. Across the Research Councils they are developing new requirements and best practice.

UKRI reviewed what happened with data sharing during the pandemic and recognised the need for cross-disciplinary policies.

OECD data recommendations were updated in 2021, and these will be considered when refreshing UKRI's policies in the future. There is more on e.g. footprint data, usage data, AI adoption. These issues are also being considered in the development of the [Research and Excellence Framework \(REF\) 2028](#).

In the future, UKRI policy will address the whole pipeline, including new data types and cross-disciplinary working. It will seek to make sharing research data as easy as possible and identify how UKRI can support that, with a particular emphasis on cost-benefit.

## 2.2 Sarah Higginson – CREDS experience

Sarah talked about the CREDS experience of the challenges involved in making the findings available from across nine separate themes.

She talked about the difficulties of recruiting and retaining Data Managers, an issue they addressed by setting up an internal 'good data practice' project and securing bespoke support from the [UK Data Service](#).

Specific interventions from the CREDS Core Team included:

- Setting up a Research and Data Quality Project and selecting a Quality Champion from each of the nine theme areas to increase awareness, skills and communication linkages across the consortium.
- Reporting on progress at Whole Centre Meetings and in quarterly reports.
- Producing a video series about [improving the transparency, reproducibility and quality of research \(TReQ\)](#)
- Encouraging every theme to produce a Data Management Plan and then collecting and cataloguing this data.
- Setting up a collaboration with UKERC on the Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH).
- Setting up a workshop (reported on in this document) to coordinate shared learning with system stakeholders and to develop recommendations for future research consortia.

Specific lessons learned include:

- Many researchers are unaware of TReQ tools.
- There are different research cultures and many different types of data.
- Data Management is not a priority and is often left until the end of a project. (Creating issues with ethics approval processes if participants are not asked for permission to share their data. There is a related issue here in that data sharing is not highlighted by ethics approval processes, an institutional issue).
- Data Management takes time and effort.
- There is a need for greater clarity around basic processes e.g. preparing the data for archiving, making sure it is supported by quality metadata, checking that data has been archived ready for sharing.
- The loops are gradually being closed – publishing, funding, consortia etc. are increasingly focusing attention on the importance of data sharing.

### 2.3 Catherine Jones – UKERC experience

Catherine has been involved in data access, management and sharing for many years and has worked for three years in the energy sector, specifically as part of UKERC's Energy Data Centre (EDC).

- UKERC has been running for 20 years and has 20 project partners.
- UKERC's current phase (Phase 4) consists of 7 themes, 3 capabilities and 3 rounds of external projects – an £18M programme.
- UKERC's EDC provides an expert team, a discovery portal and a compendium of UK energy research data.
- UKERC's vision is to provide independent whole systems research for a sustainable energy future.
- UKERC expects every project it funds to create a Data Management Plan and the majority of projects have an approved plan.
- During Phase 4 they have made data publicly available, with seven datasets in the EDC, three in the UK Data Archive, and one in an institutional repository. (There are some sharing restrictions where these have used third party data.)
- UKERC Phase 4 has a clear view of what research data are being produced and what is openly available.

### 2.4 Challenges and Lessons Learned

Following these three presentations a Q&A session explored the challenges and lessons learned in more detail.

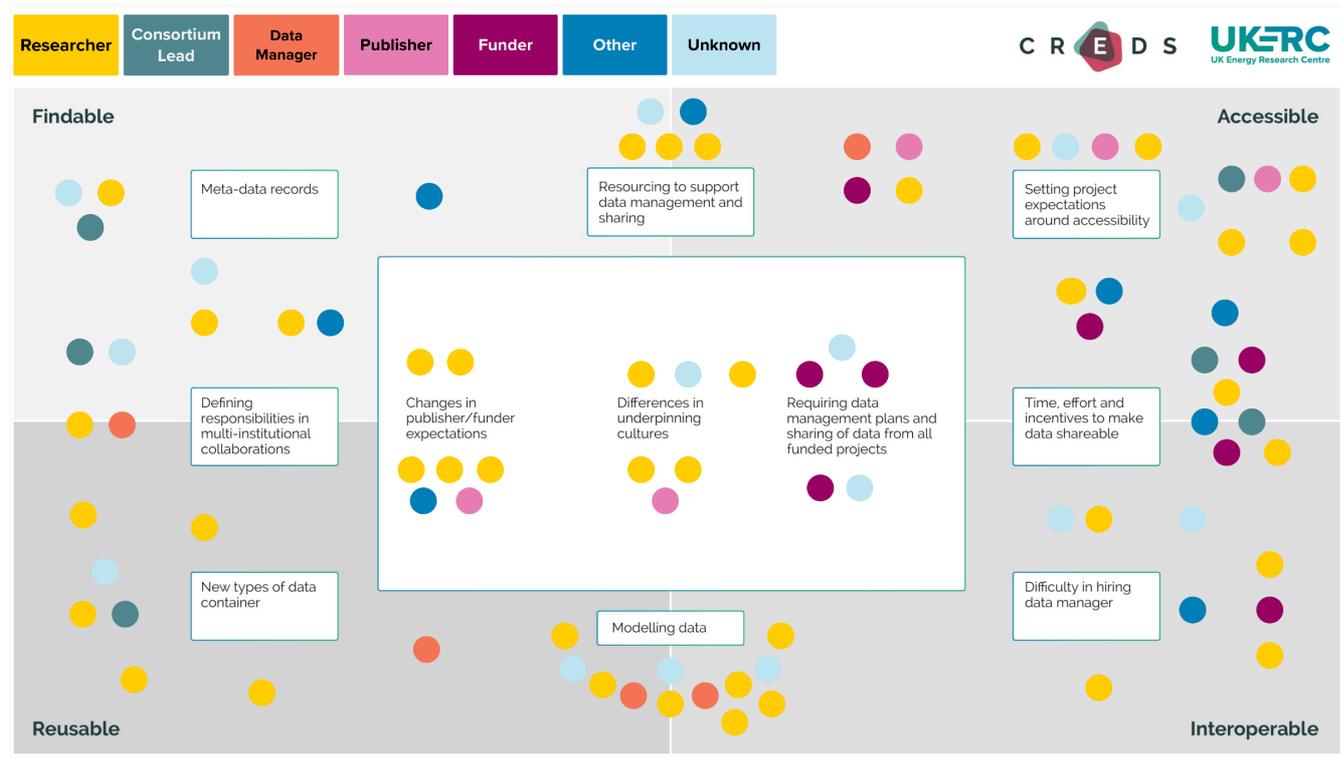
- Energy research covers a wide variety of disciplines with different expectations, practices and repositories.
- Data management planning is part of good research practice and contributes to reproducibility
- Preparing data for archiving can take a significant (often unbudgeted) amount of time - this can be significantly reduced by creating an effective Data Management Plan early in a project.
- There are challenges around the data itself, not least the ethical implications of archiving data – again, early development of a Data Management Plan will help to avoid these issues
- Data Management Plans need to be tailored to the scope of the project - large consortia need more complex processes than smaller projects, but there's no question that they all need something
- Publisher requirements on data access statements are starting to change researcher behaviours

- There is always a cost/benefit analysis to be undertaken and ways of optimising the amount and type of data to be stored and the duration of that storage, not least when considering modelling outputs
- Jupyter notebooks provide a useful research tool, but they are difficult to preserve as part of a data archiving process.
- Data from UKERC Phase 4 will be publicly available and discoverable where appropriate via the EDC

### 3 Stakeholder Responses

To gather the views of the stakeholders who had attended the workshop, participants were divided into six groups for the first session, with a mix of stakeholder roles in each group. The main focus of the discussion was to reflect on and learn lessons from the experiences of CREDS, UKERC and the wider stakeholder community represented at the workshop. Participants were also asked to consider what is needed to deliver effective data sharing whilst identifying key barriers to this process.

A visual tool (Mural) was used to capture responses from participants during the group discussions. These were captured using the FAIR (findable, accessible, interoperable, reusable) data sharing framing, and participants were asked to self-identify which role they hold (consortium lead, data manager, researcher, publisher, funder or other) when making responses. Figure 1 shows the distribution of responses from each participant group within this framing.



**Figure 1** – distribution of responses from participants within the FAIR framing

The responses of the participants are captured in detail in Appendices 4 & 5.

In the following section further analysis of these responses has been undertaken using a framing based on some previous analysis by the project team which had suggested four key considerations for effective data sharing:

- **Resources:** The need for synchronization between research objectives and project management.
- **People:** The impact of different actors in the process.
- **Methods:** The potential for consistent metrics or a set of principles that facilitate project comparisons and are sympathetic to both quantitative and qualitative research traditions.
- **Technology:** This includes both testing novel technologies and data collection technologies.

### 3.1 Resources

Using this framing, perhaps the most fundamental issue identified in the workshop was that of 'resources'. The key 'lesson' captured in this regard was that it is easy to underestimate how much resource is involved in delivering effective data sharing, and this was reflected in a number of the barriers identified.

It was generally felt that insufficient resources are assigned to the process, a problem which is compounded by the general 'lack of time' in a modern university. Also, the perception of data sharing is that it is 'time consuming, difficult and frankly not interesting'. Submitting data to an official repository can be an 'admin-heavy process' and if no-one is checking that data is being made available it drops down the priority list. Added to this, managing data across multiple institutes, ethics teams and collaboration agreements is difficult, and funding for the delivery of open access project outputs can be limited.

The stakeholders suggested that addressing these issues, requires greater recognition in institutions and research centres of value of data as an output, supported by funder policies for sharing data. Positive incentives would encourage applicants to consider data sharing at the project proposal stage and ensure that appropriate agreements are established with quality, usable data as a project output, whilst recognising that not all data can be shared and there is a cost to managing and storing data. These agreements should plan and map data flows and clarify data management arrangements, and there was a recognition of the importance of effective project management in the process, assisted by appropriate communication and engagement support.

The presentations from CREDS and UKERC had emphasised the importance of creating a Data Management Plan early in a project. There was a lot of agreement around the importance of these and the need to review them to ensure that they are comprehensive as a means of delivering focus on data sharing earlier in the research process. This may be helped by the creation of good, detailed guidance at institution or even UKRI level.

However, some stakeholders did raise questions around the role of Data Management Plans, and even asked whether they were needed in all situations. There was a desire to simplify the process where possible, which was seen as especially important for projects with lower resources or without a data manager. It is only possible to 'plan in detail for what is known now' and plans need to be able to handle changes.

Concerns were raised about creating data sharing policies based on the principle that 'it is a good idea', and consequently having to prepare data in a way that 'meets all possible needs'. Qualitative differences were identified between data produced as a product for others as against data used internally for a publication. It was suggested that different levels of effort may be appropriate in each case, which resonated with questions around the 'value' of specific data sets.

The ability to recognise the 're-use value' of datasets was seen as important in directing effort appropriately, potentially supported by an effective cost/benefit analysis. A key question identified was, 'How long should we keep research data when don't know what will be reused?'

### 3.2 People

The availability of resources is closely related to the impact of different actors in the process, and a number of the data sharing issues discussed in the workshop were related to the role of 'people' in the process.

Individuals experience 'many disincentives to making data accessible'. In particular, there is a lack of incentive for researchers to deliver good data-sharing practices, as they are not recognised or rewarded for the effort involved. The benefits are not made obvious, and it is apparently hard to provide such incentives. Also, when researchers join a project at a later stage, they may not be familiarised with the vision of data sharing that has been established, and yet they are the ones that will often be responsible for documenting the work.

This lack of incentives also extends to the data management community. In situations where it is recognised that the scale of operation is sufficient to require specific data management expertise, funding/pay is often not sufficient to attract individuals with the required levels of skill, capability and commitment to the role. Where appropriate resources are put in place, the objectives of the data manager's role need to be made clear. This could even extend to defining new variables in existing data sets.

Addressing these issues could potentially create greater clarity in the value of data sharing and encourage individuals to actively participate in the process. Alongside more incentives for data sharing, this will require senior researchers to provide leadership and promote good practice, supported by effective induction processes and training, to highlight the importance

of data sharing to researchers and provide them with a supported process for effective delivery from the beginning of their involvement in a project.

Experience among stakeholders has also shown that the nature of the partners in a project can also have a significant impact on data sharing. There are many data types, individual preferences and a lack of standard data management practices between researchers. In some cases, there will be limited responsibility for data management processes in those partner organisations. On the other hand, when working with industry, there will often be a requirement for a non-disclosure agreement to be put in place. Concerns around confidentiality or commercial interests can even lead to data providers removing elements from data sets or placing restrictions on the sharing of inputs and/or outputs of data-driven modelling exercises.

Again, data sharing agreements are important in resolving these issues and clarifying the relative value of the 'data', 'information' and 'knowledge' derived from a project. These will form part of an effective Data Management Plan that sets clear roles, responsibilities and expectations, addresses the concerns of commercial data owners, and clarifies specific data support needs.

Publishers also have a role to play in this process. They can provide additional incentives for data sharing by accepting 'short/data papers' or even publishing 'data descriptors' as a key output of a research project, rather than a by-product. This could incentivise researchers to publish their data.

### 3.3 Methods

Alongside the 'resource' and 'people' considerations, the discussion in the workshop identified the importance of the various 'methods' used to deliver consistent metrics and provide sets of data sharing principles that facilitate project comparisons. At their most effective these will be sympathetic to both quantitative and qualitative research traditions, recognising the significant challenge created by inter-disciplinary research where there can be multiple research approaches, data sources and repositories for data from the different communities and disciplines:

- In physical science and engineering disciplines, a key pillar is often that research is repeatable, leading to the question, 'Can we do a repeat test with the existing data?'
- Where modelling is an important element of the research process, model inputs and outputs can be equally important, as is the modelling process itself. Where this modelling uses stochastic or tuning methodologies, it is not trivial to reproduce the outputs from the inputs and it may be necessary to store all the model outputs which can involve huge amounts of data. Development of training data sets can be important, as can version control for dependencies where open-source software is used.

- In the social sciences it may never be possible to repeat the experiment, and this will impact how long data needs to be kept. There can also be uncertainty around factors inherent to the research process that prevent data from being shared and data sampling can be a problem.

Consequently, data sharing can mean different things to different disciplines, creating additional challenges when managing data in an interdisciplinary environment. Huge amounts of very different kinds of data can be produced and it is not possible to have a 'one size fits all' policy, creating difficulties in working to shared standards, that support cross-disciplinary access and use.

Collation of data within collaborative projects can also be a challenge, as collection criteria vary, and funders can require data to be deposited in a specific place. Key questions arise around what should happen to the data once a project finishes, and who should have access to it. Different disciplines and partner organisation answer these questions in different ways and also format and store their data differently. Consequently, there is often 'push back' against storing data in multiple locations. Added to this, the rules for data access in some repositories can be seen as unnecessarily onerous.

Specific problems arise when handling data derived from mixed methods and/or sensitive sources, particularly where consent not been secured or anonymising data is a problem. These problems are compounded where the data is in the form of transcripts - it may not be appropriate to share it all, but it is time consuming to make the necessary redactions. There can also be intangible data quality questions that are almost impossible to answer around how 'well' the data was collected.

Some of these issues can be addressed by referring to the 'data/information/knowledge pyramid' and re-visiting definitions of 'data' and 'information'. Ethics processes are also important in supporting data sharing whilst regulating access to data and ensuring that confidentiality is not breached, using tools such as well-designed consent forms, impact statements and ethics declarations. Meta-data has a role to play here too, particularly when seeking to deliver against FAIR principles of data sharing.

However, the issues are not just about the creation of data sets but also the processes used for subsequent interaction with the data. There was a call for more analysis of when and how data needs to be accessed, a process which can be helped if the data sharing has a clearly defined purpose. The Cambridge Crystallographic Data Centre was highlighted as an organisation that had been particularly successful in this regard, and there are doubtless other useful case studies to be explored.

### 3.4 Technology

Finally, some consideration was given by workshop participants to the role of 'technology' in data sharing, although these considerations were relatively limited in their scope.

There was some discussion around how to ensure that data is secure when sharing across institutions, and the use of proprietary software like SPSS for making data sharable. However, the technical discussion mainly focussed on the potential use of artificial intelligence approaches to make use of less organized data sets and the use of Large Language Models for data discovery.

## 4 Recommendations

To draw recommendations out of the above responses, participants were assigned to three new breakout groups. The main focus of this session was to reflect on learning points in Session 1 and to develop a list of priority recommendations to take forward. Groups also discussed the resources required to take the recommendations forward and the impact that they would have.

The outcome of these discussions is summarised below with more detail captured in Appendix 6.

- The data sharing experience of others is important – we need to secure better access to data for sharing, and make the methods, tools and guidance on how to do this more available. Energy consortia have a role in setting expectations and developing/pointing to resources.
- Providing metadata and good quality data indicators takes time. Managing data across multiple institutes, ethics teams and collaboration agreements can be complex. The different disciplinary domains common to energy consortia may have different standards that need to be met. All of these require expertise, attention and resourcing.
- Creating better data sets requires them to be more highly valued. Institutions need to take the value of data more seriously, funding activities effectively, rewarding individuals for taking an active role, and recognising the importance of workload management. Energy consortia should help to set this framework as part of their culture.
- Data Management Plans are an essential starting point and should be in place at the beginning of projects. However, to make most effective use of them, they should also be flexible, with appropriate mechanisms in place to reflect and learn as change occur.
- For large energy research centres in particular, proposals need to budget for a data manager, recognising that this is an important role requiring appropriate remuneration to secure quality personnel.
- Not all data are equal. The skills of the data manager should provide guidance and support to help discriminate between the value of different data sets and prioritise management effort accordingly.
- Skills and knowledge in the area of data management vary widely across the energy community, partly because of the involvement of so many different domains. Training is required to improve researcher awareness of the value of data sharing and to improve their data management skills. Energy consortia can provide/ host this training and have a role to play here, emphasizing the domain aspects of data management.
- A peer network for data managers and data stewards would be useful to enable sharing of best practice and identify areas to work on together to embed FAIR data and Open

Research practices within researcher's activities. Building on existing Energy Consortia collaboration activities, such as the Cross-Consortium Engagement Meeting (CCEM) would get this process started.

- The energy community is a large producer and user of models in a wide variety of areas and common standards for what to archive to enable FAIR data and reproducibility have not yet been agreed. Such protocols would be helpful to discuss. The energy research specific issues for sharing the outputs of energy models should continue to be highlighted

## Appendix 1

### Data sharing workshop briefing note

*(a document shared with participants ahead of the workshop)*

**Catherine Jones and Sarah Higginson**

#### Introduction

Sharing energy research data is good practice for responsible research and many funders now require it as a condition to receive grant funding. However, it is still often seen as a burden and many projects fail to fully deliver on FAIR (findable, accessible, interoperable, reusable) data sharing commitments. This workshop will bring together key stakeholders in the whole research lifecycle to develop recommendations to improve the level and quality of data sharing within the energy community.

#### Aims and outputs of this workshop

This workshop aims to explore lessons relating to data sharing in the energy research domain from the perspective of different stakeholders and use these lessons to develop recommendations. In short, what can those involved in funding, supporting and undertaking the research do to embed and enable a culture of data sharing regardless of the area of energy research? The main outputs will be a summary of key lessons and a set of recommendations, to be shared with participants and, through a blog, with the wider research community.

#### Data sharing

The importance of sharing all outputs of research has been long established. RCUK (the forerunner of UKRI) published Common Principles on Data Policy in 2011, followed up by [Guidance on Best Practice in the Management of Research Data](#) and individual Research Councils' policies. In 2016, RCUK, HEFCE, Research England and Universities UK signed [Concordat on Open Research Data](#). Funders' interest in this topic continues with the UKRI [Current Research Data Guidance](#).

Since 2011, different domains and communities have adopted different standards for, and expectations of, data sharing, in part in response to the types of data collected in research and taking into account any legal requirements. Historically some domains/funders have supported this, such as through the NERC and ESRC data centres, or the crystallography community, which expects use of the Cambridge Crystallography Data Centre before publication. In some other domains such as Engineering, where potential IP issues result from working with commercial partners, there are less well-developed community standards. Meanwhile, research dealing with human subjects, which needs ethical approval, results in

potential restrictions on sharing the outcomes. For these reasons and others, [significant variation is observed](#) in levels of data sharing between sectors and regions.

Despite this variation, it is now well established that sharing data and having others use and cite that data, enhances research careers and supports reproducibility by enhancing the transparency of the research.

## Is Energy Research special?

There are several areas where Energy research produces interesting data sharing challenges.

Firstly, energy research is often done in large consortia undertaking a wide variety of energy research. Each project will have to have provided information on overall data management as part of the bid, but setting effective standards and expectations to support and monitor the outcomes of all the different projects within the consortium requires significant work, which such consortia may lack the skills to do. Hiring data managers in this context is challenging when they are able to earn much higher salaries in the commercial sector.

Secondly, energy research covers a wide range of domains, as demonstrated by multi-funder projects. Each of these domains, and their attendant research councils, may have different community standards and expected deposit services attached to them. It is important to ensure that these are followed to encourage discovery and reuse, but also that it is possible to discover the complete outputs of a project and, ideally, other similar projects/ consortia, which might be expected to have useful data to share.

Further, as an applied area of study, energy research is often conducted in collaboration with commercial partners, potentially limiting researchers' ability to share certain data.

## Experiences from CREDS and UKERC

The knowledge and experience gained by the CREDS and UKERC Energy Data Centre teams supporting researchers to manage their research data has led to this collaborative workshop. Here we summarise the activities and outcomes of each centre before going on to pull out some lessons.

**The Centre for Research into Energy Demand Solutions (CREDS) activities**  
[CREDS](#) carries out interdisciplinary research to understand the role of energy demand change in accelerating the transition to a zero-carbon energy system, including the technical, social and governance challenges of demand reduction, flexible demand and use of decarbonised energy.

Archiving data in CREDS is a contractual obligation and, theoretically, institutions who do not do it could have payments withheld. CREDS produced a data management plan for the whole programme and went about hiring a data manager. This proved to be difficult, requiring three

recruitment rounds, and finally recruiting someone who stayed only 18 months, because there are better opportunities in commerce for people with these skills. Nevertheless, a template was produced and training provided to enable each project to produce a data management plan of its own, which most have done.

When the data manager left, an internal Research and Data Quality project was set up. The project invited someone from every one of our nine themes as a 'Quality Champion' to ensure its message reached everyone in the consortium and made regular presentations at Whole Centre Meetings. It had two main parts: the first to promote the [Transparency, Reproducibility and Quality \(TReQ\)](#) of data, which produced an excellent series of [six videos](#) (covering [Principles](#), [Pre-registration](#), [Reporting Guidelines](#), [Pre-prints](#), [Open data and code](#), and [Checklists](#)) and promoted this work through meetings, newsletters and a paper on [Improving Energy Research Practices](#). The second collected the data used within CREDS (using the data management plans) and catalogued this data. It also set up a collaboration with UKERC and the UK Data Service (UKDS) to improve the archiving and findability of CREDS data.

UKDS has run two bespoke archiving training sessions to help researchers develop their skills, as well as having a range of training resources on their website. They also help individual researchers with specific queries. Researchers submitting data to UKDS are subject to a rigorous process whereby their data and supporting documents are reviewed and corrected as necessary, to ensure the data submission has some quality control attached to it.

This workshop is part of the CREDS/UKERC collaboration and aims to take what we have learned, work with system stakeholders to come up with recommendations to improve systems still further, and pass these on to new consortia for implementation.

### UK Energy Research Centre (UKERC) activities

The [UKERC consortium](#) carries out interdisciplinary, whole systems research into sustainable future energy systems, addressing the challenges and opportunities presented by the transition to a net zero energy system and economy.

In UKERC's fourth phase (2019-2024), data management planning is a KPI and is managed by the Energy Data Centre (EDC) on behalf of UKERC. The EDC have adopted the approach "**As open as possible, as closed as necessary**". We recommend that data which is to be shared is deposited in a domain repository such as the EDC or the UK Data Service, where the potential re-users will expect to find it. The EDC has a metadata record for all shared data regardless of its location.

All identified projects within the seven UKERC themes and three rounds of FlexFund funding have been expected to produce a data management plan. The EDC team have regularly followed up with UKERC colleagues to track progress and offer specialist advice. When there

was a change in staffing, the EDC team ensured that supporting DMPs remained a priority activity. The team have provided [UKERC guidance on data management](#), covering topics from data management checklists to research software, and provided information & advice in theme meetings and individual sessions.

As a result, data has been deposited with the EDC and UKDS from completed projects in four themes. A small number of projects are not expected to deposit data at all, due to the nature of the research (e.g. elite interviews).

While not all projects have produced a data management plan, all projects know that they should. We anticipate at the end of Phase 4; it will be easier to discover and re-use the outputs than from previous phases; moving data sharing forward in the UKERC community.

## Shared challenges and lessons learnt

There are some shared challenges which have been raised through UKERC and CREDS experiences, these are highlighted here, and we are interested to explore these in addition to workshop participants' own experiences.

- **Resourcing to support data management and sharing:** Both UKERC and CREDS identified the need for specialist data managers/stewards within the project to support researchers. This is a specific specialism and they can be hard to recruit and retain.
- **Time, effort and incentives to make data shareable:** This is not necessarily an issue only for energy researchers, but perhaps the benefits and pay-offs are linked to the domain. Depending on the specific domain, expectations and knowledge around data sharing can be patchy.
- **Setting project expectations:** Sharing research data is not embedded in internal systems to ensure that credit is recognised. Projects should include guidance on how data from the project should be cited. Information on data management and sharing should be included in induction material, so that people joining later in the lifetime of a consortium are not left out, and any project reporting, so that data management is part of project planning, management and delivery.
- **Expectations of project organised funding:** Energy consortia usually have flexible funds to help decentralise Research Council funding. UKERC funded external researchers through the FlexFunds calls and expected DMPs and shared data; this should be a standard approach.
- **Differences in underpinning domain's culture:** The Energy Research community is multi-disciplinary which highlights the differences in expectations, training and disciplinary norms.

- **Responsibilities in large multi-institutional research centres:** CREDs and UKERC, and other research centres, are not legal entities, so the institutions employing the researchers have a role to play in areas such as ethics approval for research, which should help to ensure data management is a central concern. Differences in practice between institutions can make a clear message on behalf of a centre harder to disseminate and can lead to differences in expectation.
- **Changes in publisher/funder expectations:** The importance of depositing data in a reputable repository as part of the publishing process and creating data access statements is becoming more embedded in researcher practice and is starting to drive data deposits.
- **Modelling data:** A lot of Energy research outputs are models. How models and their outputs are shared and used effectively with other forms of data is a challenge that needs further consideration and work.
- **New types of data container:** Energy researchers are adopting new forms of research outputs including Jupyter notebooks which are more of a challenge to deposit and curate; demonstrating that data sharing and management is a constantly evolving field and needs to be supported by expert data stewards.

## Appendix 2

### Workshop Agenda

The workshop included three short talks about the UKRI, CREDS and UKERC experiences at the beginning and then there were two main sessions for stakeholders to work in groups, followed by a plenary discussion. Participants were divided into six groups for Session 1 which focused on reflections about lessons learned and for Session 2 (with participants in three groups this time) the discussion moved forward to develop recommendations.

10:00 **Introduction**

10:10 **UKRI, CREDS and UKERC experience**

10:45 **Session 1** – reflect on lessons learned (groups 1-6)

11:20 **Break**

11:30 **Session 2** – recommendations (groups 1&2; 3&4; 5&6)

12:15 **Plenary discussion**

12:30 **FINISH**

## Appendix 3

### Q&A

*A more detailed capture of the Q&A session following the presentations by Rachel Bruce (UKRI), Sarah Higginson (CREDS) and Catherine Jones (UKERC).*

**Q:** I'd be interested to hear more about the challenges around both model outputs and Jupyter notebooks.

**A:** Jupyter notebooks are great and live and can be put on the Jupyter Hub. They are active research topics, but it is difficult to preserve them. You would probably put them into a non-proprietary format and migrate them somehow. There is not an easy answer to this.

Models can produce vast amounts of data and it is hard to decide what you keep and how much to keep. If you are not careful you keep everything! Respondent is from a librarian background and concerned that we store too much given that data storage uses lots of energy.

**Q:** Questioner is interested in the intersection between ethics and permissions and data sharing e.g. of elite interviews. If you haven't agreed with participants in standard statements that you will share their data, then not sure that it is possible to keep their data forever, even if it is anonymised. Would like more guidance on this. How do you incorporate data sharing permissions correctly?

**A:** Not all interviews can be shared and interviews are hard to anonymise. Being aware that you will need to archive at the start of the project is important to set aside enough time and expertise to do be able to do that. Researchers may not know that it is now expected that you will archive interviews (this was not always the case in the past). Ethics should be able to advise them at the start of a project, although concerns were expressed that this isn't always happening.

Ensure that you ask participants everything required early on, as it takes time to go back to them later. It does put researchers in a difficult position if participants have not been asked for agreement on everything needed at the start of a project.

It is possible to not share certain data for good research reasons, but if it is because you haven't thought about getting permission, this is not a good reason!

**A:** It is one of the challenges of multi-disciplinary work where some disciplines have helpful information on consent and data sharing and others don't. Look at organisations where this is done in a standard way.

**Q:** Following the point made in one of the responses about data value v. storage, I've a question about data value when considering the energy efficiency of IT. There are huge amounts of data being stored and we need to throw some away! There is a big question about data value that needs to be asked as we store huge amounts of it and use vast amounts of energy e.g. the Data Centre in Slough is significant. Perhaps we need to shorten the data storage time period? Ten years is too long.

**A:** We will aim to capture this debate in Breakout rooms.

**A:** Respondent agreed that this is an important point. There should be a time limit to avoid intensive data storage. We need a big shift in how we think about the value of data. We don't make enough use of existing data! We create more and more data. We could change the ecosystem, review the value of the data and choose to use more of what we already have. We need to get a balance with the use of data v. the cost of storage.

**A:** Respondent agreed with both perspectives. When UKRI has considered what is most important to examine in depth, it is a cost/benefit analysis. We are looking at the question of choosing what to keep and why, which is very complex. This is something which UKRI will prioritise in a more pan-UKRI approach.

## Appendix 4

### Session 1 – reflection on lessons learned (summary of responses from each group)

For Session 1, participants were divided into six groups, with a mix of stakeholder roles in each group. Roles represented at the workshop were Consortium lead (CL), Data manager (DM), Researcher (R), Publisher (P), Funder (F) and Other (O). Participants introduced themselves briefly. The main focus of the discussion was to reflect on and to learn lessons from the experiences of all stakeholder groups represented, including CREDS and UKERC, and to consider what is needed to deliver effective data sharing whilst identifying key barriers to this. Mural (an online visual tool) was used, which was divided into sections based on FAIR with space for overarching issues and participants recorded their responses in the relevant section noting their role. Each group had a separate Mural board and responses from all groups were collated before Session 2.

#### Group 1

**Facilitator:** Gesche Huebner

Roles included in group: R, F, CL, O.

This group noted the challenge that there are so many repositories that it is hard to know which is most appropriate to use and often the rules for data access are often onerous. The difficulties of developing a Data Management Plan for cross-disciplinary research and access were noted. The publication of ontologies helped with finding a common language to make data interoperable in one situation. There was a point noted about whether a Data Management Plan is always needed and if not, how do you know in which cases it is required? An overarching theme raised was the time and resources required for data management and sharing.

#### Group 2

**Facilitator:** Sarah Higginson

Roles: R, O, F

This group identified that clear and consistent guidance is needed for data sharing with expectations explained. Defining the most appropriate meta data for data sharing is an ongoing challenge and more difficult in collaborative projects when the criteria are different. The requirements for different disciplines need to be considered. Given the time and effort involved preparing data for sharing, this group mentioned the lack of incentives for researchers to do so. It was suggested that short papers could accompany each dataset, as researchers are rewarded for publications. Funders might find ways to encourage data

sharing where it is appropriate. It was recognised that smaller projects struggle with resources for this.

It might be useful for data managers to be established at institution or UKRI levels rather than at the beginning of a project. When researchers join a project at a late stage, this is even more of a challenge, it is important that they are brought up to speed with data sharing preparation methods, which could be through induction or training.

### Group 3

**Facilitator:** Catherine Jones

Roles: R, P, CL

This group noted the importance of setting project expectations around making data accessible. Clear data sharing agreements which outline who is responsible for what were identified as helpful. There can be fear about doing the wrong thing. Data sharing is important but may mean different things to different disciplines. When working with industry there will often be an NDA, which might mean that model inputs could not be shared. Social science research may not be easily repeatable, which may affect how long the research data is retained.

It was recognised that dealing with mixed methods and sensitive data is challenging and ethical considerations need to be thought through at an early stage. Changes to data sharing policy part way through a project can have a big negative impact.

### Group 4

**Facilitator:** Marina Topouzi

Roles: R, F, O, DM, CL

This group discussed the significant resources needed for data sharing as an issue. Given that it is important scientifically that research can be repeated, might the focus of research be repeating tests with existing data rather than constantly gathering new? It is also useful to revisit the definitions of 'data' and 'information' to maximise the usefulness of the data. Is the data in the same format across institutes/ partners and what is needed by the funder? It is helpful to note which data you have in what format.

How can researchers be encouraged to publish their data? Some publishers use a 'data descriptor' as an output of a research project which could incentivise researchers to publish.

Modelling data was mentioned in this group and that both inputs and outputs are equally important, as is the process of producing outputs.

The difficulties in hiring Data Managers were also discussed and that being clear about objectives at the outset is helpful.

### Group 5

**Facilitator:** Mike Fell

Roles: R, DM, O (?)

Lack of resourcing to support data management and sharing was also a key topic in this group's discussion. It is important that a supported process is in place for researchers from the beginning of a project and also that the value of data as an output is recognised. Sometimes the incentives and benefits of data sharing are not obvious. It can be a heavy administrative process to submit data to an official archive, particularly if there are multiple data types. The level of effort can be different for data produced for internal use to data for external use.

How long should we keep research? It was noted that a cost/benefit analysis could be useful.

Modelling data was mentioned as a challenge - inputs and outputs can both be huge and take a long time to process.

### Group 6

**Facilitator:** Mike Colechin

Roles: P,F, DM, R

Resourcing to support data management and sharing was also discussed by this group. The need to identify suitable resources in a Data Management Plan was raised and to be clear who is responsible at an early stage (particularly in multi-institutional collaborations), with defined expectations. A plan to handle any changes that might occur during a project was also noted as useful. It is important to ensure that appropriate agreements are in place so that quality, useable data is the output.

Funding issues were identified as a possible reason for difficulties in hiring Data Managers.

Modelling data was discussed, and it was suggested that research to refine the results would be useful and to identify the best methodology.

## Appendix 5

### Session 1 – reflection on lessons learned (summary of all points captured on Mural boards)

When adding comments to the Mural boards, participants were asked to self-identify their role from the following list: Consortium lead (CL), Data manager (DM), Researcher (R), Publisher (P), Funder (F) and Other (O) – which we asked participants to specify.

#### Findable

R - clearer and consistent guidance on data sharing and management expectations

R - too many repositories and not clear where to put things

CL - scared of doing wrong, scared of responsibilities - wide range of disciplines

R - too many locations and repositories for different communities

#### Meta data records

O - Software engineer. Defining the most appropriate meta data to make the data FAIR is an ongoing challenge.

O - difficult to create shared standards, cross disciplinary access and use limited

R - referring to DIKW pyramid and trying to maximise the usefulness of the data and their potential users, it would be useful to consider both "Data" and "Information" (what particular sets of data means).

R - <https://www.ncrm.ac.uk>

#### Findable/Accessible

#### Resourcing to support data management and sharing

R - in smaller projects, lack of resource to support data management and sharing (especially ensuring that format is suitable)

R - Is this expected to be a researcher skill, does it have to be done by the people creating the data, or can we imagine there being project management support?

R - Change in policy through PhD about sharing the data, which means it wasn't set up to share - impact of policy change

O - Our centre underestimated how much resource was involved in data sharing and it was originally a bolt-on to the Knowledge Exchange Role. This wasn't realistic and requires different expertise

Link to Communications and Engagement Officer

How to make data secure when sharing across institutions?

O (research support) - need to identify this in the data management plan so that expectations and who is responsible is clear

## Findable/Reusable

### Defining responsibilities in multi-institutional collaborations

R - collation of data within collaborative projects, especially when criteria for sharing are different e.g. if funders require depositing in a specific place. We've recently had this when working with teams in the US.

CL - Data personal data

CL - work on that - data sharing agreements, where shared, who is responsible for keeping? - sharing with agreements

DM: Is the data in the same format across institutes/partners and what is needed by the funder?

R - planning data flows & data management in the agreements - monitoring & evaluation project, - reporting back mid-project, dealing with personal data (GDPR)

R - lack of resources/time

R - cascade and flow-back of responsibilities needs to be mapped from the project outset

## Reusable

CL - How much responsibility do I have for ensuring data management processes for projects in 'my' theme, particularly for partners in other institutions? (Formally I have no power over them)

R - lack of training at an early stage so expectations aren't clear at outset

R - One key pillar of science is that it is repeatable, can we do repeat test with existing data, e.g. like in medicine, rather than always look for collecting new data

R - many data types, individual preferences and lack of standard DMP practices between researchers

R - Difficulties around transcript data, may not be appropriate to share all, but time consuming to edit

R - using stochastic/tuning methods in modelling makes reproducibility challenging - model outputs then needed

DM - Development of training data sets

DM - Defining new variables in existing datasets could be a DM responsibility.

What happens to the data once the project finishes? who has access?

## Reusable/Interoperable

### Modelling data

R - Could data be as easy to discover as content is via ChatGPT these days? Just describe what you need and it will give you ideas, alternatives (based on info contained in data documentation)? I think LLMs could be useful way for data discovery, at least as entry point.

R - Modelling data, both inputs to the model and modelling outputs are equally important. But also, the process of producing outputs is important.

R - Modelling data should be done with a lot of research to refine results and choose the best methodologies.

R - Model outputs huge, but not always trivial to reproduce from inputs. Inputs can be large as well

Greater recognition of data as an output

Especially important for lower resource projects without data manager

Ability to recognise re-use value of datasets and direct effort appropriately

Can AI approaches make use of less organised/ described datasets?

Maybe not just about datasets, but also analysis/ interactivity

DM with guidance of DM, data modelling may fit the dataset requirement or not.

R - version control in open-source software for dependencies

R - Experience of data providers removing data means people want their own copy

## Accessible

R - Researchers may join project at a later stage and are rarely familiarised with the vision of data sharing, yet they are the ones often responsible for documenting, etc.

Perhaps good inductions? Courses? Promoting practices by senior researchers.

R - some rules for data access in some repositories is particularly onerous when not always necessary

DM - Target audiences?

P - ask for an impact statement - from publication and data : thinking about ethics which is on the paper as part of ethics declaration

CL - Time and how projects and requirements may change over time

R - What type of data you have and in which format

P - data sharing important but might mean different things to different areas

R - Uncertainty around factors that may mean data doesn't have to be shared (like the elite interviews example)

DM - Sensitive data (even if technically public). (De-)anonymisation.

R - Quite admin heavy process to submit data on official archives like UKDS.

Repository perspective - getting consent is often not done, anonymising is often a problem, ethics need to be reformed, regulating access to data is also possible so confidentiality is not breached

Also, the consent forms used by researchers need to be considered. Most of the time we see consent forms that have statements like 'only the research team has access to the data', ; research data will be destroyed after xxx years'. Such statements should be avoided as these

precludes data sharing. So, there is no way to share data if the consent form has such statement and the only way is to obtain retrospective consent which is usually not possible.

### Setting project expectations around accessibility

R - Incentives - are there any, beyond the requirements of some publishers? There are many disincentives!

Time consuming, difficult and frankly not interesting as a research task. - for 'normal' projects where the purpose is not data sharing.

P - handling mixed methods & sensitive data, authors thinking about making shareable, quantitative data easier (unless legal) Would insist access to as such data in review process - elite interview

F - Open access funding can be limited

DM - Should we keep everything forever? Cost/benefit when we don't know what will be reused.

### Interoperable

CL - There is a temporal aspect of the value of data deposited that needs greater understanding in many areas, e.g. data can become invalid/superseded

### Difficulty in hiring data manager

O - Are objectives of the role clear? Do you know what data will look like at start of program?

F - Might be a funding problem to attract experts in data management.

Comment that one organisation hadn't been successful/was challenging in recruiting for research data manager. Apologies if this was said in one of the talks but was it a lack of interest or a lack of relevant skills?

## Accessible/Interoperable

### Time, effort and incentives to make data shareable

R - what is the incentive for researchers? They are not recognised nor rewarded for the effort (in a similar manner they are for publications, funding). Perhaps short papers should accompany each dataset that gets cited. DOIs are fine for datasets, but researchers will not put it on their CV under 'Journal papers' section. Possible journals could accept 'short/data papers'?

R - Nobody has time in a modern university

O (research support) - this is vital to ensure appropriate agreements are established and quality usable data is the output.

R - Benefits / incentives not always obvious.

O - Software Engineer: We are struggling a lot in this area - we are finding we need to provide incentives due to the time it takes to share data but are struggling to do so.

R - Perhaps data managers should not be only hired when a project kicks-in but be established at institution or even UKRI levels, to harmonise things. Otherwise, it's left to later stage of a project when researchers may not have time to work on data documentation.

R - proprietary software (SPSS)

F - As a Funder, we need to identify positive incentives to encourage and support data sharing - whilst also recognising that not all data can/should be shared, and the cost of managing/storing data.

F - Challenge of managing data in a very interdisciplinary environment. Huge amounts of data produced, very different kinds of data - cannot have a 'one size fits all' policy and need to consider different disciplinary needs.

F - How can we encourage applicants to consider data at the application stage?

CL - Consideration for any external partners involved in data collection, what their role is and what their requirements are (e.g. data sharing agreements)

CL - Managing data across multiple institutes, ethics teams and collaboration agreements

R - working with industry, had an NDA

O - in a multidisciplinary centre, different disciplines store their data in different ways/databases and we get push back from them to have to store their data in multiple places

R - good to see some publishers publish "Data Descriptor" which could be a key output of a research project, rather than a by-product of research projects. This could incentivise researchers to publish their data.

R - so can't share model inputs but can share outputs. Need to be within the agreement

R - data-driven modelling on industrial data cannot be made accessible

## Over-arching

### Changes in publisher/funding expectations

R / P - promote journals that allow publishing data descriptors

R - not clear what the value of data sharing is / does it pay off?

R - sampling a large problem, need a strategy, group into categories without anonymising

R - Lack of focus on data sharing early in research process.

R - Solution -- needs to be highlighted for researchers with supported process from beginning.

R - Solution -- greater recognition in centres of value of data as an output

O (research support) - you can only plan in detail for what we know now and ensure that there is a plan to handle changes

### Differences in underpinning cultures

R - there are intangible data quality questions that are almost impossible to answer in some areas around how 'well' the data was collected.

Encouraging people, finding time to actually deposit

R - it helps if the sharing has a well-defined purpose. This is central to all of the industry-led conversations that I have been involved in. At the moment, the policy seems to be to share it based on the principle that "it is a good idea", which means that you end up trying to prepare the data in a way that meets all possible needs. This is difficult. This resonates with the question of "value"

R - no one is checking if you make data available

P - social sciences not able to repeat the experiment will impact on how long it kept

R - Value of data vs knowledge, and perception by commercial data owners

## Requiring data management plans and sharing of data from all funded projects

F - do you need a DMP for all? Or consideration if needed

F - we need more analysis on when needed

F - want to be able to make sure easy - but there are differences

O - Recommend speaking to successful data sharing platforms e.g. Cambridge Crystallographic Data Centre about why it works

Funder policy for sharing data?

Qualitative difference between data produced as product for others, vs data used internally for a publication. Different level of effort appropriate?

O (research support) - these need to be reviewed to ensure that they are comprehensive

## Appendix 6

### Session 2 – recommendations (responses from groups)

Participants were assigned to new breakout groups for Session 2 of 6-10 people (the six groups from Session 1 were merged into three groups). The session began with a short opportunity for participants to introduce themselves to each other and to network. The main focus of this session was to reflect on learning points in Session 1 and to develop a list of recommendations to take forward, listed in priority order. Groups also discussed what resources would be needed for the recommendations to be delivered. Responses were again captured on Mural. Each group nominated one person to feedback at the Plenary session.

Key questions asked:

- What would you recommend to future centres/projects?
- What resources will be needed to make this happen?
- How will things be different if we get this right?

#### Groups 1 & 2

**Facilitators:** Sarah Higginson, Gesche Huebner

Roles: R, F, CL, O

Recommendations in priority order:

Priority	What?	Resources	Impact
1	Hire a data manager who does the hard work of publishing data and pay them well (for large centres)		
2	Start from the beginning with DMP		
	'Sell' DMP as being first and foremost for you / your project		
	Disseminate venues for data publishing with standard academic attributes to make them more standard		
	Review consent forms (whilst held institutionally, we can suggest modifications)		
	Copyright/ownership – create rules when you can stop owning it and pass it on		

**Group 3 & 4**

**Facilitators:** Catherine Jones , Marina Topouzi

Roles: R, P, CL, F, O, DM

Recommendations in priority order:

Priority	What?	Resources	Impact
1	Expectations to have DMPs in place early on and reflect on learning from changes over time/flexibility		
2	What are the practical things to learn from others' experience of data sharing	Make more available – the methods, tools and guidance for data sharing in practice  Make easier access to data sharing	Science could be repeatable
3	Meta data and good quality data indicators	Staff time, but have same metadata for same type of data e.g. sensor  Managing data across multiple institutes, ethics teams and collaboration agreements	

**Group 5 & 6**

**Facilitators:** Mike Colechin, Mike Fell

Roles: R, F, P, DM, O

Recommendations in priority order:

Priority	What?	Resources	Impact
1	Universities to fix workload crisis	Funding  Make institutions take seriously	Better rewarded people  Better datasets as more highly valued
2	Training to improve researcher data awareness skills (and value of data sharing)		
3	Better ability to discriminate between value of different datasets and prioritise effort accordingly		
	Clear process for data sharing throughout project (starting early and throughout data lifecycle.)		
	Clear practices across disciplines for data storage/sharing (including where to store)		
	More effective communication of what data is available (and where, especially given the multitude of places data could be stored)		
	Alternative (non-project-based) funding models for data archiving		
	Quality assurance of software used for data analysis (could undermine reproducibility) e.g. better reporting of QA processes		
	Better highlighting of value of good data practices for own future use		

## Plenary discussion

**Facilitator:** Mike Colechin

Each group provided feedback from Session 2 via their nominated spokesperson on

- Top two priority recommendations
- Resources needed to make these happen
- How would things be different if these recommendations were successfully achieved?