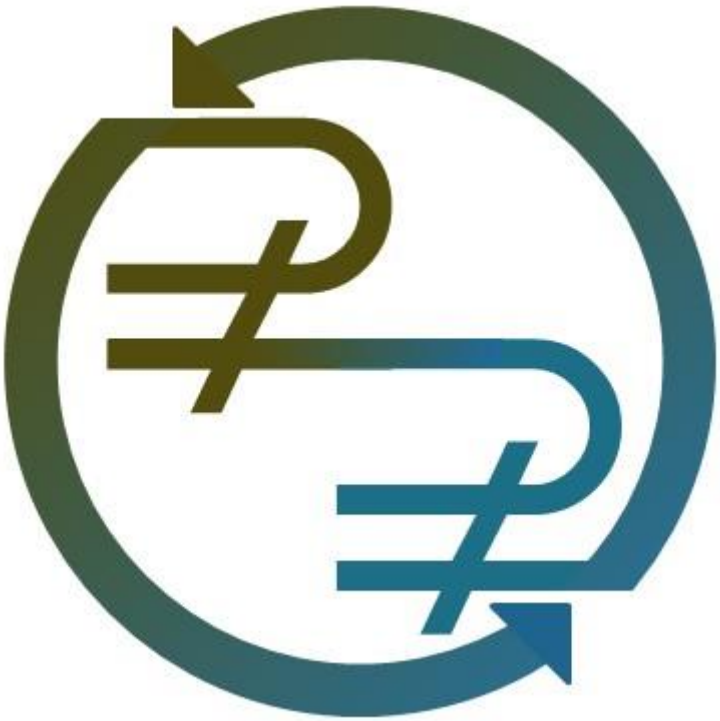
Participatory Situational Analysis

How can policy and regulation support resource recovery?

Synthesis report



RESOURCE RECOVERY FROM WASTE

Department for Environment Food & Rural Affairs

E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

Funding Declaration: This report was produced independently by Resource Recovery from Waste with funding from the Natural Environment Research Council, Economic and Social Research Council and the Department for Environment, Food and Rural Affairs.

Acknowledgements: We are grateful for the contributions made by all participants of the workshops in Belfast, Edinburgh, Cardiff and Leeds. We sincerely thank Kenneth O'Callaghan and Alan Holmes for their advice during the initiation and delivery of this project.

Please cite this report as: Velenturf, Anne P.M., Marshall, R., Suarez-Suarez, A, Christensen, Yu, E., Falagan, C., Sapsford, D., H., Gomes, H.I., Mayes, W. (2018) *Participatory Situational Analysis: How can policy and regulation support resource recovery? Synthesis workshop report.* Resource Recovery from Waste

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Resource Recovery from Waste

Executive summary

Introduction

The Resource Recovery from Waste (RRfW) programme strives to facilitate a radical change in the waste and resource management landscape in the UK. The programme envisions a circular economy that contributes to a resilient environment and human well-being. The urgency to transition towards such resource efficient, circular economy is well recognised. Realising more circular practices requires action and hence strongly increased engagement from all relevant actors (Velenturf and Purnell 2017). With that in mind, RRfW coordinates on-going engagement of actors in academia, government, and industry; aiming to articulate a vision for a circular economy, develop approaches to realise it and support its implementation.

Research within the programme resulted in the recommendation that the effective collaboration with government partners would benefit from activities which identify policies and regulations linked to specific RRfW technologies, applications and approaches. Understanding how change in the governance of waste and resource management can be achieved is vital to promote resource recovery and increase resource efficiency as part of the circular economy.

The results presented in this report arise from four workshops that took place throughout the UK in Northern Ireland, Scotland, Wales and England. Using a 'participatory situational analysis approach (see main Report Section 2.1.3)' each workshop strived to answer the question: "If we wanted to realise resource recovery in the UK, how would it be possible within our policy and regulatory context?"

Each workshop was split into two sessions with a morning session that focussed on the circular economy and RRfW vison in general, and an afternoon session concentrating on specific waste types and associated resource recovery technologies. The aim of having these two sessions was to examine both the overarching strategy required for a transition to a circular economy, and differences and overlaps in strategies required to promote resource recovery in the technical areas covered by the RRfW programme.

Therefore, each workshop had the same focus in the morning session followed by a technology specific focus in the afternoon. Table 1 summarises the wastes and technologies examined in each workshop.

Table 1: Workshop schedule.

Date	Place	Technology area
4 October 2017	Belfast	Producing soil conditioners from bioenergy residues
13 October 2017	Edinburgh	Copper recovery from distilleries' wastewater and mine drainage
22 February 2018	Cardiff	Metal recovery from wastes stored in industrial landfills and around mines, using passive leaching technology
27 April 2018	Leeds	Metal recovery from steel slag landfills

The objectives of the workshops were to:

- Identify relevant policies and regulations related to the RRfW vision and technologies.
- Identify regulatory and policy drivers and barriers to realising the RRfW vision and technologies.
- Analyse strategies/measures to overcome policy and regulatory barriers. Who in government, industry, academia or elsewhere needs to act and what do they need to do?

The results provide an insight into the perceptions of stakeholders in the field of resource recovery and circular economy across the four UK countries. Stakeholders ranged from academia, government, industry and the NGO WRAP. This report captures their insights into the diverse legislative areas that need to be integrated and aligned when aiming for a more circular economy, the ways in which policy and regulation enable this, and which particular actors need to be involved and the actions they should take.

Role and organisational activities in support of a circular economy:

The workshops attracted organisations both from within and outside the waste management sector, suggesting that resource recovery and circular economy is not just delivered by actors in that sector. Participants were also asked to describe their role and the role of their organisation in support of a circular economy (Section 3.1). As evidenced by Table 3 and Table 4 there is a high diversity in types of roles and organisations involved in resource recovery and circular economy. This provides an interesting insight into the types of jobs needed to plan for and deliver circular economy.

Cost and Benefits of Resource Recovery

The participants were asked to identify the costs and benefits associated with resource recovery and which organisation types these related to. The full results are shown in Section 3.2. **Interestingly the costs can be allocated with relative ease to particular actor types. Conversely, values are often created at a system level and/or are shared between two or more actor types. This may constrain the realisation of a circular economy.** The government needs to ensure that the organisations that carry costs associated with transitioning to a sustainable circular economy also can capture a sufficient share of the values that are created, in order to make it worth their change of practices. **The timescales of the costs and benefits were also perceived to be problematic** with companies looking for a reasonable environmental and economic return on investments in new technologies or changed practices. Doing nothing now was perceived as creating more financial value and as less risky in the short term; this barrier needs to be overcome by communicating the costs of missed opportunities due to resource recovery in the longer term.

Results of the participatory situational analysis (PSA)

Q: How did perceptions differ when comparing circular economy in general to specific resource recovery situations?

The PSA activity asked participants to consider the policy and regulation, drivers, barriers, actors and actions related to circular economy in general in the morning, and specific resource recovery technologies and approaches in the afternoon. Results for these separate sessions can be found in Section 3.3 (for circular economy and resource recovery in general) and Section 3.4 (for technology specific). In this summary, we make a comparison between the two sessions highlighting which areas participants considered important and how this differed between consideration of wider circular economy and the specific resource recovery examples. In theory, the general and rather abstract vision on resource recovery would be more open to less concrete, diffuse responses. Conversely, when discussing specific technologies, arguably the discussions had to become more particular and this could give a better insight into the practicalities of implementing resource recovery at the technology- and thereby also at the general level.

Policy and regulation:

Policies and regulations that were perceived as relating to circular economy and resource recovery in general are outlined in Table 7 in the main report. **Most legislation related to implementing the general circular economy vision fall into the area of environmental governance. Economic development and sustainable growth were also mentioned in all the workshops.** Policies and regulations relating to social aspects and innovation were only sporadically mentioned. **The results indicate that EU legislation directs national policies and regulations in all nations of the UK.** The departure of the UK from the EU offers an opportunity to revisit waste regulations and establish policy integration on resource use, energy, waste, transport and education.

There was more focus on EU level directives in the morning sessions whilst in the afternoon (Table 12) the discussion focussed on UK level policy and regulation directly affecting resource recovery technologies. **The breadth of policy areas covered was greater in the afternoon session where policy and regulation relevant to particular technologies were included** (for example agricultural policy in relation to the use of wastes on land and contaminated land regulation in discussions around industrial wastes).

Drivers

The full set of results for drivers for resource recovery/circular economy in general and technology specific can be found in Table 8 and Table 13 respectively in the main report. The drivers given most importance by participants were **a clear government strategy on circular economy, economic development strategy, building on EU legislation, tax measures to improve relative value of secondary materials, extended producer responsibility and growing demand for sustainable products by consumers.** Turning to the drivers that were most relevant for implementing technologies and applications, a broadly similar picture

emerges that prioritises **a policy and regulatory environment amenable to resource recovery, the importance of economic viability of specific innovations, creation of jobs and waste reduction.**

Barriers

The full set of results for barriers to resource recovery/circular economy in general and technology specific barriers can be found in Table 9 and Table 14 respectively. The barriers most often identified for circular economy pertained to **government leadership and strategic vision for radical change, policy and governance integration**, **regulatory barriers regarding waste definition, cross-sectoral understanding underpinning circular economy, acceptance by general public, innovation funding, and understanding the link between costs and benefits.** For the implementation of new resource recovery technologies similar barriers emerge, with the most important ones on **regulatory barriers around definition of waste and achieving end-of-waste, financial and technical challenges regarding upscaling, economic viability of resource recovery and attracting investment, and public perception**.

Actors

The full results for actors identified can be found in Table 10 (general vision) and Table 15 (specific resource recovery examples). From the workshop reports it emerged that a larger number, and more EU-level, actors were suggested in the morning sessions, and a smaller range of generally more local actors in the afternoon.

Stakeholders from across the workshops saw policy and regulation, and the actions of government bodies, as critical to increase sustainable resource and waste management in the quest for a resource efficient, circular economy. While the role of government was perceived as crucial, **other actors such as companies and industry organisations, academia and funders, general public, NGOs and media also need to play their part.**

Government needs to involve these actors in the preparation and delivery of actions towards greater circularity. Moreover, a dual-layered approach is necessary, preparing an overarching long-term strategy for realising a circular economy and embedded within that plans for types of wastes. All policy and regulation involved needs to be (re-)aligned to prevent and solve areas where legislative-, economic- or other types of conflicting interests will emerge.

Actions

The actions for realising the circular economy/resource recovery vision in general (Table 11) reflected the broad array of drivers and barriers that were identified. In the afternoons actions were more focused on specific steps that need to be taken to implement a new technology (Table 16). In the afternoons the actions were possibly better linked to actors.

To promote resource recovery in general, the most mentioned government actions covered the preparation of a non-politicised long-term industrial and environmental strategy

incorporating circular economy, and education of the general public to realise a radical cultural change regarding prosperity, ownership of things and use of recovered resources.

Actions tailored to particular sectors and wastes need to be embedded in the general approach outlined above. For example, better policy and regulation means different things depending on the sector and/or waste type; in some cases more ambitious waste/ pollution reductions targets combined with stricter enforcement and in other cases a more conversational flexible approach would render the best results. Similarly, education is broadly referenced, but the exact contents of education for the general public, industry or indeed other government departments differs from sector to sector. Resource recovery can also result in trade-offs, such as indicated in the workshops on secondary mining, where the benefits from one sector may cause negative impacts on other sectors. This is a recurring theme in resource recovery research when effects are examined at a systems level. A government framework that clarifies long-term priorities could help solve such issues and approaches assessing impacts of policies at a systems level can offer opportunities to check for unintended consequences.

Conclusions and main recommendations

As discussed at the end of the main report the following action plan can be recommended:

1. Develop a blueprint of a circular economy for the UK and a long-term strategy to realise it, integrating aspects of the Industrial Strategy, Clean Growth Strategy, 25 Year Environment Plan and the Resource and Waste Strategy. The Circular Economy Strategy needs to be developed by a cross-departmental team involving at least DEFRA, BEIS and HM Treasury. Other departments should be involved including transport and international trade where relevant and their devolved colleagues. In addition strategy development should include sector-specific government actors, specialist industry groups, industry and academics and consider the views of the general public. The strategy needs to cover all resource- and waste stocks and flows in the UK economy, and discuss how the UK will become a world leader in sustainable circular economy practices including changing consumption patterns and ownership models.
2. Aggregate data in resource and waste stocks and flows within the UK economy to underpin government policy and investment decisions. Build on the emerging initiative of the National Materials Database.
3. Prepare and deliver an education programme for the general public, both as community members and consumers. This should aim to reduce consumption of products with high primary material contents, change perceptions around the need to own products to having access to products when needed via sharing- and service based models, and inform consumers about the health and environmental impacts of using primary and secondary materials. Education should be delivered via school programmes and (social) media channels. Local authorities plan an important role in delivery but organisation and development of materials may be developed in a more cost-effective manner when centrally organised.

4. Review policies and regulations and align their contents and implementation to the circular economy blueprint and strategy. Priority areas to review are waste management and especially definition of waste (Defra) and tax on primary and secondary resources (HM Treasury).
5. Increase capacity of environmental regulators to enable enforcement but also advisory service for companies while they adapt more circular practices. This will require education for the regulators themselves to change the regulatory culture into a balanced approach to environmental risk and economic relevance. In other RRfW publications, it has been recommended that the implementation of circular economy may require a facilitative separate organisation running a Circular Economy Network. Such network can also help signposting companies to the right regulator to assess resource recovery- and other circular initiatives.
6. Fund research into circular economy technologies and business models, from blue sky research all the way to innovation funding to implement solutions within companies (UKRI).
7. Prioritise primary- and secondary (i.e. waste-) resource types, form stakeholder networks including whole supply chains representation and other relevant actors, and identify resource specific legislative challenges and solutions to be implemented by actors able to act upon them (Defra led in partnership with other relevant government bodies).

Contents

1. Introduction

1.1 Resource Recovery from Waste

The British economy is overly reliant on unsustainable production and consumption practices. The economy depends on finite resources that are consumed at a fast pace, causing the depletion of natural resources, climate change and pollution through emissions and wastes. Ecosystem services are being degraded to the extent that planetary boundaries, which indicate the safe operating space for our society, have been crossed (Rockström et al. 2009). Such environmental degradation severely impacts on human well-being overseas and in the UK (MEA 2005, Velenturf and Purnell 2017). Maintaining current production and consumption patterns violates human rights and risks destabilising the economy (OHCHR and UNEP 2012). It is of crucial importance to change our resource economy, i.e. the practices through which our waste and resource flows are organised.

The Resource Recovery from Waste (RRfW) programme strives to facilitate a radical change in the waste and resource management landscape in the UK. The programme envisions a circular economy that contributes to a resilient environment and human well-being. The urgency to transition towards such resource efficient, circular economy is well recognised. Realising more circular practices requires action and hence strongly increased engagement from all relevant actors (Velenturf and Purnell 2017). With that in mind, RRfW coordinates on-going engagement of actors in academia, government, and industry; aiming to co-produce a more desirable future, develop approaches to realise such shared vision and help to bring them into practice.

1.2 Participation Action Research

Academia can actively contribute to knowledge for, and the actual implementation of, sustainable development, resource recovery and CE through participatory action research (PAR) (Velenturf and Purnell 2017). RRfW integrated PAR approaches into the delivery of programme activities aiming to support the transformative societal changes that are necessary whilst contributing to scientific progress (Bacon et al. 2005). PAR develops through cycles of activities (Figure 1).

In preparation of the first PAR cycle, RRfW initiated an engagement strategy by analysing the network of actors involved in waste and resource management in the UK to identify key actors that could drive change, researched how these actors are learning and innovating, and designed activities to engage with them in the programme delivery.

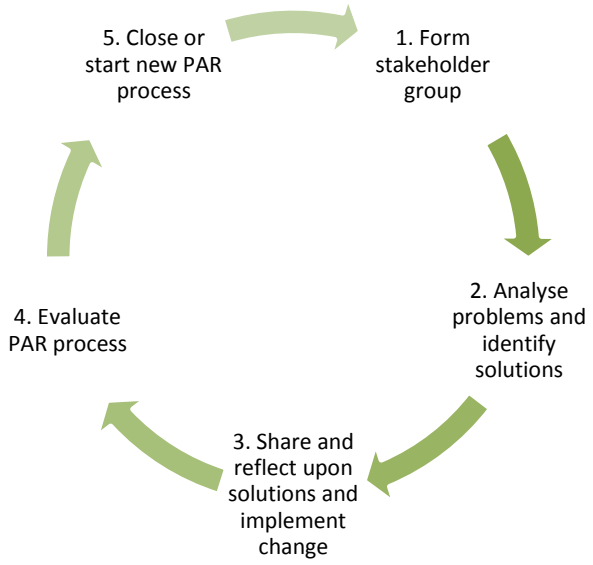

Figure 1: Participatory Action Research cycle.

The first cycle of engagement revolved around the co-production of a vision and approach for resource recovery and circular economy (Velenturf et al. 2018). This PAR cycle resulted in the recommendation that the effective collaboration with government partners would benefit from activities which identify policies and regulations linked to specific RRfW technologies, applications and approaches; researching in what way these could be realised within the policy and regulatory context; and link such analyses to solutions and recommendations explicitly to policies and regulations in a specific region. This mini-project brings these recommendations into practice in a second PAR cycle engaging people in government as well as industry, academia and other relevant organisations.

1.3 Project aim and objectives

In this mini-project a "participatory situational analysis" is carried aiming to:

1. Understand how the RRfW vision and technologies can be brought into practice in the UK policy and regulatory context.
2. Promote knowledge exchange between academic, government and industry partners to encourage uptake of research outcomes and feedback for on-going and follow-on research.

Four workshops were carried out throughout the UK in Northern Ireland, Scotland, Wales and England. Each workshop strived to answer the question: "If we wanted to realise resource recovery in the UK, how would it be possible within our policy and regulatory context?" with the following objectives:

- Identify relevant policies and regulations related to the RRfW vision and technologies.
- Identify regulatory and policy drivers and barriers to realising the RRfW vision and technologies.
- Analyse strategies/measures to overcome policy and regulatory barriers. Who in government, industry, academia or elsewhere needs to act and what do they need to do?

Understanding how change in the governance of waste and resource management can be achieved is vital to promote resource recovery and increase resource efficiency as part of the circular economy. Based on this research, policy recommendations will be formulated for governmental bodies throughout the UK.

A secondary objective of this project was to share research findings from academia with governmental, industry, and other relevant stakeholders to facilitate integration of perspectives. As introduced in section 1.2, this is considered crucially important for the continued transition towards a circular economy.

Proceedings from each workshop have been prepared (Velenturf et al. 2018 a, b, c, d). This report synthesises the results to extract overarching findings in response to the objectives above.

2. Workshop methods

2.1 Data collection

2.1.1 Workshop schedule

Four 1-day workshops were organised, each focusing on resource recovery in general and one technology or application developed within RRfW projects (Table 1). The RRfW programme includes six projects (Figure 2), five of which participated in this project:

- The AVAnD application combining the wastes digestate and wood ash with complementary nutrient profiles into one soil conditioning product.
- MeteoRR which builds bioelectrochemical systems using waste resources to recover materials such as copper as well as energy from manufacturing wastewaters.
- R3AW, B3 and INSPIRE passive leaching technologies for the targeted mobilising of metals from industrial legacy landfill sites and from mines and wastes stored around mines.

Figure 2: The Resource Recovery from Waste programme has six major research grants.

Table 2: Workshop schedule.

Date	Place	Technology area
4 October 2017	Belfast	Producing soil conditioners from bioenergy residues
13 October 2017	Edinburgh	Copper recovery from distilleries' wastewater and mine drainage
22 February 2018	Cardiff	Metal recovery from wastes stored in industrial landfills and around mines, using passive leaching technology
27 April 2018	Leeds	Metal recovery from steel slag landfills

2.1.2 Participants

For each workshop participants from academic, industry and government backgrounds were invited. In this way, this mini-project functioned as a vehicle to facilitate cross-sectoral conversations while achieving the core objectives of identifying policies and regulations, drivers and barriers within the governance system, actors who can drive change, and actions to overcome barriers and capitalise on the drivers.

The workshops were designed to remain small-scale events of up to 15-20 participants. This was meant to enable high-quality, reciprocal communication between all participants and

also with the facilitators, building on established principles of successful knowledge exchange that require personal contact (Nutley et al 2007; Harris and Lyon 2013). Existing contacts from the projects introduced in section 2.1.1 were invited and complemented with further participants with expertise in resource recovery in general and the targeted technology areas specifically (Table 1).

Invited participants received an information sheet (Appendix A) providing background information about the workshops and enabling informed consent. Consent forms (Appendix B) were signed at the workshops. Data collection, analysis and storage procedures were explained, and participants could withdraw at any moment and without explanation.

2.1.3 Activities

Each workshop followed the same design:

- 9:30 Registration
- 10:00 Welcome
- 10:15 Participant introductions
- 10:45 Participatory situational analyses RRfW vision
- 12:30 Lunch (& guest presentation in Belfast workshop)
- 13:30 Participatory situational analyses technology/ application
- 15:30 Workshop evaluation & Next steps
- 16:00 Close

Participant introductions: To enable participants to introduce themselves to each other and gauge their perceptions on resource recovery and circular economy, a poster exercise was carried out. Each participant prepared an A4 poster individually, including their name and four sections on:

- Something about their position
- Affiliation and organisation's role in waste management, resource recovery and/or circular economy.
- Most important costs associated with the uptake of more resource recovery practices.
- Most important values to be gained from increased resource recovery.

Participants wrote or drew their answers. Upon completion, they organised their poster based on perceived contribution of their organisation to a circular economy, on a continuum from linear- to circular economy on a wall in the workshop space. They were invited to read each other's posters ahead of the next exercise.

Participatory situational analyses: In the morning session a situational analysis was carried out around the RRfW vision for a circular economy. This was followed in the afternoon by the same exercise but focussing on the specific technology presented at the meeting. The RRfW vision and the technology/application was introduced by the workshop facilitator at the start

of each session. These analyses were performed in groups and comprised of the following steps:

- Write policies and regulations related to the vision or technology on post-its and organise them on large posters.
- Determine drivers and barriers and organise them in relation to the policies and regulations. Participants were asked to value the drivers and regulations in terms of importance, with 1 used to denote 'not important' to 5 being 'essential'.
- Identify actors who are responsible and/or controlling the most important drivers and barriers.
- Define actions for the actors, to overcome barriers and strengthen drivers.

Evaluation: At the end of the workshop participants were asked to complete an evaluation form with the following questions:

1. How did you rate the event? Rating format of the day, content and activities, relevance for your organisation, networking opportunities, and arrangements and organisation with a score of excellent, good, satisfactory or poor.
2. Are there any new things that you have learned today? If yes, what?
3. Are you going to change anything in your day-to-day work or organisation as a result of this workshop? If yes, what?
4. Are there any further comments that you would like to share?

The workshop concluded with a presentation of the next steps following the workshop. Immediately after the workshop the facilitators met to prepare a memo about the workshop delivery, the setting, and anything that seemed relevant to take on board during the further processing and interpreting of the data.

2.1.4 Data entry

Introductory posters: Photos were taken from each poster to turn them into images that could be analysed further; this image data will be kept within the project team only and not shared as they are not anonymised data. The position of the posters on the linear-to-circular continuum was entered in percentages in which completely linear is 0% and completely circular is 100%.

Participatory situational analyses: Data were entered into excel listing policies and regulations, drivers and their values, barriers and their values, actors and actions. Any relations between these data categories were included in comments within the respective cells and supported with photographic evidence of the poster prepared by the participants.

Evaluation: Data were entered into excel to enable analyses of the verbatim and numbered data.

2.2 Data analysis

2.2.1 Introductory posters

The objective of analysing the image data produced from the introductory posters was to understand the diversity of starting points and perceptions present in the workshop. Images were coded using literal (only in the case of words) and interpretive coding. No coding trees were developed beforehand; the coding exercise was bottom-up although directed towards preparing lists of:

- Types of organisational- and individual roles present in the workshop (Section 3.1)
- Costs of not adopting resource recovery and circular economy (Section 3.2)
- Benefits/ values of resource recovery and circular economy (Section 3.2)

The numerical data on the contribution of the organisations to the circular economy was plotted in a graph to gauge the distribution of perceptions.

2.2.2 Evaluation data

It was felt that it was unlikely to observe mentality change in the short time-span of the workshop. Hence, data were collected on indications that changes in mentality- or, even better, practice may occur as a result of the interactions at the workshop (although different theories for mentality- and behaviour change may give different weighting to the relative importance of mentality- and behaviour change – see Seyfang 2009). For each workshop, the percentage of participants reporting to have learned something new and to change a practice was calculated and detailed with the suggestions provided by the participants.

2.2.3 Participatory situational analysis

Data consisted of factors identifed under each of the areas examined in the situational analysis:

- Policy and regulation
- Drivers
- Barriers
- Actors
- Actions

Data were processed by grouping similar suggestions and counting the number of groups that mentioned a policy or regulation, driver, barrier, actor or action. In the case of drivers and barriers, if a suggestion was made more than once, then the average value (varying from 1 to 5) was calculated. More importance was allocated to suggestions that were made more than once and/or that had a higher (average) value.

Results from the PSA focussed on RRfW vision are presented in Section 3.3 and those from the technologies presented in Section 3.4.

2.3 Comparative analysis

A combined analysis of data from all four workshops was performed, with the aim to compare between:

1. UK countries: Northern Ireland, Scotland, Wales, England – based on data focussed on the RRfW vision for resource recovery in general (Section 3.3).
2. Technologies – based on data on implementing specific resource recovery technologies and applications (Section 3.4).
3. General vision for a circular economy and issues with regard to specific resource recovery technology/approaches (Section 3.5).

3. Results

3.1 Workshop participation

3.1.1 Participant types

The workshops attracted 52 participants in total: 17 in Belfast, 10 in Edinburgh, 10 in Cardiff and 15 in Leeds (Figure 3a-d). In three out of four workshops the three targeted participant types were present, representing academia, government and industry. In Edinburgh, government participants could not join the workshop. In Belfast and Cardiff there was also an NGO, adding to the diversity of participating organisation types. Table 2 shows the organisations present at each workshop. The workshops attracted organisations both from within and outside the waste management sector, suggesting that resource recovery and circular economy principles and aspirations are recognised to be of interest for actors beyond this industry.

At the workshops, smaller groups were formed with representation from all organisation types. The diverse groups facilitated discussion with input from different organisational perspectives.

Table 3: A diverse set of participants was attracted to the workshops in four countries of the UK.

	Belfast	*Edinburgh*	*Cardiff*	*Leeds*
Governmental	Belfast City Council DAERA Agri-Food and Bioscience Institute	N/A	Department for Economy, Science and Transport Natural Resources Wales	Environment Agency DEFRA Natural Resources Wales Redcar and Cleveland Council
Industry	ADBA Albion Recycling International Synergies NI Harvey Accountants Strategic Investment Board	Chivas Brothers Interface Scotch Whisky Research Industry Anonymous industry organisation	VITO	CIWM/ independent consultants CL:AIRE MPI UK
NGO	WRAP NI	N/A	WRAP Cymru	N/A
Academia	Lancaster University Questor	Newcastle University University of Strathclyde University of South Wales	KU Leuven University of Wales Trinity Saint David Bangor University Cardiff University Newcastle University	University of Leeds University of Hull University of Nottingham

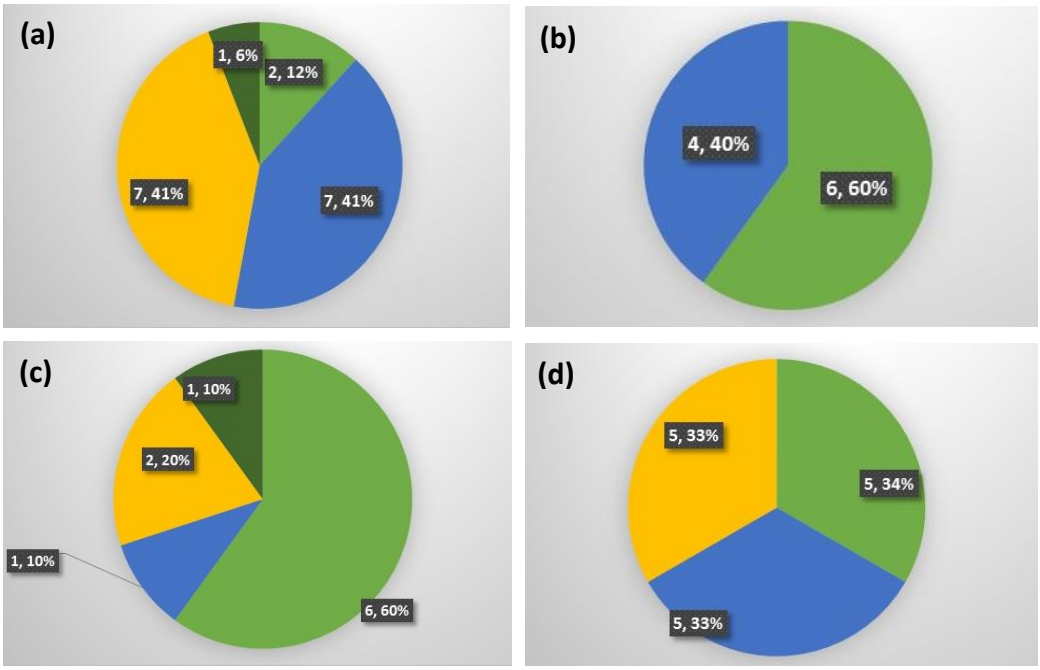

Figure 3: The workshop attracted 52 participants in total from diverse organisations in academia, business, government and NGOs (a=Belfast, b=Edinburgh, c=Cardiff, d=Leeds). Legend: yellow=governmental; blue=business; green=academia, dark green=NGO.

The workshop in Belfast was the most diverse regarding the number of organisations and participants with a relatively high representation from industry. The workshop in Leeds was a close second in terms of diversity, with 10 organisations and 16 participants evenly spread over organisation types. The Cardiff workshop was less diverse with 10 participants from 9 organisations, with high representation from academia. The workshop in Edinburgh was least diverse, although representation from industry and academia was evenly spread. Participant diversity could have impacted on the degree of learning that took place at the workshops and the resulting changes in practices. This will be further discussed in Chapter 5.

3.1.2 Individual roles

Table 3 compares the roles and activities of workshop participants in their positions. The workshops in Belfast and Leeds attracted a relatively high proportion of participants in leading positions (e.g. directors and senior management). All workshops attracted participants in delivery oriented roles i.e. those that are responsible for day-to-day delivery of R&D, consultancy and academic research projects, implementing regulations via company and other site-visits, etc. At each workshop, there were project leaders/managers and (academic) researchers. Consultants were also present at most workshops. The results suggest that there is a high diversity in types of roles involved in resource recovery and circular economy, reflecting the need for all layers of society to engage with sustainability concepts to make progress towards a circular economy. As a side note, this provides an interesting insight into the types of jobs needed to plan for- and deliver circular economy.

Research and evidence building were activities mentioned at each workshop (Table 3), as was network development to enable collaboration. Other types of actions mentioned in most

workshops included teaching and educating, business support, managing projects, policy development, and translating knowledge into practice. Further activities were lobbying government, sourcing funding and project development, and implementing government measures.

Table 4: Types of roles and activities carried out by workshop participants in their job positions.

	Belfast	Edinburgh	Cardiff	Leeds
Role types	Project leader Researcher Consultant Head of policy Team head Director Strategic adviser Waste manager	Project managers Academic researchers Consultant Knowledge exchange associate Environmental sustainability manager	Project managers Academic researchers R&D managers Government sector leads Circular economy experts	Project directors Project managers Project management Academic researchers Consultants Regulatory officers Engineers Account managers Business development managers
Action types	Provide evidence Project management Lobby Build networks Business advice Government advice Translate (inter)national- into local legislation Translate knowledge into business action Source funding	Research Teaching Lobby for sustainability Network development Business support Develop research strategy	Research Project management Teaching Network development Develop government strategy and regulation Deliver government priorities Implement technologies in industry Supply chain development	Research Deliver education Collaboration support Support planning Policy development Regulatory advice Knowledge exchange Business advice Project development Waste monitoring Develop remediation plans

3.1.3 Organisational activities in support of a circular economy

Table 4 summarises how participants described the role of their organisations in support of a circular economy.

Governmental organisations were seen to have five main tasks:

1. Develop strategies and policies for circular economy
2. Regulation, guidance and enforcement
3. Enable innovation via funding, collaboration, and exploring solutions
4. Collaborate across government bodies
5. Promote circular economy

Additionally, government bodies can play an active part in gathering evidence in support of policies, impact on circular economy via procurement, and directly play a role via waste management.

Companies and industry bodies have a few similar roles to government, although government has a more general and strategic orientation for the economy as a whole, and add more practical activities:

1. Embed circular practices within own business operations
2. Support other companies to innovate through knowledge exchange, evaluating new technologies, consultancy to enable waste valorisation and project management
3. Research and development
4. Build networks and promote collaboration
5. Promote circular economy, resource efficiency, sustainable production and the waste hierarchy

Some companies participating in the workshops also lobby the government, but this seems quite rare.

The **NGOs** focus on:

1. Supporting network development
2. Accessing grant funding
3. Developing and delivering circular economy strategy

Universities were also seen to have five main tasks:

1. Interdisciplinary, risky research into new technologies and sustainable products
2. Teaching and education on waste management, environmental standards, resource recovery and circular economy
3. Collaborate with organisations outside academia
4. Support innovation via knowledge exchange and attracting funding for projects
5. Manage projects

Moreover, universities are waste producers that need to manage their own wastes sustainably. In this way they can lead by example, similar to governmental organisations through their procurement strategies.

Table 5: Activities of participating organisations.

Actor type	Belfast	Edinburgh	Cardiff	Leeds
Govern-ment	Delivery of circular economy via regulating and enforcement actions		Implement regulations	Fulfil regulatory roles by issuing permits, ensuring compliance, sanction polluters, provide guidance and support companies in sustainable

				practices, resource recovery and circular economy
	Developing a vision and framework for circular economy Legislate		Develop policies	Develop policies and strategies
	Promoting circular economy			Promote circular economy
	Support via funding and engagement Exploring solutions for waste- and nutrient management in agriculture		Enabling innovation for new products, processes and services	Collaborate with other organisations such as universities on scientific research
			Collaborate across government	Collaborate across- and advice other governmental organisations
	Educate			
	Collection and treatment of wastes			
	Procurement in line with circular economy			
				Provide evidence for policy-making
Industry	Matching solutions and problems Supporting businesses	Evaluating new technologies ahead of implementation in industry and support knowledge exchange Co-lead and advice on industry initiatives and projects	Support other companies to realise a circular economy through waste valorisation	Disseminate scientific findings about resource extraction and recovery Communicate best practice on waste management, resource recovery and land-use Provide consultancy services Transfer technologies about land remediation and resource recovery in order to help companies create value from waste and reduce liabilities associated with waste
	Closing the loop of organic wastes with AD, in some cases combined with CHP Deliver infrastructure to meet EU requirements	Contribute directly to sustainable development Build closed loop systems for water, nutrients and other materials		
	Promoting circular economy and resource efficiency rather than waste management			Promote sustainable production, waste hierarchy and circular economy

	Building international connections	Promote collaboration		Build networks of companies
		Deliver research projects	Research	Investigate reuse of soils
				Lobby government
NGO	Development of sectoral approaches to circular economy		Deliver a circular economy vision	
			Access funding from government and industry	
	Support network building			
Academia	Research	Higher risk research into new technologies, applications and products in the subject area waste management and resource recovery – both within and outside the UK	Academic research into recycling, resource recovery, circular economy, sustainability, product development, and waste valorisation Promote interdisciplinary collaboration	Interdisciplinary research into waste management, resource recovery and circular economy
	Engagement outside universities		Transdisciplinary collaboration with companies	Collaborate and network with organisations outside academia
	Advice for companies on waste- and nutrient management	Knowledge exchange activities and engagement of industry and policy Promote innovation for resource recovery	Attract projects and funding	
	Project management			Manage research projects and programmes
		Education including aiming to change culture in favour of environmental friendly and cost-effective resource recovery	Teaching on waste management and environmental standards	Teaching in resource recovery and circular economy
			Manage own wastes	

3.2 Anticipated costs and benefits of resource recovery

Section 3.2.1 discusses the costs and section 3.2.2 the values associated with resource recovery. This data arose from the introductory exercise described in Section 2.2.3 in which participants identified costs and benefits of resource recovery. Following the data collection, the costs and benefits were allocated to different actor types: government, industry and academia. The costs could be allocated with relative ease to particular actors however benefits identified were often system level or shared between actor types. The costs can be allocated with relative ease to particular actor types. Conversely, values are often created at a system level and/or are shared between two or more actor types. This may constrain the realisation of a circular economy. The government needs to ensure that the organisations that

carry costs associated with transitioning to a sustainable circular economy also can capture a sufficient share of the values that are created, in order to make it worth their while to change practices.

3.2.1 Costs associated with adopting resource recovery practices

Table 5 summarises the costs that were communicated at the workshops in association with the uptake of resource recovery for each actor type.

Government actors face costs such as:

- Staff- and associated costs of policy- and regulatory change: from political process to policy development, communications, in some cases the associated regulatory change, and monitoring of performance.
- Costs associated with regulating such as checking compliance, project management, and end-of-waste procedures – mostly human resources costs.
- Costs of site investigation, analysis and remediation including dealing with illegal sites.
- Education to drive behaviour change in the general public.
- Local authority waste collections including provision of bins and education on source segregation.
- Funding for research projects.

For companies the costs associated with resource recovery include:

- Compliance costs, environmental management and potential costs of dealing with misdirected waste flows (sometimes the latter has to be carried in part or fully by government).
- Capital investments into new infrastructure such as grid connections, plants and equipment; at times costs to decommission obsolete infrastructure are incurred first.
- Operational expenditures on chemicals needed for the resource recovery, energy, transport; all to be offset by the value of recovered materials.
- Manage supply and demand i.e. market development, storage costs, and cost of disposal or even Landfill Tax if materials cannot be sold.
- Innovation costs on technology development, staff time, trialling and upscaling. Part of these costs are shared with academia.
- Business change costs including managing changed product specification when using secondary input materials, adapting business models, and training staff and managing their concerns.

In general, companies are looking for a reasonable environmental- and economic return on investment into new technologies. Moreover, doing nothing is less costly and risky in the short term; this barrier needs to be overcome by communicating the costs of missed opportunities due to resource recovery in the longer term.

Academia has a well-defined set of activities which have costs associated with them:

- Research into new technological development and sustainability assessment, from basic to experimental and demonstration research projects.
- Research costs for upscaling technologies including funding for industry engagement, redesigning production- and waste management systems, and supply chain development.
- Train companies in sustainable circular business models.
- Promote change in governance system.

The academic contribution on rethinking society, and proposing alternative ways forward that may or may not depend on technological progress, was underrepresented in all workshop results.

There were costs that remained unallocated. These are for example some costs that are associated with environmental implications, and there was also discussion around which actor should bear the costs of changing infrastructure (i.e. clearing the old and investing in new infrastructure). On both occasions, however, the results in Table 5 imply that industry is the first in line to carry those costs and government steps in when needed. However, existing reality in the UK appears to be in reverse order and this means significant diversion of these responsibilities from government to industry must be upon us.

Table 6: Costs associated with resource recovery per actor type

	Belfast	Edinburgh	Cardiff	Leeds
Govern-ment	Local authority collections		Provision of binfrastructure and education around source segregation	
	Staff capacity in devolved and central government: political, policy development, communications, monitoring performance			Costs of institutional- and regulatory change
	Education		Educate the general public to drive mentality change	Education for behaviour change of general public
	Regulatory costs, check compliance			Human resources and time required for project management by regulator Legislative process on end-of-waste
	Remediation legacy/ illegal sites			Site investigation and analysis

				Funding for resource recovery project
Industry	Develop solutions, technology development and upscaling Time investment	R&D for technology development, trialling and scale-up (shared with academia)		
	Planning, installation and infrastructure such as grid investment (possibly partly a cost for government) and IT systems			Capital investment into new infrastructure (plants and equipment)
	Organise material flows incl. transport and logistics Waste processing and added substances		Capital- and operational expenditures (such as chemicals and energy needed for the recovery process and transport costs thereof) for resource recovery processes (to be offset by value of recovered materials)	Process costs of resource recovery such as energy, transport Waste segregation
	Compliance		Clearing misdirected waste flows (possibly government cost if offender is not found)	Compliance costs and need to manage environmental impacts of resource recovery process
	Potential negative impact on product quality	Investment in new skills and costs to deal with fears over job losses when transitioning from linear- to circular practices		Risks of changing business models/ innovation costs
		Costs of decommissioning obsolete infrastructure (in some cases potentially shared with government)		
	Managing supply and demand, incl. market instability and storage	Risk of waste disposal if no outlet is found for recovered resources	Developing markets (shared with government)	Landfill tax
Academia		Technology development through research, costs associated with sample collection, demonstrating practical application and sustainability assessment	Basic, experimental and demonstration research projects	Research into new technologies
		Funding to translate technology into market and real world;	Scale-up costs for technological development, and	R&D and the costs of upscaling (shared with business)

	implementation into existing production systems & redesign of production- and waste management systems – trialling and scale-up	engagement with industrial partners to test technologies and develop complex supply chains.	
			Promote regulatory change Get environmental impacts onto the policy agenda
	Training companies in alternative business models other than the linear high-throughput ones		

3.2.2 Values created through resource recovery and circular economy

Table 6 offers an insight into the values that are created for various actors when resources are recovered. Before turning to discuss the values that benefit government and industry, it is first notable that no values were articulated for academia. Universities do, of course, gain something from contributing to resource recovery via funded research, uptake of intellectual property, and teaching. In the future it would be useful to clarify such values for academia, to understand why academics may want to contribute to resource recovery and circular economy.

Another notable difference from the costs discussed above are the amounts of values that could not be allocated to one type of actor in particular. In other words, everybody benefits yet nobody specifically captures the benefits generated by resource recovery. These are benefits that emerge at system level and, in some cases, pertaining to the general public such as:

- More sustainable environment, society and economy.
- Reduced impact from natural resource extraction by using less primary resources and more sustainable extraction and production processes.
- Raise awareness for circular economy and resource recovery, change public perceptions in using recovered resources, and change societal behaviour on resource consumption; i.e. presented here is a rational change process (Seyfang 2009).
- Shared knowledge and wealth in a more cohesive, resilient society.

Other values include greater food security, taking a globally leading role in resource recovery and products designed for circularity, reduced waste and more innovation.

Values that mainly benefit government include:

- Achievement of environmental targets such as reduced greenhouse gas (GHG) emissions, pollution and landfill, improved quality of soils, water and air; and the associated benefits for human health and well-being as well as preventing to violate basic human rights.
- Creation of skilled jobs.

There are also benefits in terms of avoided costs for government. The list above already implies that costs to deal with illegal waste sites can be avoided by better enforcement that includes advice to companies regarding valorising of wastes as resources. Additionally, greater resource efficiency is also a known measure to reduce carbon emissions, such as emissions associated with extraction of new natural resources. Moreover, of national importance is the provision of resource security through increased resource circularity and this avoids government costs of dealing with supply disruptions of for example critical materials for low-carbon technologies.

Some benefits can be found on the intersection of government and industry:

- Increased resource security, adding to national resilience for the whole country and lower costs and risks associated with material supplies for companies.
- Less waste which helps to achieve landfill reduction targets and lower waste management costs for business.
- Increased compliance with EU legislation.
- Investment and new business development, becoming a global example and opening export opportunities.

Benefits mostly for companies are:

- Economic benefits including cost reductions, net-value generation from wastes and new products from recovered resources, and improved competitiveness.
- Increased energy efficiency.
- More effective waste management and better production processes.
- Better reputation.
- Risk reductions for business operations.

Other benefits include improved products and new business models.

Table 7: Values associated with resource recovery per actor type

	Belfast	Edinburgh	Cardiff	Leeds
Govern-ment	Climate change mitigation/ less GHG emissions Improved soils/ nutrients (also benefits	Contribute to achieving targets on reducing environmental pollution and landfill	Reduced pollution Protecting ecosystems and safeguarding societal well-being and human rights	Healthier environment Happier people due to less waste and improved health

	companies), water and air quality			
	Jobs (created and sustained) Skills	Employment Upskilling of students/ engineers		Jobs
	Increased GVA Demonstration/ example for other regions			
Gov/ ind	Investment in high-tech	Social enterprises	Development of new industries Potential for export	New technologies and initiatives for green growth New business- and export opportunities; economic growth
	Resource security (quality and quantity at the right time and place)	Manage resource security risks	Increase resource security for high- and green-tech applications and construction materials	Greater resource security and retention of valuable materials, with the added benefit for government of national resilience and for business a lower cost on raw materials
	Responsible waste management/ less waste		Reduced landfill/ waste management costs	Reduced impact of waste treatment
	Compliance with UK and EU regulations			
				Design for reuse
Industry		Improved reputation	Reputation as ethical/ sustainable producer	Reputational benefits
	Economic benefits including reduced operating costs, improved competitiveness, established markets for products	Economic value from waste	Recover resources that have a positive economic value	Economic value of recovered resources, revenue generation
	Energy efficiency and self-reliance of business operations	Maintaining financial- and energy values of materials for as long as possible; increase energy efficiency		
		For companies involved in land management there are reduced risks as cleaner sludge is returned to land		Reduced liabilities from legacy wastes
	More effective management of resources			Process improvements
			Regulatory compliance	
			New business models	

		Better products		
Academia				
Not allocated	Public behaviour change Awareness raising	General benefit of social awareness around resource recovery and changing perceptions	Change public perception in favour of materials from waste	Change in societal behaviour becoming less consumption focussed Circular economy awareness and taking responsibility at each stage
	Resilience		Shared knowledge Shared wealth	New shared knowledge More cohesion
			Being prepared for a future in which other countries may demand products/ materials designed for circularity Being a leader in resource recovery	
	Resource conservation/ protecting natural resources		Reduced usage of primary materials and avoided impacts from mining, adopting more sustainable production processes	Reduce impact of raw material extraction
			Land remediation and making it available for other purposes	
				Increased innovation
				Waste reduction
	Food security			
	Better society/ social well-being Better environment		More sustainability with social, economic and environmental benefits in general	Greater sustainability and the creation of environmental, social and economic win-win-wins

3.3 Country comparison

Using data collected from the morning PSA session at each workshop this section compares policies, drivers, barriers, actions and actors relevant to the promotion of the RRfW vision for resource recovery. This comparison strives to untangle whether any of the UK countries are better equipped to promote resource recovery, and whether there are any approaches in any part of the UK that could be beneficially duplicated in other countries too. Analysing the linkages between the sections from policies and regulations to the drivers and barriers attached to that context, the actors in power to change it and what they should do, strengths and weaknesses are identified to inform recommendations for the governance of resource recovery.

3.3.1 Policies and regulations

Which policies and regulations related to the RRfW vision were considered relevant?

At the workshops in Northern Ireland and Scotland, participants identified policies and regulations from local up to national, UK and EU level. In Wales and England, the focus was less on local policies and regulations.

Areas of policy and regulation that were discussed were highly variable between the workshops (Table 7). The variation may be a reflection of the primary interests of the participants present at the workshop, which were related to the technologies discussed in the second half of the day. Interpreting the information presented in Table 7, it is clear and perhaps unsurprising that waste management policies and regulations were described in the greatest diversity. Related to that, circular economy was mentioned at nearly all workshops aside from England (where terms like resource efficiency and resource productivity may be preferred). Other areas of policy and regulation listed in three out of four workshops pertained to environment and water. Overall, it can be observed that most legislation related to implementing the RRfW vision fall into the area of environmental governance. Economic development and sustainable growth were also included in all workshops. Policies and regulations relating to social aspects and innovation were only sporadically mentioned.

The results indicate that EU legislation directs national policies and regulations in all nations of the UK. The departure of the UK from the EU offers an opportunity to revisit waste regulations, and the definition of waste was singled out in Leeds as a particular area where improvements could and should be made. Other EU directives are still in the process of being implemented in the UK such as the Industrial Emissions Directive, which has been embedded into the environmental permitting system but is yet to be completed with enforcement and sentencing guidelines. It was also felt that, in general, government could drive more change via voluntary agreements and economic incentives.

Participants related extended producer responsibility to corporate social responsibility and this indicates a route via which actions could be directed.

There is still progress to be made in terms of policy integration on resource use, energy, waste, transport and education. The recently developed Industrial Strategy and 25-year Environment Plan offer(ed) an opportunity for this.

Finally, it is interesting to note that human rights were not mentioned in any of the results, despite these being mentioned explicitly in the opening presentation on the RRfW vision. In Edinburgh, a co-facilitator mentioned the human rights, but the participants were explicit in their rejection regarding its suggested relevance to resource recovery and circular economy. This contrasts with the strong social convictions often expressed throughout the growth of sustainable development principles.

Table 8: Results on policy and regulation from participatory situational analysis on resource recovery in general; [in brackets] = number of groups that suggested the result if more than 1.

Policy area	*Belfast (3 groups)*	*Edinburgh (2 groups)*	*Cardiff (2 groups)*	*Leeds (3 groups)*
Waste	*Law and practice* *Enforcement regime* Regional waste management plans [2] NI Waste management strategy [3] Food Waste Regulations (NI) 2015 Waste and Contaminated Land (NI) Order 1997 Hazardous Waste Regulations 2005 Household Waste Recycling Act 2003 2020 Recycling Targets [2] Waste regulations 2011 Waste management licensing End-of-Waste classification Landfill Targets [2] (Biodegradable Municipal Waste, Local Authority Collected Municipal Waste) Landfill Tax EU Landfill Directive Waste Framework Directive [3] WEEE Directive Extended Producer Responsibility (WEEE, ELV)	Landfill (Scotland) Regulations 2003 [2] Waste (Scotland) Regulations 2012 [2] Producer Responsibility Regulations Waste Incineration Directive/ Industrial Emissions Directive EU recycling targets	Landfill tax Landfill directive [2] Waste regulation Waste framework directive Extractive waste directive Transfrontier waste shipment regulation Industrial emission directive EU directives	Plastic bag tax Landfill tax Quality protocols, End of waste criteria Extended producer responsibility [2] Waste framework directive, definition of waste [3] Landfill directive [2] WID/IED [2]
Circular economy	Circular Economy strategy NI Circular Economy Package	Zero Waste plan Scotland Circular Economy sector study on beer, whisky and fish (report) Food and drink commitment (voluntary agreement across UK groceries sector)	Toward zero waste	
Environment		One Planet Prosperity, regulatory strategy SEPA IPPC	Wales environment act Environmental protection regulation Environment Act	25 year environment plan [2] Resources and Waste Strategy Environmental protection act 1990 & Environmental Permitting regulations [3] IPPC [2]
Nature and landscape conservation			Heritage + SSSI protection	

Water	Water (NI) Order 1999 Water directive Sewage sludge directive Urban Waste Water Treatment Directive	The sludge (use in agriculture) regulations 1989 The Water Environment (Controlled Activities) (Scotland) Regulations 2011 The Scotland River Basin District (Classification of Water Bodies) Directions 2009		Water Framework Directive
Agriculture	Agricultural strategies [2] Common Agricultural Policy Nitrates Directive			
Air quality	Air quality directive			
Climate		Carbon targets		Climate change act Clean growth strategy
Renewables	*Renewable energy strategy & regulator policy*	Renewables targets		
Economic development	Invest NI/ DfE economy strategy Industrial Strategy	SEPA Sustainable Growth Agreements (with individual businesses)	Economic development plan & actions	Industrial strategy [2]
Sustainability			Well-being for future generation act [2]	
Planning				Planning fees
Innovation				UK R&D innovate funding

3.3.2 Drivers and barriers

How were policies and regulations driving and constraining the realisation of the RRfW vision?

Participants provided a long list of drivers, some of which already in place but mostly a wish-list for the future, including:

- A clear, long-term and evidence-based programme of government policy for resource efficiency and circular economy was highlighted in all workshops and was given high importance by the majority of groups identifying it. Specifically groups mentioned the need for new targets and metrics; integrated policies across government departments and the need for policies to be supported with funding. It was also noted that there is high diversity in performance towards circular economy across the UK and nations should be learning from each other.
- Reputational benefits were considered a highly important driver in 3 of the 4 workshops. This was particularly focused on corporate responsibility and the importance of public perception especially against the backdrop of increasingly critical consumers.
- Mechanisms such as taxation and incentives were highlighted in 3 out of the 4 workshops with high importance given to these areas in a number of cases. Taxation

mechanisms identified included landfill and differentiated tax rates depending on recycled content. Pull mechanisms and incentives mentioned included green procurement and minimum recycled content, end-of-use legislation and extended producer responsibility (EPR).

- Resource security was highlighted in all the workshops but the importance given to this factor was highly variable between locations. This may once again be a reflection of the background and industry the participants were selected from.
- Technological advances were considered important for enabling resource recovery and opening new business opportunities.
- Two groups identified and gave high importance to the role of strategies for economic development (i.e. the industrial strategy) in driving the circular economy and hence resource recovery.
- Data was identified as important by two groups as crucial for underpinning targets and to develop a better understanding of waste flows. More ambitious targets need to be monitored and supported by better data.
- EU legislation was considered of high importance in the Belfast and Edinburgh groups but was not mentioned in the Cardiff and Leeds workshops. The role of the EU in driving current waste legislation was mentioned and the need for resilience in legislative drivers for the circular economy after Brexit
- Enforcement was a particularly important issue in the Belfast workshop with a number of issues around waste crime identified. Increasing the value of waste could contribute to reducing waste crime but well-resourced enforcement was also considered important. Enforcement was also identified in the Edinburgh workshop but in neither of the other two.

A number of other drivers were identified by two or less groups including:

- Drive circularity via planning regulations.
- Strategy for sustainable agriculture.
- Enforcement and funding to enable this.
- Education to change consumer behaviour.
- Monetary benefits (for government and industry).
- Environmental benefits.

Funding from central government for UK nations, as well as an investment profile in line with the creation of a sustainable circular economy, was seen as crucial change needed to enable resource recovery.

Table 9: Results on drivers from participatory situational analysis on resource recovery in general; [in brackets] = number of groups that suggested the result if more than 1; drivers and barriers were rated 1-5 and reported as {(average) score}.

Theme	*Belfast (3 groups)*	*Edinburgh (2 groups)*	*Cardiff (2 groups)*	*Leeds (3 groups)*
Clear government strategy on circular economy	Clear evidence-based programme of government policy for resource efficiency and circular economy backed up by funding [3] {4.7} Targets and metrics {3}	Government CE strategy {4}	Welsh Government environmental and circular economy strategy {4}	Clear government objectives on policies {5} Leadership by government and large companies on green economy [3]{1.8}
Economic development strategy	Industrial strategy {5}		Economic development, government plan & actions {4}	
EU	Resilience after Brexit [2] {4.5} Circular Economy Directives {3} Penalties EU for UK/ NI {3}	EU legislation {4}		
Tax	Differential resource tax (levy) {4}		Increased tax and cost for landfill {1}	Economic incentives (Landfill tax, Waste Framework Directive, Innovation) [2]{4.9} Taxation {5}
Other incentives	More pull mechanisms (green procurement, recycled content) {4}		Packaging recovery notes {3}	Design of buildings and products such as vehicles {1.7} End-of-Life legislation {1.1}
EPR	Extended producer responsibility {5}		Extended producer responsibility {4}	
Legislation	Legislation {3}			Legislation {0}
Planning	Clear predictable planning regime {2}			Solar panels link to planning policy, making their use obligatory in new developments and drive resource recovery from panels, glass and metals {1.4}
Sustainable agriculture	Sustainable agriculture management strategy {4}			
Enforcement	Risk based well-resourced enforcement {4} Waste crime {4} Capacity increase {2}	Enforcement {3}		
UK collaboration				Learn policy lessons within UK – what are Northern Ireland, Wales and Scotland doing better than England {2}
Disasters				Disasters/ things going wrong drive change {1}
Data	Better data capture, part of duty of care {4} Product pass {4}			Data and targets (Barrier lack of data and targets) {2.3}

Resource security	Supply chain management {5}	Resource security {3}	Increase metal demands and resource scarcity {1}	Resource security {0}
Technological advances		Technological progress {4}	Research + technological development {4}	R&D creating new business opportunities by creating new markets {0} Innovation funding such as via Innovate UK) {0}
Monetary benefits		Commercial gains {5}		
Reputational benefits		Corporate Social Responsibility {4} Corporate Governance Committees image {2} Investor/ shareholder demands {0}	Social responsibility {3} Trust + integrity public opinion for a 'green future' {4}	Corporate social responsibility {0} Positive public perception, green consumerism in the EU [2]{2.5} Benefits of good PR from resource recovery, supporting profits {4.3} Opinion of community on corporate social responsibility {3}
Consumer vote	Community consultation, votes/ democracy [2] {4}			Public/consumer awareness, changing social attitudes [2]{4}
Education	Education {0}	Consumer education {3}		Education in schools and media {3.4}
Environmental benefits		Environmental wins [2]{3}	Environmental impact, pressure on land {2}	

A large number of barriers were identified – 24 uniquely themed barriers in total. Only half of them were brought forward in more than two workshops. Most often mentioned were:

- Lack of government leadership and strategic vision for radical change
- Complex supply chains across sectors and borders that are poorly understood
- Negative public perception of wastes and new technologies due to lack of education
- Issues with innovation funding that does not cover the full process towards market uptake
- Lack of local infrastructure capacity (leading to waste crime)
- No clear link between costs and benefits, constraining investment
- Poor data to measure resource and waste flows
- Regulatory barriers to waste status causing uncertainty for investment

Moreover, mentioned in two workshops:

- Lack of policy integration due to complicated devolved and fragmented governance structure for waste (especially in England)
- Brexit
- Limited inclusion of business in regulatory change processes
- Gaps in knowledge and technological capability
- Suboptimal mix of economic sticks and carrots for the preservation of technical value

A couple of barriers were local issues, such as challenges around the border in Northern Ireland and the overly energy-focused circular economy strategy in Scotland. For other barriers, it can be concluded from data presented in earlier sections of this report that they are unlikely to be unique to the country where they were mentioned, such as the lack of extended producer responsibility and issues around enforcement capacity.

The barrier of relatively low economic value of secondary resources was only mentioned once. This barrier has regularly been mentioned at other policy-related occasions, however, deserves further investigation as to whether it holds true. Unpublished evidence (Purnell 2018) suggests price differences between primary and secondary resources are not that significant, preference for primary stocks may be caused due to the price volatility of secondary resources and perhaps also the stability of the resource quality.

Comparing barriers and drivers suggest that there is a split in the general public which on the one hand support resource recovery with positive perceptions and raised awareness, and on the other hand constrains with negative opinion and perceived risks of using wastes in new products.

Table 10: Results on barriers from participatory situational analysis on resource recovery in general; [in brackets] = number of groups that suggested the result if more than 1; drivers and barriers were rated 1-5 and reported as {(average) score}.

Theme	Belfast (3 groups)	Edinburgh (2 groups)	Cardiff (2 groups)	Leeds (3 groups)
Leadership and strategic vision for radical change	Political mindset and leadership, low priority [3]{3.3} Poor government ambition resource efficiency and circular economy {5}	Lack of government leadership {5}	Short-terminism and short turnaround in government [2]{4} Lack of strategic thinking (vision) {4}	Lack of long-term planning through national industrial and environmental strategy that shows clear leadership rather than changing direction with every new government [2]{3.8} Complacency in public & industry & political {2} UK only strategy {2.2}
Policy and governance integration	Lack of joined up government approach [2]{5}			Lack of integrated policy development for environment, transport, health, society and economy and using waste as an opportunity {2.2} Governance structures for UK administrations {5} Governance system in England not well coordinated with too many departments and initiatives, and over- and under legislation {4}
Brexit	Brexit [2]{5}	Brexit {3}		
Cross-sectoral	Poor understanding of circular economy across sectors {4}	Complex supply chains {4} Limited knowledge of sectors producing wastes	Complexity of issue {5} Lack of transparency {3}	Part of complex international market, cheaper products with

		that could be raw materials for others {3} Production demand (output & quality) {5}		lower labour conditions/environmental standards [2]{1.6}
Public perception	NIMBYism, planning [3]{0.6}	Acceptance of new technology {5} Consumer education {3} Public attitudes {2}	Lack of education {5}	Negative public perception {3} Public/industry perceive using 'waste' in products as risk {3} Taking on liabilities of previous industries e.g. mining {3}
Business involvement regulatory change process	Lack of pragmatism in business implementation and limited business input in new regulations [2]{4}			Naive process design {3} Limited inclusivity of regulator in planning permitting process {0}
EPR	Lack of extended producer responsibility [2]{4}			
Innovation funding	Lack of government support for innovations across "valley of death" {5}	Securing finance (certainty of supply and demand) {4} Funding focus on SMEs only {3} Funding {3}	Technological challenges and government R&D funding when not ready to implement yet [2]{4}	Technology readiness level & funding for new processes and products {0} Misallocation of funds (R&D business development funds) {3}
Enforcement	Crime/ enforcement [2]{4} Government capacity decrease {0}			
Lack of infrastructure	Lack of capacity caps for right local infrastructure [2]{1.5}		Lack of proper infrastructure and illegal disposal as a result {4}	Lack of infrastructure {1.4}
Costs and benefits balance	Costs/ funding to implement circular economy [2]{3.5} Short-term target vs long-term benefit {3}		Lack of capital investment {4}	No clear link between initiatives and benefits, need for more PR to promote action [2] {4.3} Market uncertainty [2]{2.5} Cost/social effort {0}
Waste hierarchy	Lack of differential in hierarchy different EfW technologies {4}			
Data and metrics	Poor data {4} Targets and metrics {3}		Redefining waste metrics to define value {3}	Available resources for recovery not well quantified yet indications that volumes are insufficient [2]{1.5}
Regulatory barriers waste status	Differential treatment of primary versus secondary materials {4}	Regulatory demands on wastes & by-products {4}	Legislation {4}	Regulation such as definition of waste creating uncertainty for investors and limiting appetite for change [3]{3.3}
Incentives	Lack of pull mechanisms {4} Cliff-edge renewable energy incentives {3}			

Natural capital	Lack of policy in natural capital {3}			
Resource price			Economics of recovered resources vs primary resources that are cheaper [2]{4}	
Knowledge gaps		Skills/ knowledge gap {5} Technology development risk {4} Technology gaps {3}	Lack of knowledge + complex material {2} Research on substituting material {0}	
Environmental permit			Environment permitting	
Economic interest			Unethical economic interest {3}	
Economic development plans			Economic development plan & actions	Economic carrots and sticks (incentives, fines, tax) promoting preservation of technical value and renewables [2]{1}
Policy adaptation				Slow adaptation of outdated policies and regulations impeding innovation; reluctance to distort existing markets [3]{2.8}
Specific to country	Geography and border {2}	CE energy focused approach {0}		

3.3.3 Actors

Which actors were considered important to overcome policy and regulatory constraints and capitalise on the drivers?

At all workshops, a broad range of governmental actors was identified, in most cases ranging from organisations operating locally (such as local authorities) to globally (such as UN and WTO). Environmental regulators play a key role, and at most workshops, governmental departments preparing environmental policy were also listed. Other critical governmental organisations include those working on economic development, local communities, tax collection and investment. Politicians were mentioned a few times due to their potential to provide leadership to overcome barriers.

Turning to industry, companies from across supply chains need to be involved as well as trade organisations, investors, product standard bodies, technology providers, and consultancies and research institutes.

Universities need to be involved due to their ability to support innovation and teaching. The latter task should also be delivered via various other organisations such as schools.

Traditional and social media can enable the uptake of more resource recovery and circular economy practices. Additionally, communities and consumers were distinguished. NGOs such

as pressure groups and charities (e.g. WRAP) can play a part. Finally, environmental pioneers were mentioned.

Table 11: Results on actors from participatory situational analysis on resource recovery in general; [in brackets] = number of groups that suggested the result if more than 1.

Actor type	*Belfast (3 groups)*	*Edinburgh (2 groups)*	*Cardiff (2 groups)*	*Leeds (3 groups)*
Government	Government departments: DAERA [5]; DfE [3]; DfC [3]; DoF [2]; DfI NIEA [3] Regional governments, councils [3] incl. planning departments Politicians [2] BEIS UK government NI government Invest NI EU Exac committee DCs (?)	Zero Waste Scotland [2] SEPA [2] UK government Scottish government EU UN Local authorities Research councils, Innovate UK, UKRI Marine Scotland Scottish National Heritage Scottish Water DEFRA Scottish Enterprise, Highlands and Islands Enterprises	Government [2] Regulators (NRW, EA, SEPA)	Governmental departments: DEFRA [3]; Cabinet [2]; BEIS [2]; Treasury; HMRC; DCLG Environment Agency Sector specific government actors Select committees Prime Minister Secretary of State EU WTO
Industry	Industry, SMEs [3] Trade organisations (CBI, CEF, NICC, NFU) [2] Farmers Illegal waste operators	Companies [2] Investors, banks [2] Industry- and trading associations End users Product standard bodies (CEM 185) Scotch Whisky Association Scotland food and drink federation Technology companies and spin-outs	All industry such as manufacturing and waste management [2] Technology providers	Waste producers Service providers Technical industry experts Legacy industries
Academia	Academia [2]	Universities	Research & teaching organisations	Industry - academia collaboration Innovators / researchers Department for Education; National Union of Teachers; OFSTED; Schools
NGO	NGOs [2]		Non-governmental organisation, charities and pressure groups	
Media	Social media Media		Media	TV Social media
Community	Public, community [3]		Society/ communities [2]	
Consumer		Consumers		Consumers
Other		Environmental pioneers		

3.3.4 Actions

Which actions should be taken to overcome constraints and enable the realisation of the RRfW vision?

Various actions were recommended for government, including the development of a non-politicised long-term industrial and environmental strategy. This long-term planning should involve insights from sector-specific government actors as well as specialist industry groups to incorporate practical expertise, and promote collaboration between academia and industry, all to deliver on the ambition to be a global leader in this area. Moreover, the strategy should prioritise taking care of industrial wastes domestically.

Other government actions include [in brackets any actors that were associated with the actions]:

- Improve enforcement and implementation of polluter pays principle.
- Clarify/ alter the definition of waste, possibly launch a forum to develop waste standards, and apply standards consistently [environmental regulators and product standard bodies].
- Educate the general public via (social) media campaigns and school programmes, to change views on prosperity and ownership of things as well as changing attitudes to become more positive about resource recovery and teach new skills [local authorities].
- Implement differentiated tax on primary and secondary resource use.
- Enable research via funding into infrastructure research, implementation of solutions, and ease procedures to obtain trial permits; paid for from higher tax on primary resource use.
- Regulate resource recovery (not just waste management).

Companies should focus on investment and share investment risks where necessary; this action falls mainly on investors and banks in partnership with relevant governmental bodies such as Scottish Enterprise. They should manage their materials more circularly and act upon extended producer responsibility. Finally, in collaboration with academia, they need to carry out research, innovate and contribute to best practice transfer.

Academia needs to develop new ideas and technologies, gather evidence, and make this available for government and industry. Focus needs to change even more towards the implementation of solutions and development of new business models for circular economy. Collaboration outside academia is essential.

Table 12: Results on actions from participatory situational analysis on resource recovery in general; [in brackets] = number of groups that suggested the result if more than 1.

Actor type	*Belfast (3 groups)*	*Edinburgh (2 groups)*	*Cardiff (2 groups)*	*Leeds (3 groups)*
Government	Vision, ambition, encouragement at government level	Prioritise industrial waste domestically, through government strategy	Targeted policy	Non-politicised long term industrial and environmental strategy Create industry specific specialist groups & target industry groups and specific CEOs
		Regulation including recovery (not only management)		
		Increase in R&D funding for trial and application	Increase funding for infrastructure research	Relaxation of permit rules for R&D pilot trails
		Taxing (activities, waste streams, resource use)		Remove VAT or 5% VAT on recyclables
	Enforcement Polluter pays/ fines		Pay as you produce waste	Legislative changes and enforcement
	Redefining waste terminology and classification	Forum for agreement of waste product standards (to reduce regulatory burden) Re-definition of waste as a resource (standards)		Clarify definition of waste Consistent collection of waste and standards Change policy to enable reuse of legacy waste
	Education, communicate to raise awareness [2] Advocate Change societal view on prosperity/ ownership	Education for the public	Community engagement Educate	Produce materials for school, colleges to get resource issues in the curriculum Effective social media materials and use of traditional media "Attenborough effect"
Industry	Readily available finance, investment [3]	Sharing risk (investors and industry)		
			Materials management	
	Implement extended producer responsibility [2] Research and innovation Best practice transfer			
Academia	Generate and provide evidence New business models for dematerialisation	Research collaborations driving policy Focus and funding for translational technology and implementation [2]		Develop technical solutions and novel ideas Test beds to plug and play waste streams Collaboration (sand pits)
		Knowledge- and technology transfer [2] Horizon scanning		

3.4 Technology comparison

This section identifies how policy and regulation can support the implementation of resource recovery technologies and applications. It builds up the argument from listing policies and regulations in place, to the drivers and barriers attached to that legislative context, the actors in power to change it, and what they should do.

3.4.1 Policies and regulations

Which policies and regulations related to the technologies were considered relevant?

In total 13 areas of policy and regulation were identified as relevant to the implementation of technologies and applications developed within RRfW [in brackets number of workshops where the policy area was discussed]:

1. Waste management [4]
2. Environment [4]
3. Water [4]
4. Contaminated land [3]
5. Planning [3]
6. Circular economy [2]
7. Nature conservation [2]
8. Climate change [2]
9. Agriculture [2]
10. Economic development [2]
11. Health and safety [1]
12. Renewable energy [1]
13. Sustainability [1]

The diversity reflects the differences in technologies and applications discussed at the workshop. There were a couple of striking omissions, such as the circular economy- and sustainability strategies in Wales and climate change policies in relation to the use of ash and digestate covered in Northern Ireland. Most remarkable, however, is the sheer diversity of areas of policy and regulation relevant to the implementation of resource recovery, couple this to the analysed limited integration and coordination across government bodies (Section 3.3) and the scene is ideally prepared for causing bottlenecks to achieve greater circularity.

Table 13: Results on policies and regulations from participatory situational analysis on technologies and applications; [in brackets] = number of groups that suggested the result if more than 1.

Area	Belfast (3 groups)	Edinburgh (2 groups)	Cardiff (2 groups)	Leeds (2 groups)
Waste management	Collection mechanisms NI food waste regulations [2] ABPR pasteurisation/ hygienisation	Waste (Scotland) Regulations 2012 Industrial Emissions Directive	Waste framework directive (NRW + Local Authority) Strategy for mine wastes (from EA)	Landfill directive [2] Waste framework directive, Waste definition, Concerns list [2]

	Quality protocols, PAS 110, and End-of-Waste procedures [3] Waste management licensing Transfrontier shipment regulations Waste management legislation 2003 EU recycling targets		Waste management regulations, landfill regulations, end-of-waste procedures The Hazardous Waste (England and Wales) Regulations 2005 Mining waste directive [2]	
Contaminated land	Waste and contaminated land order		Contaminated land regulations	Land ownership policies, liability 'ownership' Contaminated land, land reclamation [2]
Circular economy	Circular Economy strategy (aspirational)	Circular Economy Strategy for Scotland (Making things last)		
Environment	Environmental permitting regulations & pollution control	Environmental protection policies IPPC EU Environmental quality standards	Environment Act (England & Wales) 1990, part 2A Environmental permitting regulations	Environmental permitting regulations [2]
Health and safety				HSE COSHH, Cr/chromium regulations
Nature and landscape conservation			SSSI (Natural England/ NRW), Scheduled ancient monument (heritage sites) [2] Natura 2000, habitat- and birds directive	The Conservation of Habitats and Species Regulations 2017 Habitats directive [2]
Planning	Planning regulations		Local authority planning regulations	Planning
Renewable energy	Renewables obligation RHI EU Renewable Energy Directive			
Climate change		Carbon reduction targets		Climate change act, CO_2 reduction targets
Agriculture	Nitrate and Phosphate regulations [2] Sustainable land use strategy EU fertiliser regulations	The sludge (use in agriculture) regulations 1989 [2]		
Water	Water Framework Directive [2]	The Water Environment (Controlled Activities) (Scotland) Regulations 2011 [2] The Scotland River Basin District (Classification of Water Bodies) Directions 2009	River- and basin regulations on pollution Water framework directive	Ground water regulations Water framework (WF) directive
Sustainability	Prosperity agreements			
Economic development			Economic development policies	Economic development plans

3.4.2 Drivers and barriers

How were policies and regulations driving and constraining the uptake of technologies?

Eight types of drivers that appear to be largely in place now were extracted from the suggestions captured in Table 13 [in brackets the number of workshops where the drivers were discussed]:

- Economic drivers combining anticipated resource scarcity with growing demand, and adding value to recovered resources by further processing them into products as well as government-induced incentives for resource recovery [4].
- Policy and regulatory drivers pertaining mainly to targets on waste and pollution demand-side measures were only mentioned once [4].
- Land availability, remediation and revaluing for alternative development [3].
- Reduce waste [2]; and other environmental drivers such as reduced dependency on fossil fuels, better water quality, reduced pollution, and business policies on environmental management [3].
- Job creation and maintenance [2].
- Public perception [2].
- Concerns about future generations [1].

The combination of economic- and policy and regulatory drivers offers strong incentives for resource recovery. However, government also caused barriers in terms of limited integration across departments, absence of end-of-waste panel (now reinstated) and throwing up regulatory hurdles – for example around nature conservation. The number of drivers that depend on environmental targets such as waste reduction, air- and water quality etc., suggest that ambitious government targets can drive more circularity. Education from government for the general public is also considered crucial to enable secondary mining operations.

Table 14: Results on drivers from participatory situational analysis on technologies and applications; [in brackets] = number of groups that suggested the result if more than 1; drivers and barriers were rated 1-5 and reported as {(average) score}.

Theme	*Belfast (3 groups)*	*Edinburgh (2 groups)*	*Cardiff (2 groups)*	*Leeds (2 groups)*
Economic drivers	Nutrient management in growing agrifood sector reaching peak phosphate [2]{4.5} Potential added value from export [2]{3.5} Added value of mix/ product {4} Renewables incentives {3}	Economic benefits of alternative products; Higher value products such as copper catalysts for CO_2 reduction rather than selling as raw material [2]{1.8} Anticipated future resource scarcity [2]{2}	Economic development {3} Economic importance of metals {3} Tourism "Heritage mining" + products from recovered metals {3}	Carbon credits and their trading value that may increase in the future [2]{2.5} Clean technologies creating market for vanadium {4} Economics; have to make enough money to self-perpetuate {4} Resource vanadium {3} Increase in vanadium prices {0}

Policy and regulatory drivers	Recycling policy on food waste [2]{3} Landfill tax avoidance {4} Regulators {3}	Regulation {5} Changing environmental policy {5} One Planet Prosperity, regulatory strategy SEPA (encouraging collaboration and resource efficiency without being regulatory) {3}	Pollution prevention and control [2]{5} Promote waste hierarchy (& therefore reuse/material recovery) {2}	Limits on vanadium emissions, increase environmental regulation to promote its removal [2]{1.5} Policy {5} Aggregates Levy creating demand for recovered resources (community) {0}
Job creation	Securing jobs throughout supply chain {4}			Job creation in government and industry {4}
Reduce waste	Ash collection {4}			Bulk reuse of steel slag {4}
Diverse other environmental drivers	Reduced dependency on fossil fuel fertilisers {4}	Scotch Whisky Association's environmental strategy commitments {3}	Improving water quality {4} Coastal erosion causing immediate pollution risk {0}	
Land		Limited land banks for sludge application (< 10 years) {4}	Promote remediation and revalue land [2]{2.5}	Land development {3}
Public perception		Public perception {3} Sector image & sustainability {2}	Public perception (positive) {0}	
Future generations			Protection of future generations {0}	

Turning to the barriers, in total 13 types of barriers were identified. Only 5 occurred in the majority of workshops [in brackets the number of workshops where the barrier was mentioned]:

- Waste supply security including diverse quality, data on quantities available, and means to estimate the value [4].
- Regulatory barriers for example around end-of-waste, lowering waste treatment ambitions, land classification, and biodiversity conservation [4].
- Issues around accessing investment and funding [3].
- Public perception on using wastes as resources and impacts of resource recovery processes (see trade-offs below as well) [3].
- Economic viability which can be negatively impacted by for example transport costs, value of recovered materials, and commercial risk [3].

Mentioned in two workshops:

- Environmental and economic trade-offs due to environmental risk and potential loss of tourism income when secondary mining takes place.
- Technical and economic challenges associated with scaling up.
- Policy uncertainty due to Brexit and absence of legislation.
- Knowledge gaps around technological solutions.

Four barriers were mentioned in one workshop alone, but most are not unique to the technology and/or location. Lack of joined up governance was mentioned in Section 3.3 too. Openness to change appears to be a general issue that is often mentioned in participation process management. The issue around problem ownership of legacy waste sites is a recurring issue in the decommissioning of industrial structures (Purnell et al 2018). The absence of a market for mixed ash and digestate, however, appears specific to the case of the AVAnD application in Northern Ireland.

Table 15: Results on barriers from participatory situational analysis on technologies and applications; [in brackets] = number of groups that suggested the result if more than 1; drivers and barriers were rated 1-5 and reported as {(average) score}.

Theme	*Belfast (3 groups)*	*Edinburgh (2 groups)*	*Cardiff (2 groups)*	*Leeds (2 groups)*
Waste supply security	Dash for ash, ash availability constraining upscaling [2]{5} Diluted nutrient value digestate {5} Variation in digestate type due to waste variation {1} Dry matter analysis on whole digestate "PAS 110" {3}	Inconsistency of waste stream {2}	Estimating value of industrial wastes {0}	Not knowing where the legacy slag is located exactly {3}
Secondary resource market	Lack of local market & opportunity to store and dispatch to farmers when needed [2]{4} High Nitrate and Phosphorous in soils {4} Farmer/ grower resilience/ reluctance to change [2]{4} Lack of enthusiastic champion UFU {2}			
Limited policy integration	Lack of joined up government approach, combining economic growth with sustainability [2]{4}			
Policy uncertainty			Brexit {0}	Little legislative incentive {5} Lack of policy {5}
Regulatory barriers	Regulatory hurdles [2]{3} No End-of-Waste panel {5}	Relaxed treatment standards (to be confirmed shortly) {2}	SSSI barrier to anything about mining waste {5} Keep sites as is, and promote biodiversity and indigenous species {4} Planning application (because of landscape aesthetics) {3} Regulatory & organisational complexity {3}	Regulation of vanadium emissions {3} Land classification {3} Independent auditing of success for carbon credits {3} Vanadium tolerant habitats such as particular grasses {2}

			Need redefining waste as a material {0}	
Finance	Capital investment in technology {5} Funding developments in government {3}	Funding {5}		Investment risk & time {5}
Public perception	Public perception of ash and digestate {4}		Public perception on visual impact of metal mining although not as obvious as coal and mines far from population [2]{4}	Public, recreation {0}
Economic viability	Transport {3}	Commercial risk for low TRL of technology [2]{4} Academic's communication of business case for technology {4}		Economics - if it does not make money then it will not happen {4} Scale of operation {0} Lack of economic incentive compared to need to produce steel at low cost {0}
Trade-offs			Mining chases away segment of tourism (that like it as it is) {2}	New technology creates other environmental issues {0}
Scaling up		Scale up implementation {5}	Energy cost + technology complexity, difficult to extract metals from E-tech waste {5}	
Openness to change			Openness to change {5}	
Knowledge gaps			Need mapping technologies {4}	No recognised technical solution {2}
Problem ownership				Identify who owns the legacy site, multiple owners may be responsible {3}

3.4.3 Actors

Which actors were considered important to overcome policy and regulatory constraints and capitalise on the drivers?

Results from the workshops suggest that actors from across government need to be involved in the implementation of resource recovery technologies and applications. Regulators, organisations enabling circular economy (if present in a country), local authorities, departments for environment, investment, economy, etc. There were a few differences between the workshops, since organisations relevant to a particular technology need to be involved; for example for AVAnD this includes the Food Standards Agency and for B3 and INSPIRE the Coal Authority. Especially the regulators were considered important because they were seen as empowered to change regulations and the way in which they are implemented. Whether that is the case, however, needs to be further discussed because alternative evidence suggests they are only delivering and the real source of change needs to be the associated (environmental) government department (Velenturf 2016).

For AVAnD and MeteoRR is was important to involve industry representatives from along the whole supply chain, including investors. Buy-in and acceptance from actors downstream in the supply chain are crucial in order to have a market for recovered resources. For B3, INSPIRE and R3AW this is a difficult matter since it is not always clear who is the landowner and the problem owner. Participants in the R3AW workshop did list manufacturers that may recover and use the resources. In the workshop with B3 and INSPIRE it was anticipated that companies might not play a role at all in the metal recovery from old mines and the mining wastes stored around them or from closed industrial landfills; leaving open the question which actor should take this task upon them.

Academia was interpreted to cover universities and funders. The latter was linked to being able to help to overcome barriers for upscaling and commercial risks of low TRL technologies

Other actors include NGOs (in the case of AVAnD, B3 and INSPIRE), community (B3 and INSPIRE only although probably equally relevant for R3AW), and media (only mentioned once but likely to be important for all).

Table 16: Results on actors from participatory situational analysis on technologies and applications; [in brackets] = number of groups that suggested the result if more than 1.

Type	*Belfast (3 groups)*	*Edinburgh (2 groups)*	*Cardiff (2 groups)*	*Leeds (2 groups)*
Government	NIEA/ NIEA TFS [3] DAERA, DAERA Minister [3] Department for Economy [2] Department of Finance Department for Investment NI Assembly Council planning department NI Executive HMRC AFBI NI water (regulator? Operator?) Consumer council Food Standards Agency	SEPA [2] ZWS organic waste unit Government	Government Local Authority (responsible for legacy landfills and MSW) [2] EA (metal mines) NRW (metal mines) Coal authority; "orphan mines" coal authority (coal mines) and few metal mines [2] English Heritage, CADW sites	Government PHB (?) DEFRA BEIS Treasury Cabinet office Natural England Environment Agency [2] Local authority Local partnerships
Industry	Farmers/ growers [3] AD operators and wood ash producers [3] Food processors [2] Food processors such as MOY Park [2] UFU British Retail Consortium	Distilleries [2] Scotch Whisky Association [2] Developers Enterprise companies (facilitators of interaction) Other users semiconductors and PCB companies		Landowner Industry in UK or multinational Manufacturers
Academia	NI academia	Funders (innovation grants) [2] Researchers	BGS Academics	Innovate UK, NERC and other funders

			Partnership between National Geological Society and academics	Academia in diverse disciplines (economy, psychology, sociology) [2]
NGO	Environmental NGOs		Organisations working on tourism Pressure groups	
Community			Community	
Media				Media

3.4.4 Actions

Which actions should be taken to overcome constraints and enable the uptake of technologies?

The actions are highly patchy, and none of the actions was recommended by participants in all workshops.

For government the following is suggested:

- Three out of four workshops resulted in recommendations to make the regulatory environment more amenable to resource recovery, though in very different ways:
  - "Lighter" regulation that is more flexible and involving reciprocal communication with the regulator.
  - More ambitious, i.e. stricter on emission limits and more focus on enforcement than incentives.
- Two workshops recommended incentivising local companies to recover more resources, for example via government procurement.
- Two workshops recommended to educate the general public; this is a much heard action in the results of the PSA on the RRfW vision, government narrative (Velenturf et al 2018) and business case for resource recovery (Velenturf and Jopson 2018).

The latter point deserves further discussion, especially for the recovery of resources from "Anthropogenic ores". Considerable thought was given to actions to win over communities and pressure groups in favour of metal recovery, through education, media campaigns and local jobs; and arguably it is the local authority that needs to lead on these actions. A trade-off between the benefit of a more diverse economy including secondary mining and potential decreasing mining tourism due to changes in the landscape needs to be resolved with relevant organisations, pressure groups and communities.

Similarly, currently the biodiversity and SSSI regulations create the perverse incentive that technologies that can limit pollution cannot be put into practice, and this needs to be acted upon. The Coal Authority was singled out as a potential leader to overcome barriers posed by the mine waste strategy, in favour of remediation. Moreover, the pollution risk needs to be estimated to overcome barriers posed by SSSI regulation and act upon the imminent pollution caused by coastal erosion; recovering materials can both reduce pollution and offer an opportunity for economic progress.

Various unique suggestions were put forward for government action, although none are particular to the region or technology:

- Aggregate data to inform policy. This is a known challenge, and the government is acting upon this with the National Materials Database initiative.
- Reinvest landfill tax in resource recovery (e.g. via a landfill tax fund).
- Manual to direct organisations that are interested in recovering resources from legacy sites to the right governmental organisations. This was put forward in Wales and may be a recurring issue throughout the UK.
- Streamline end-of-waste procedures. This is a recurring issue and arguably one that the Environment Agency England has acted upon.

Regarding the end-of-waste procedures, this could involve the development of new quality protocols, such as suggested for the mix of ash and digestate. However, such regulatory change is resource intensive and it needs to be assured that such approach is both appropriate given the technical considerations and justified given the potential benefits that could be achieved via such measure.

Industry was recommended to take action in the following ways:

- Three workshops mentioned that companies should investigate the potential for market uptake of resource recovery (government funded organisations offering business support could play a role here too)

Various single recommendations were shared but none appear specific to a location or technology:

- Educate other companies (producers, retailers)
- Integrate resource recovery into Corporate Social Responsibility policies
- Promote local employment in resource recovery jobs

Funding for academic research needs to be directed to translating outcomes into impacts, enabling industry and government to implement new knowledge and technology, for example via trials, KTPs, embedding technology into existing processes, and providing evidence for government policy and regulation (mentioned in three workshops). Such knowledge exchange arrangements require action from government and industry too. Moreover, academia could investigate the valorisation of recovered resources for various industries i.e. carrying out cost-benefits analysis and build the business case (mentioned in two workshops). Specific recommendations were made for secondary mining. Academics and organisations inventorying geological aspects were identified as important. Further research is needed to inventory the resources/ wastes present in existing repositories (by a consortium of Coal Authority, government and local authorities), map technologies for recovering metals (by a partnership of National Geological Survey and academia), and design smarter repositories for the future.

Table 17: Results on actions from participatory situational analysis on technologies and applications; [in brackets] = number of groups that suggested the result if more than 1.

	Belfast (3 groups)	*Edinburgh (2 groups)*	*Cardiff (2 groups)*	*Leeds (2 groups)*
Government				Data aggregation and consolidation for policy
	Adopt EU Circular Economy package Develop End-of-Waste and Quality Protocol for mix [2] Reclassification of waste as resource Ease TFS constraint across Ireland			
				Ring-fence landfill tax for investment
	Local green procurement			Support the adoption - incentivise local companies to act
	Light touch regulation, with greater flexibility and reciprocal communication [3]	How well the new technology will be regulated		Policy and regulatory environment that demands uptake (regulation enforce, not incentivise as main driver); put Vanadium on Waste Framework Directive concerns list [2]
			Write a manual that tells operators where to go when recovering resources	
	Educate community		Public education [2] Media campaign, report/documentary	
Industry	Re-education producers Educate retailer Meet CSR responsibility for sustainability			
			Local employment	
	Market assessment and development	Investigate marketing of by-products (developer may help)		If works in principle, then industrialise. Industry led.
Academia	Fund research to generate good evidence for regulator [2]	Funding to increase TRL and trials in factories KTPs Making knowledge of technology available Develop technology for up-scaling and system integration		Academic-industry collaboration for knowledge on problem, definition & solutions [2] Technology development Need more research before deciding go/no go. Applied research. Pilot studies. Social media, communication Target local MP and councils

	Improve the presentation of socio-economic case for technology Further research in increasing the value of by-products Identify other sectors to apply technology (e.g. Coal Authority mine drainage)/ Identify other copper polluting companies [2]		Cost benefit analysis
		Clarify imminent pollution risk to overcome SSSI barrier Inventory repositories (resources + wastes) Smarter design of waste repository through further research Mapping technologies for legacy industrial waste	

3.5 Comparing general and specific resource recovery implementation

The final comparison, between responses given in the morning regarding the general vision on resource recovery and in the afternoon regarding the implementation of specific resource recovery technologies, was designed into this project to grasp the different layers of thinking on realising resource recovery. In theory, the general and rather abstract vision on resource recovery would be more open to less concrete, diffuse responses. Conversely, when discussing specific technologies, arguably the discussions also had to become more particular and this could give a better insight into the practicalities of implementing resource recovery at the technology- and thereby also at the general level.

3.5.1 Policy and regulation

In three out of four workshops there were more policy and regulatory areas covered in the morning when the general vision for resource recovery was discussed than in the afternoon in the cases of specific resource recovery technologies and applications. In all cases the differences were just 1-2 policy areas in total.

There were some pertinent differences between the entries made in the mornings and afternoons though. In the case of the general resource recovery vision more entries were made about EU legislation. Given that EU legislation is transposed into policies and regulations at UK and national levels, and that those apply more directly to the implementation of resource recovery technologies throughout the UK, it is logic that the EU directives themselves were consistently less often mentioned in the afternoons.

Comparing the number of entries per policy and regulatory area in the morning and afternoon sessions, only in the workshop in Edinburgh were there significantly more areas with more

entries in the morning than in the afternoon. For the workshops in general, though, it can be concluded that the degree of detail overall was the same.

There was variation in areas that received more or less detail in the morning and afternoon. For circular economy and waste the number of entries was consistently higher in the morning than in the afternoon; this makes sense given that the afternoon focused on a particular technology and associated waste type to which many areas of policy and regulation may be less relevant. Conversely, contaminated land was only discussed in the afternoons, apparently this is not a concern for enabling resource recovery in general.

Areas of policy and regulation relevant to the particular technologies and applications were added to the array of legislative areas in the afternoons. For example, in the case of AVAnD agriculture was added, and in the case of R3AW additions were made on contaminated land, health and safety and nature and landscape conservation.

Table 18: Comparison of number of entries per policy area per workshop in the morning and afternoon.

Policy area	*Belfast*		*Edinburgh*		*Cardiff*		*Leeds*	
	AM	*PM*	*AM*	*PM*	*AM*	*PM*	*AM*	*PM*
Agriculture	3	3		1				
Air quality	1							
Circular economy	2	1	3	1	1			
Climate			1	1			2	1
Contaminated land		1				1		2
Economic development	2		1		1	1	1	1
Environment		1	2	3	3	2	4	1
Health and safety								1
Innovation							1	
Nature and landscape conservation					1	2		2
Planning		1				1	1	1
Renewables	1	3	1					
Sustainability		1			1			
Waste	18	8	5	2	8	5	7	2
Water	4	1	3	2		2	1	2
Total areas	**7**	**9**	**7**	**6**	**6**	**7**	**7**	**9**

3.5.2 Drivers and barriers

The individual workshop proceedings suggested that barriers and drivers in the morning were more long-term, broad range and general, and the barriers and drivers in the afternoon were short-term, specific and covered more depth. An attempt was made to assess this more objectively by counting the number of individual entries of drivers and barriers that are likely to apply to all sectors and wastes, interpreted as "general", or to a selection of sectors and wastes, interpreted as "specific" (Table 18). The proportion of general drivers and barriers, relative to the total number of suggestions, indicate that the suggestions in the morning were indeed more general (close to 100%). Conversely, in the afternoon only roughly half of the suggestions were of a general nature.

Comparing the nature of drivers brought forward in the mornings and afternoons, the most important ones for resource recovery in general are a clear government strategy on circular economy, economic development strategy, building on EU legislation, tax measures to improve relative value of secondary materials, extended producer responsibility and growing demand for sustainable products by consumers. Turning to the drivers that were most relevant for implementing technologies and applications, a broadly similar picture emerges that prioritises a policy and regulatory environment amenable to resource recovery, the importance of economic viability of specific innovations, creation of jobs and waste reduction.

The most important barriers for resource recovery, in general, pertain to government leadership and strategic vision for radical change, policy and governance integration, regulatory barriers regarding waste definition, cross-sectoral understanding underpinning circular economy, acceptance by general public, innovation funding, and understanding the link between costs and benefits. For the implementation of new resource recovery technologies similar barriers emerge, with the most important ones on regulatory barriers around definition of waste and achieving end-of-waste, financial and technical challenges regarding upscaling, economic viability of resource recovery and attracting investment, and public perception.

Table 19: Number of drivers and barriers that are likely to apply to all sectors and wastes (general) compared to selection of sectors and wastes (specific); noted as general/total number of suggested drivers or barriers.

	Belfast		***Edinburgh***		***Cardiff***		***Leeds***	
	AM	*PM*	*AM*	*PM*	*AM*	*PM*	*AM*	*PM*
Drivers	18/19	4/10	11/11	5/9	9/10	5/10	17/20	4/10
Barriers	21/22	7/15	15/16	5/6	16/16	6/12	21/22	7/15

3.5.3 Actors

From the workshop proceedings reports it emerged that more and more EU-level actors were suggested in the mornings, and a smaller range of generally more local actors in the

afternoons. Consistently more actors were suggested in the mornings than in the afternoons. The trend regarding EU/ global actors was less clear. In two of the four workshops, EU and/or global actors were listed for resource recovery in general but not for the technologies; in one workshop EU and global level actors were not identified at all; and in one workshop these actors were noted both for resource recovery in general and as playing a role in implementing the technology.

The initial observation that more detailed suggestions made in the afternoons than the mornings could not be explicitly confirmed. There were some differences worth noting, for example in the workshop in Belfast the way the general public was discussed changed from "community" in the morning to "consumers" in the afternoon, referring to the changing role of the general public. It was also striking that in the workshop in Cardiff, industry was not listed as playing a direct role in the recovery of resources from legacy landfills and mine tailings stored around old mines; arguably this is also an opportunity for government to take more control and initiate the recovery of resources that are of growing global relevance. In Leeds the academic disciplines required to investigate resource recovery was more detailed in the afternoon. Although the idea that suggested actors that need to be involved in the implementation of resource recovery technologies were more detailed in general, when compared to realising the proposed vision for resource recovery, could not be confirmed; perhaps the actions were more detailed.

Table 20: Number of EU and global actors compared to the total number of actors for resource recovery in general (AM) and implementing specific technologies (PM), expressed as EU and global / total actors.

	Belfast		***Edinburgh***		***Cardiff***		***Leeds***	
	AM	*PM*	*AM*	*PM*	*AM*	*PM*	*AM*	*PM*
Actors	1/28	0/22	2/28	0/10	0/13	0/12	2/26	1/21

3.5.4 Actions

The preliminary analysis from the workshop proceedings indicated that the actions listed in the morning were at times more vague, however, this was not a general trend throughout all workshops. On all occasions it was felt that the suggested actions in the mornings and afternoons were different in nature, with the actions for realising the resource recovery vision responding to the broad array of drivers and barriers that were identified, and in the afternoons more focused on specific steps that need to be taken to implement a new technology. In the afternoons the actions were possibly better linked to actors.

To promote resource recovery in general, the most mentioned government actions covered the preparation of a non-politicised long-term industrial and environmental strategy incorporating circular economy, and education of the general public to realise a radical cultural change regarding prosperity, ownership of stuff and use of recovered resources. Other actions to realise resource recovery and an increasingly circular economy need to fit

into the overarching vision, and in practice need to become more aligned such as in the case of the definition of waste.

Actions tailored to particular sectors and wastes need to be embedded in the general approach outlined above. For example, better policy and regulation means different things depending on the sector and/or waste type; in some cases more ambitious waste/ pollution reductions targets combined with stricter enforcement and in other cases a more conversational flexible approach would render the best results. Similarly, education is broadly referenced, but the exact contents of education for the general public, industry or indeed other government departments differs from sector to sector. Resource recovery can also result in trade-offs, such as indicated in the workshops on secondary mining, where the benefits from one sector may cause negative impacts on other sectors. This is a recurring issue, see for example the case study on pulverised fly ash by the CVORR team (Millward-Hopkins et al 2018), with effects emerging at systems level. A government framework that clarifies long-term priorities can help solving such issues and offer a coherent pathway forward across all countries in the UK, for example, if there is indeed evidence for a trade-off between secondary mining and tourism – is it more important to have resource security for renewable technologies or should we prioritise heritage mining tourism?

4. Conclusions

This project set out to answer the question: How can policy and regulation promote resource recovery in the UK? Understanding how change in the governance of waste and resource management can be achieved is vital to promote resource recovery and increase resource efficiency as part of the circular economy. The results have provided an insight into the diverse legislative areas that need to be integrated and aligned when aiming for a more circular economy with increasing resource recovery, the ways in which policy and regulation enable this, and which particular actors need to be involved and the actions they should take in order to realise an increasingly circular economy.

The first observation is that policy and regulation, and the actions of government bodies, are critical to increase sustainable resource and waste management in the quest for a resource efficient, circular economy. While the role of government is crucial, other actors such as companies and industry organisations, academia and funders, general public, NGOs and media also need to play their part. Government needs to involve these actors in the preparation and delivery of actions towards greater circularity. Moreover, a dual-layered approach is necessary, preparing an overarching long-term strategy for realising a circular economy and embedded within that plans for types of wastes. All policy and regulation involved needs to be (re-)aligned to prevent and solve areas where legislative-, economic- or other types of conflicting interests will emerge.

Taking the results into account, the following action plan can be recommended:

1. Develop a blueprint of a circular economy for the UK and a long-term strategy to realise it, integrating aspects of the Industrial Strategy, Clean Growth Strategy, 25 Year Environment Plan and the Resource and Waste Strategy. The Circular Economy Strategy needs to be developed by a cross-departmental team involving at least DEFRA, BEIS and HM Treasury, involving other departments such as transport and international trade where relevant and their devolved colleagues, sector-specific government actors, specialist industry groups, industry and academics and involve views of the general public. The strategy needs to cover all resource- and waste stocks and flows in the UK economy, and discuss how the UK will become a world leader in sustainable circular economy practices including changing consumption patterns and ownership models.
2. Aggregate data in resource and waste stocks and flows within the UK economy to underpin government policy and investment decisions. Build on the emerging initiative of the National Materials Database.
3. Prepare and deliver an education programme for the general public, both as community members and consumers, to reduce consumption of products with high primary material contents, change perceptions around the need to own products to having access to products when needed via sharing- and service based models, and inform consumers about the health and environment impacts of using primary and secondary materials. Education should be delivered via school programmes and (social) media channels. Local authorities plan an important role in delivery but

organisation and development of materials may be developed in a more cost-effective manner when centrally organised.

4. Review policies and regulations and align their contents and implementation to the circular economy blueprint and strategy. Priority areas to review are waste management and especially definition of waste (Defra) and tax on primary and secondary resources (HM Treasury).
5. Increase capacity of environmental regulators to enable enforcement but also advisory service for companies while they adapt more circular practices; this will require education for the regulators themselves to change the regulatory culture into a balanced approach to environmental risk and economic relevance. In other RRfW materials, it has been recommended that the implementation of circular economy may require a facilitative separate organisation running a Circular Economy Network (Marshall et al. 2018). Such network can also help signposting companies to the right regulator to assess resource recovery- and other circular initiatives.
6. Fund research into circular economy technologies and business models, from blue sky research all the way to innovation funding to implement solutions within companies (UKRI).
7. Prioritise primary- and secondary (i.e. waste-) resource types, form stakeholder networks including whole supply chains representation and other relevant actors, and identify resource specific legislative challenges and solutions to be implemented by actors able to act upon them (Defra led in partnership with other relevant government bodies).

Project outcomes will be converted into an open access scientific publication. The report will be shared with relevant government bodies, the implementation of recommendations depends on numerous factors and not least on the relative costs and benefits of each one. A business case for government intervention needs to be evident.

5. Workshop evaluation

5.1 Impact

Participants completed an evaluation for at the end of the workshop. They reported whether they learned something new and whether they would be changing any practices as a result of the workshop. The evaluation had the dual purpose of researching whether the workshop format and diversity of participants had an effect on the achieved impacts, and to report the impacts for monitoring purposes for RRfW.

5.1.1 Learning points

All participants reported to have learned new points in the workshops in Edinburgh, Cardiff and Leeds, and 92% of participants in Belfast reported to have picked up something new. This is a high percentage in all workshops.

At all workshop the participants reported to have learned new things about the specific technologies that were discussed (Table 20). Associated with these, participants listed to have a better understanding of the technology-specific challenges regarding the market- and policy and regulatory context. Moreover, they gained a better understanding of the general challenges regarding circular economy; and in some cases also mentioned benefits of adopting circular economy practices. They learned about the actual policies and regulations. Importantly, they got a first-hand experience about the organisations that need to be involved in the transition towards greater circularity; and the different views of circular economy that need to be aligned when negotiating change. Other points pertained to learning about likelihood that government approaches will change in the future, industry initiatives, the importance of inter-disciplinary research in the subject area of circular economy and an appreciation of the workshop model.

Table 21: Learning points listed by participants after the workshop.

	BELFAST	***EDINBURGH***	***CARDIFF***	***LEEDS***
	92%	*100%*	*100%*	*100%*
UNDERSTANDING TECHNOLOGIES	Understanding research into AD and available applications for digestate, AD technology and soil management	Understanding of a new technology Understanding potential change in copper discharge	Understanding of landfill mining and the opportunity for metal recovery from legacy wastes in addition to recovery from collected wastes.	R3AW project details on vanadium recovery and characteristics Previous studies done including potential values from future innovations New ideas to promote resource recovery
CHALLENGES		Understanding the challenges for circular economy, especially in	General understanding of the	Industry perspectives and challenges around steelworks legacy

		the case of the whisky industry	complexities around circular economy. Appreciation of heritage and SSSI protection preventing metal recovery from legacy waste repositories.	pollution and for industry to become more sustainable Economics of vanadium recycling from steel slag and the need for the process to become profitable
BUSINESS BENEFITS	Benefits of circular economy for business			Drivers and barriers to resource recovery
UNDERSTANDING POLICIES AND REGULATIONS	Understanding policy and regulation around end-of-waste, agriculture, drivers and barriers, and circular economy approaches	Policies and regulations impacting on distillery	Insight into the many regulations, national laws and European directives in relation to circular economy and human rights. The importance of waste protocols.	
NETWORK INSIGHT	New contacts, a sense of support through shared troubles, and insight into the network of organisations involved	Range of organisations that need to be involved in change and their perceptions on circular economy General awareness of linkages in the supply chain for resource recovery	Insight into the actors involved in resource recovery and the importance of collaboration between different sectors of society.	
UNDERSTANDING CIRCULAR ECONOMY		Aspects of circular economy in general and for distilleries in particular		Better understanding of resource recovery and circular economy, and perspectives on this from other organisations and their roles
OTHER	Industry initiatives		Potential for- and willingness of changing the government approach to recycling. Appreciation of the workshop model of Drivers / Barriers / Policy/ Actors / Action.	Need for additional social, economic and political input into the RRfW programme

5.1.2 Changing practices

The workshop motived considerable proportions of delegates to initiate changes in practices. The highest proportions were reported in Belfast and Cardiff (76% and 70% respectively). In Edinburgh the percentage was lower at 50%, which may be either due to the advances already made in the transition towards circular economy or because the technology that was discussed is still in the early stages of technology readiness. The low technology readiness level of the application discussed in Leeds resulted in a low proportion of actors that could start to change practices (36%).

The types of actions listed by the participants was more diverse than the learning points discussed in the preceding section (Table 21). Actions pertained to adapted communication and network activities, rethinking who should be involved, at what time and through which communication means. In general, it was clear that networks should be broadened. That also went for research strategy and collaboration, which may require a broad range of local stakeholders. New collaborations were also suggested for supply chains within which new resource recovery technologies would be embedded. Other actions were aimed at student education, inventorying and dealing with barriers and benefits for resource recovery innovations that go beyond finance alone, facilitating uptake of circular economy practices in industry, developing a new guideline for soil recovery, and using the workshop model in another research project.

Table 22: Actions suggested by participants as a result of the workshop.

	BELFAST	***EDINBURGH***	***CARDIFF***	***LEEDS***
	76%	*50%*	*70%*	*36%*
COMMUNICATION & NETWORK	Timely engagement of regulator and, vice versa, government to facilitate dialogue with more actors Expand- and make better use of network	Think about actors that need to be contacted to address a circular economy problem	Develop a better vision and integrated strategies, to strengthen communication to colleagues, public- and policy makers – especially on metal pollution.	Communicate the environmental benefits of resource recovery
RESEARCH STRATEGY & COLLABORATION	Search for local solutions	Take a wide outlook when developing research strategy	Explore new line of research.	
SUPPLY CHAIN	Better information and support for clients. Collaborate with retailers to use digestate in production of food for people	Broaden the range of industries involved in research project to cover more processors and users of copper		Discuss resource recovery in steel sector and with relevant government bodies

OTHER	Start reviving initiatives to facilitate industrial symbiosis	Introduce more learning materials on waste recovery and resource conservation into undergraduate courses	Look into developing a soil protocol for recovered soils from construction excavation. Use workshop model. Investigate other values in addition to purely financial benefits.	Work on the barriers for industry to adopt new resource recovery practices

5.2 Diversity effects

The workshops were designed to attract a small but highly diverse audience to create a context within which people could discuss resource recovery and specific technologies in sufficient depth to enable learning and change. Here we evaluate whether more diversity resulted in more effective learning and behaviour change. Diversity can be measured in terms of the number of participants, organisations and types of organisations represented at the event. Section 3.1.1 identified the workshop in Belfast as the most diverse and was followed closely by Leeds, and then Cardiff and Edinburgh (summarised in Table 22).

Table 22 compares the participant diversity to the degrees of learning and suggested changes enabling resource recovery. There is no clear pattern associating higher diversity with more learning and change. The most diverse workshop (Belfast) did result in the highest proportion change but learning was slightly lower than the other workshops. The second most diverse workshop resulted in the lowest degree of behaviour change and this may be due to the low technology readiness level of the discussed application, combined with an unambitious policy context regarding resource recovery. This was interesting, because a similar type of technology was discussed in Cardiff, yet reported actions that suggest a far higher potential for behaviour change in favour of circular economy. This may be due to the participants in Cardiff being more general- and internationally oriented. For them, the workshop offered an excellent opportunity for networking and gaining insight into the type of research carried out by universities in Wales. The small scale of the workshop enabled effective development of ideas along a broad spectrum. In Edinburgh the limited diversity of the types of organisations, missing the government actors specifically, resulted in less effective identification of actions in the transition to the circular economy. Participants put much emphasis on government action and, in the absence of governmental organisations, the negotiating of the roles and responsibilities of various types of actors (who controls what in the circular economy transition) may have been less effective.

Table 23: Comparison of diversity indicators and degrees of learning and suggested change in circular economy practices at the workshops.

Workshop	*Diversity-ranking*	*Participants*	*Organisations*	*Organisation types*	*Learning %*	*Behaviour change %*
Belfast	1	17	11	4	92	76
Leeds	2	16	10	3	100	36
Cardiff	3	10	9	4	100	70
Edinburgh	4	10	9	2	100	50

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Appendix A: Participant information sheet

Participatory Situational Analysis

How can policy and regulation support resource recovery from waste?

This project is part of the Resource Recovery from Waste programme, funded by the Natural Environment Research Council, Economic and Social Research Council, and the Department for Environment, Food and Rural Affairs. Resource Recovery from Waste strives for a circular economy that contributes to a resilient environment and human well-being.

Workshop locations

Project aims and objectives

This mini-project aims to promote knowledge exchange between people in academia, government and industry to enable you to access research outcomes and shape our on-going work.

We will organise four workshops throughout the UK (see map on the right). At the workshops you will find out about the Resource Recovery from Waste vision and approach for the transition towards a circular economy, which is co-produced by academia, government and industry. You will also get insight into our environmental technologies, aiming to recover valuable resources from legacy landfills, bioenergy wastes and by-products, industrial wastewater, road dust and more.

Each workshop strives to answer the question: "If we wanted to realise resource recovery in the UK, how would it be possible within our policy and regulatory context?" We will ask for your knowledge and experience to carry out a policy analysis, identifying drivers and barriers for resource recovery in general and for specific technologies, and identify which actors could drive required changes in the policy and regulation landscape.

Understanding how change in the governance of waste and resource management can be achieved is vital to promote resource recovery and increase resource efficiency as part of the transition towards the circular economy. Based on this research, we will formulate policy recommendations for governmental bodies throughout the UK.

Workshops: Four 1-day workshops will be organised, each focusing on one technology area. To find out more and sign up for one of our workshops, please contact Anne Velenturf using the details below.

Date	*Place*	*Technology area*
4 October 2017	Belfast	Producing soil conditioners from bioenergy residues
13 October 2017	Edinburgh	Copper recovery from distilleries' waste water and mine drainage
22 February 2018	Cardiff	Metal recovery from legacy landfills using passive leaching technology
27 April 2018	Leeds	Metal recovery from steel slag landfills

Project team

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Additionally, the project benefits from two independent advisors Ken O'Callaghan and Alan Holmes.

Data collection, analysis, storage and dissemination of results

Data collection and consent: Data will be collected through written workshop materials and notes. Written consent is sought from participants during data collection (a consent form will be provided); signed consent forms will be kept by Anne Velenturf, the principle investigator of this project, at the University of Leeds. We will keep your responses confidential. While the researchers will maintain confidentiality, we cannot promise this on behalf of other participants but do request all participants, including yourselves, to respect your own and other participants' confidentiality.

Withdrawal: Please contact Anne Velenturf using the contact information below if you have any concerns regarding this study or if you wish to withdraw. You have the right to withdraw from this study at any time without prejudice and without providing a reason. In the event of withdrawal from the study, we will make every effort to retrieve the information provided by you; bearing in mind most data will be collected through interaction with other participants whose data will be retained.

Data analysis: Anonymised data will be accessible to members of the research team (Anne Velenturf, Ana Suarez, Henriette Christensen, Helena Gomes, Carmen Falagan Rodriguez, and Rachel Marshall) for data analysis.

Dissemination of outcomes: All project outcomes will be fully anonymised. With your permission, the name of your organisation, institution or company may be mentioned in the outcomes, which will include workshop reports and may also include peer reviewed publications, conference presentations, and written and spoken government advice.

Data storage: Anonymised data will be offered for storage at the EIDC http://eidc.ceh.ac.uk/, as recommended by our main project funder NERC. Metadata including a description of the dataset will be visible to researchers, this excludes insight into the actual data collected from you. Fully anonymised data will be available for reuse by other researchers, pending an access procedure including their agreement to preserve confidentiality of the information as agreed in this study.

Contact and further information

Find out more about Resource Recovery from Waste on our website or connect to us on Twitter, LinkedIn and ResearchGate. We welcome any questions, ideas and comments, for the programme overall and this mini-project in particular. Please contact the principle investigator Anne Velenturf by mail or telephone, using the contact details on the right.

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Resource Recovery from Waste

Appendix B: Consent form

Consent to take part in: Participatory Situational Analysis

How can policy and regulation support resource recovery from waste?

	Please tick if agreed
I confirm that I have read and understand the information sheet dated 7 September 2017 explaining the above research project and I have had the opportunity to ask questions about the project.	☐
I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason and without there being any negative consequences. In addition, should I not wish to answer any particular question or questions, I am free to decline.	☐
I give permission for members of the research team, as introduced in the information sheet, to have access to my anonymised responses. I understand that my name will not be linked with the research materials, and I will not be identified or identifiable in the report or reports that result from the research.	☐
I understand that my responses will be kept strictly confidential. While the researchers will maintain confidentiality, we cannot promise this on behalf of other participants but do request all participants, including yourselves, to respect the confidentiality of your and other participants' participation.	☐
I give permission for my organisation, institution or company to be named in the project outcomes.	☐
I agree for the data collected from me to be stored and used in relevant future research in an anonymised form.	☐
I understand that other genuine researchers will have access to this data only if they agree to preserve the confidentiality of the information as requested in this form.	☐
I understand that other genuine researchers may use my words in publications, reports, web pages, and other research outputs, only if they agree to preserve the confidentiality of the information as requested in this form.	☐
I understand that relevant sections of the data collected during the study, may be looked at by individuals from the University of Leeds or from regulatory authorities where it is relevant to my taking part in this research. I give permission for these individuals to have access to my records.	☐
I agree to take part in the above research project.	☐

Name of participant	**Date**	**Participant's signature**
Name of researcher	**Date**	**Researchers' signature**