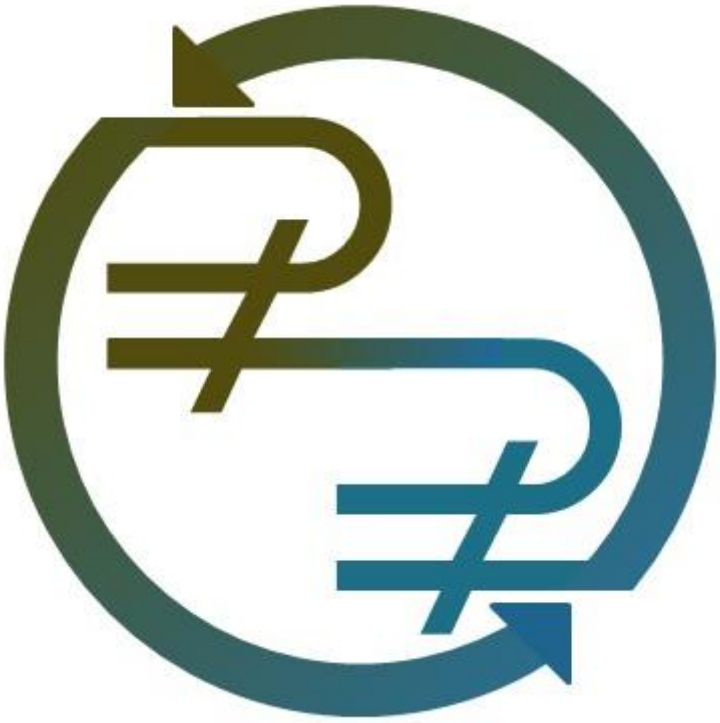
Preliminary analysis

Delivering Radical Change in Waste and Resource Management: Industry Priorities



RESOURCE RECOVERY FROM WASTE

Department for Environment Food & Rural Affairs

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

NERC SCIENCE OF THE ENVIRONMENT

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1. Introduction

Our current dominant operational model for the use of raw materials, components and products follows a linear 'take – make – use – dispose – repeat' (TMUDR) pathway that induces two environmentally deleterious consequences. First, it causes unsustainable depletion of finite natural resources, disrupting ecosystem services and storing up associated economic and social risks for the future as resources become scarce. Secondly, it produces ever-increasing quantities of waste that natural ecological processes cannot neutralise, requiring the application of technical processes – waste management – to prevent short-term damage to human health and longer term damage to the environment that supports life (Velenturf and Purnell 2017a). Overexploitation of resources and environmental pollution have direct adverse effects on basic human rights. The rights to water, food and health, and thus the right to life in general, are all affected both by resource depletion (which renders access to these resources inequitable as prices rise or hoarding takes place) and pollution (which either directly renders existing resources unfit for human use, or indirectly impinges on personal safety and security by changing climates, water flows or land use).

The speed with which we have simultaneously depleted and polluted the environment in the last century have led some investigators to suggest that we are severely breaching the safe long-term operating space for humanity. Rockstrom et al. (2009) and Steffen et al (2015) define this operating space in terms of nine planetary boundaries and conclude that as a species we have breached four of these; specifically, those associated with climate change, biosphere integrity, biogeochemical loading, and land system change. Action is urgently required to adapt or transform our operational model in order that we can return our activities to within this operating space. Since the current operational model is inextricably linked to our dominant economic paradigm (i.e. growth through consumption, disposal and new consumption) the way in which resources are organised, managed and distributed within society, we must adopt a new economic model. The circular economy is frequently suggested as a potential ideal organisation of production, consumption and waste systems. Although variously defined, the essence of the circular economy is that technical materials and products should be designed such that they and/or their components can be easily reused and recycled with the minimum additional energy input, preserving their functional value for as long as possible. Biological materials should be non-toxic and compostable and their use prioritised over synthetic materials except where the functional benefit of using them outweighs the environmental cost (Purnell et al 2018). This requires not only waste management and recycling innovation, but also changes in product design, for example using a minimum number of materials, ensuring products can be easily disassembled and refurbished, and labelling recyclable materials clearly, as well as changes in business models, for example prioritising provision of service via leasing over purchase of goods (Ellen MacArthur Foundation 2017, Purnell 2017).

Nonetheless, during the transition towards a circular economy in which wastes are effectively eliminated, a radical rethink of how we recover resources from waste (rather than just prevent it from polluting the environment) is required. Resource Recovery from Waste (RRfW) is an academic research programme envisioning a circular economy that makes a positive contribution to a resilient and healthy environment, with benefits for people such as reduced air pollution and employment opportunities, and clean economic growth (Velenturf and Purnell 2017a, Velenturf et al 2018a). The programme aims to facilitate radical change in waste and resource management in the UK by

establishing the much-needed relations between the goal of a circular economy and the sustainable development of waste management technology, systems, policy and business models that will be required to get there. As well as carrying out technical and policy research, the programme works at co-creating research questions and potential interventions in the waste management system with other academics, governmental and industrial stakeholders. This paper is one of series that presents the results of these co-creation activities (Velenturf and Purnell 2017a, Velenturf et al 2018a). In these activities, the RRfW programme uses the simplified definition of a circular economy set out by the Waste and Resource Action Programme (WRAP) *"…an alternative to traditional linear economy (make, use, dispose) in which we keep resources in use as long as possible, extract the maximum value from them whilst in use, then recover and regenerate products and materials at the end of each service life"* (WRAP 2016).

The adoption of circular economy principles is given as an objective by many governmental and industrial actors throughout society. The EU has published an *Action plan for the circular economy*, and China passed the *Circular Economy Production Law* back in 2009; the potential social and economic benefits they are intended to promote (in addition to the obvious environmental advantages) include job creation, materials security, competitiveness, and raising resource utilisation and efficiency rates. London, New York and Tokyo have published similar strategic aims. The Ellen MacArthur Foundation website publishes a list of "*CE100*" industrial partners who are committed to the circular economy agenda. For example, Apple aims to implement a closed-loop supply chain, Ikea have committed to becoming a zero-waste business, and Unilever's innovation process is now based on circular economy principles. Many of these businesses cite improving the security of the materials supply chain as a key driver (Purnell et al 2018), recognising that actions which design wastes out of the economy and recover resources at end-of-use reduce resource inputs and improve the functional intensity with which materials and products are used.

Despite these good intentions, the global economy was estimated to be only 6.5% circular in 2005 (Haas et al 2015). Socio-economic growth (generally measured using such metrics as increase in GDP) is, in a TMUDR paradigm, associated with the continued accumulation of materials in physical infrastructures (including waste repositories such as landfill) and products, and the amount of resources stored in the technosphere has increased by 23 times in the 20th century (Krausmann et al 2017). Global resource use and trade have accelerated, and more material input is required to generate a unit of GDP; i.e. we are becoming less, not more, resource efficient (UNEP 2016). Material demand has been driven by growing consumption; this is more intense in richer countries which consume materials and resources mined and processed in less economically developed countries; thus, wealthy nations have been able to offshore the negative social and environmental impacts associated with production (UNEP 2016). While governments around the world are increasingly concerned with resource and waste management (Purnell et al. 2018), and half of CEOs globally considering to adopt circular practices (UN Global Compact and Accenture Strategy 2016), clearly more concerted action is required to deliver on sustainable consumption and production (UN 2015).

It is undoubtedly clear that more collaboration is required to align the incentives of academic researchers, government policy, industrial and commercial operations, and public attitudes and behaviours, in order to deliver a circular economy. Numerous coordinated interventions across the supply chain – not just 'end of pipe' innovations at the waste management stage – must be designed

and implemented if we are to reap the purported social, economic and environmental benefits of the circular economy. The RRfW programme catalyses collaboration between actors in industry, government and academia in order to co-produce not only visions of a desirable future but also the practical steps that need to be taken to synthesise scientific, technological, policy and business innovations into practical actions. This paper presents the results of our engagement with industrial actors, complementing our previous work with academic and governmental stakeholders (Velenturf and Purnell 2017a, Velenturf et al 2018a). It aims to capture perspectives from across several industries with an interest in UK resource and waste management. The objectives are to identify, categorise and priorities themes, barriers, opportunities and actions that can communicate and deliver radical changes in the sector.

Section 2 introduces the methods adopted for the co-creation process, including an industry focused workshop and survey. The results are presented in Section 3, detailing what an ideal circular economy would look like from the perspective of industry, the most important barriers they encounter and the drivers for changing business practices. Section 3 concludes with actions suggested for industry, government, academia and other organisations. In the discussion in Section 4 we reflect upon the results and compare them to the previous co-creation results from academia and government. Section 5 concludes the report, summarising the main findings and the next steps.

2. Methods

2.1 Co-creating a Vision and Approach for a Circular Economy

The Resource Recovery from Waste (RRfW) programme coordinated a co-creation process to formulate a shared vision, and approach to realise it, for sustainable waste and resource management in the UK (Resource Recovery from Waste 2016). The reasoning for adopting a participatory action research approach that underpins the co-creation process has been published separately (Velenturf and Purnell 2017a). Academic, government and industry contacts of RRfW have been engaged during the co-creation process which consisted of four steps (Figure 1):

1. Initial vision formulated within academic RRfW team (published in Velenturf and Purnell 2017a)
2. Developed vision and approach with governmental organisations (published in Velenturf et al 2018a)
3. Developed vision and approach with industry contacts (presented herein)
4. Prepare shared vision on waste and resource management in the UK (in preparation)

The first two steps of the co-creation process have been completed and focused increasingly on circular economy (Velenturf and Purnell 2017a, Velenturf et al 2018a). This article presents the results from the third step. Industry was engaged through two activities: a workshop and online survey.

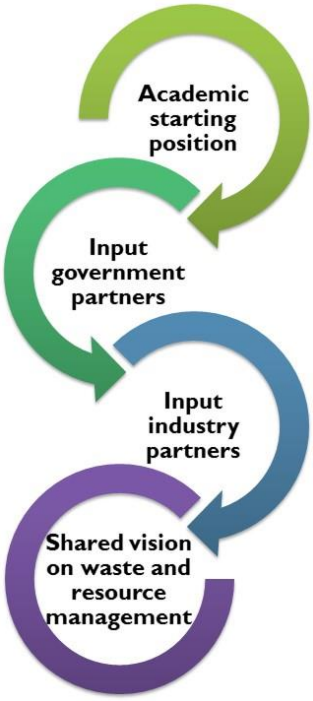

Figure 1: Resource Recovery from Waste co-creation process for a vision and approach for waste and resource management.

2.2 Workshop

In December 2016 a half-day workshop was held in Leeds during the Resource Recovery from Waste annual conference with mixed participation from industry, academia and government. The workshop was focused on industry and also open to other participants of the conference. There were 30 participants for the workshop from industry, academia and government.

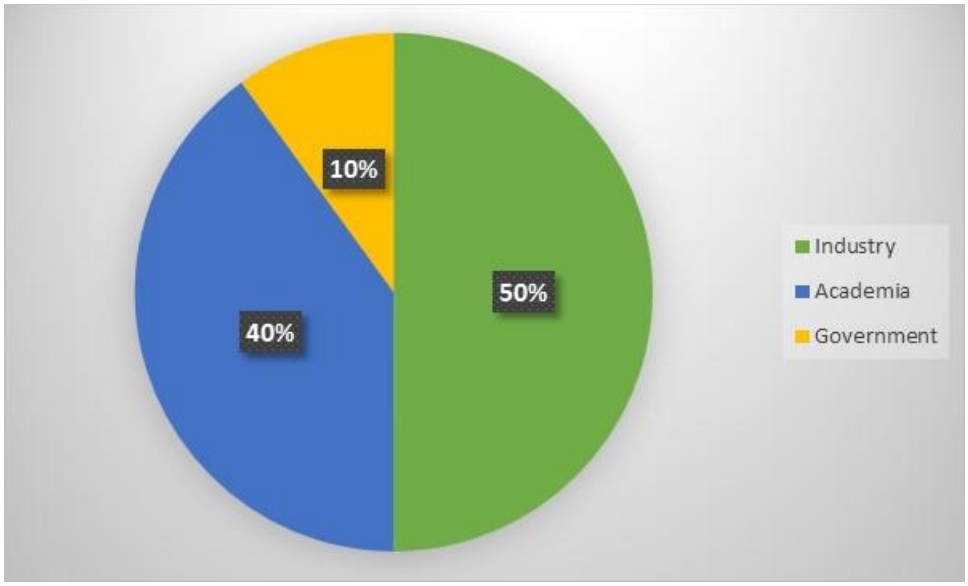

Figure 2: The co-creation workshop in December 2016 attracted diverse participants to discuss industry perspectives on resource recovery and a circular economy.

This workshop offered RRfW partners the opportunity to formulate, share and join-up perspectives regarding their ideal vision for the waste and resource management landscape in the UK and to explore how partners, and especially industry, could contribute to realising such vision. Three questions were answered during the workshop:

1. What should the waste and resource management landscape ideally look like in 2020, 2030 and 2050?
2. What are the key drivers and barriers?
3. How could industry, government, academia and the general public contribute to realising the described vision?

Activities were structured to collect individual perspectives initially, which were then integrated as the workshop progressed. First participants prepared individual posters, articulating initial ideas about a vision for resource and waste management, barriers and drivers, and what their own organisation can do to realise the vision. All posters were displayed at the workshop, and participants were given a set number of sticky dots to vote for key points expressed in the posters. The key points were then discussed in groups with mixed participation from industry, academia and government; preparing another poster that integrated the perspectives that were expressed. Each group presented their poster in a plenary setting after which key messages were selected through another round of votes using sticky dots. The workshop facilitator then gave a summary of the main outcomes and closed the workshop.

The results were published in an internal report and shared with the participants directly (Resource Recovery from Waste 2017). The workshop results were wide ranging and, importantly, contained suggestions made not only by industry. A second round of engagement was planned. Key changes, drivers and barriers (listed in the results section) were extracted from the workshop report and formed the basis for an online survey focused purely on industry.

2.3 Survey

In January 2018 an online survey was launched to capture perspectives from companies and professional bodies, to demonstrate how radical change in waste and resource management in the UK can be delivered. Building on the results from the workshop, it aimed to prioritise and complement the workshop results. The objectives of industry engagement remained the same: 1) Identify what the future waste and resource management landscape should look like; 2) Key drivers and barriers; and 3) Actions from industry, government, academia and others to promote resource recovery.

The survey consisted of 8 questions and took 12-15 minutes to complete. A copy of the complete survey has been included in Appendix A. The first series of questions aimed to collect basic details about the participants, such as the sector that they are most active in, materials they are working with, and the type of organisation. This information was used to ensure a representative sample of people participated in the survey. Participants were mostly active in the sectors water and waste management and in professional, scientific and technical activities (Figure 3). Participants were also attracted from manufacturing and mining and quarrying. Unfortunately no participants from wholesale and retail were attracted to the survey. Participants were mostly working with bio-based resources and plastics, followed by metals and aggregates (Figure 4). There were 23 responses in total, with two from academia which had to be excluded from the results for the purposes of this industry focused study.

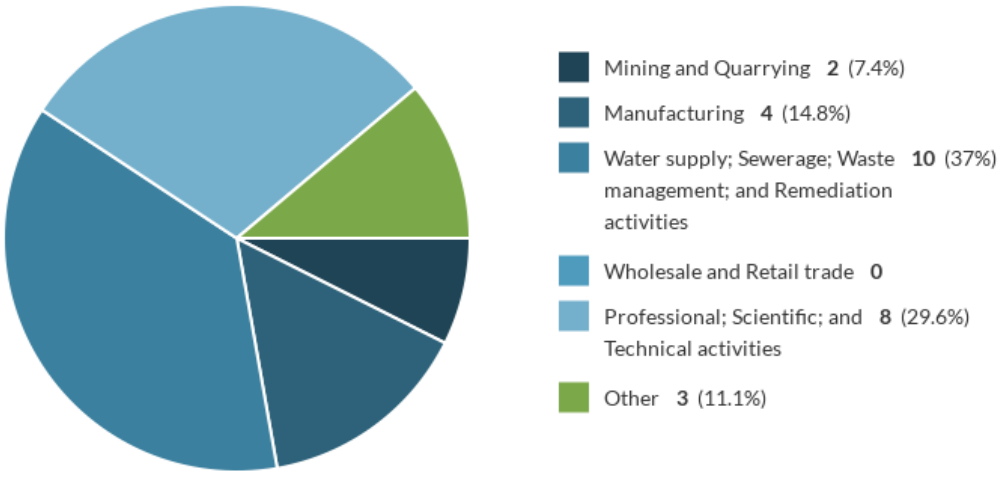

Figure 3: Participants of the survey were active in key sectors covered by the Resource Recovery from Waste programme.

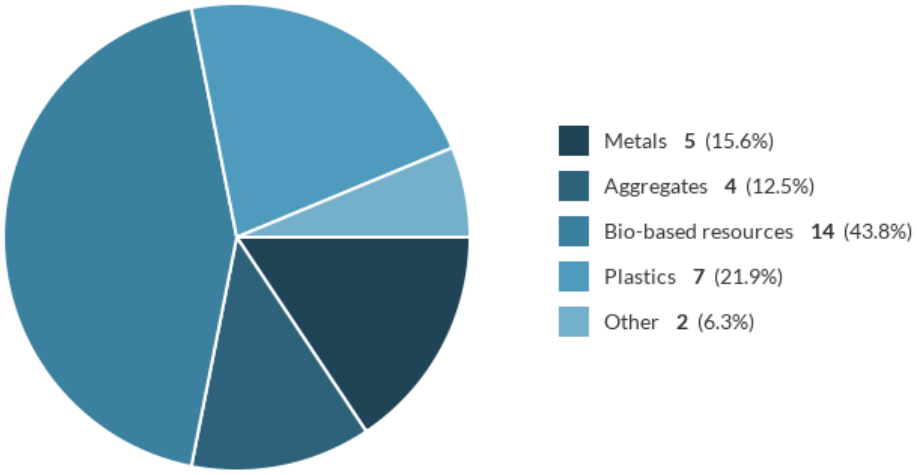

Figure 4: Participants were working with organic materials, plastics, metals, aggregates and other resources.

Key changes, barriers and drivers that were proposed in the workshop, were listed in 3 consecutive questions to be valued as:

1. Unimportant
2. Of little importance
3. Moderately important
4. Important
5. Very important

   Don't know

Participants could also add comments about the listed answers, and add other changes, drivers and barriers that were not mentioned yet. The actions that industry, government, academia and/or other organisations should take to realise the envisioned future resource and waste management were inventoried with open questions, offering space to list actions.

All data were imported into MS Excel and analysed using descriptive statistics for the numerical answers and qualitative analysis for the verbatim data. For the numerical answers the range was determined by noting the highest and lowest value as an indication of consensus or divergence regarding the suggestions. The mean was calculated to rank suggestions and determine the most and least valued ideas. The verbatim data was coded with themes and then organised to be presented in narrative form.

3. Results

Section 3.1 details what the waste and resource management should ideally look like from an industry perspective. Section 3.2 and 3.3 prioritise the most important drivers and barriers. Section 3.4 outlines actions that industry and other actors should take to realise a radically different waste and resource management landscape in the UK.

3.1 Future waste management landscape

At the workshop, participants outlined what the waste and resource management landscape ideally should look like in 2020, 2030 and 2050, resulting in 20 aspects that were included in the survey:

a. Move from waste to resource productivity.
b. Design for durability, reuse and recyclability becomes embedded in supply chains.
c. All costs, including environmental and social externalities, are internalised into business models, supply chains and society.
d. Progress is redefined beyond GDP and purely financial values, to include environmental and social benefits.
e. Establish an Office for Resource Stewardship (OfReS) that collects data on waste and resource flows, formulates policies for- and enables investment in circular economy.
f. View the transition towards a circular economy as an economic- rather than an environmental policy task.
g. Introduce circular business models such as products-as-service.
h. Strengthen regulation for extended producer responsibility.
i. Introduce regulation for consumer responsibility.
j. Government funds innovation, instead of production.
k. Appoint “celebrity champion” to inspire consumers to change consumption and recycling behaviour.
l. Educate general public to normalise resource recovery behaviour, including programmes at schools.
m. Eradicate waste by 2050.
n. Simultaneous reduction of pressures on resources for energy, water, food and materials.
o. Climate change mitigations and adaptations are in place.
p. The role of biodiversity in maintaining ecosystem services is recognised and effective conservation is in place.
q. Leadership, e.g. from OfReS [e], by guiding R&D, investment in circular economy infrastructure, knowledge exchange, low-carbon behaviours, etc.
r. Respect basic human rights such as a safe, healthy, and ecologically balanced environment, and promote equal opportunities.
s. Penalise bad behaviours of consumers and producers that reduce recycling, and incentivise good behaviours that increase recycling.
t. Government and industry collaborate to improve the mapping of resource availability.

Figure 5 gives an overview of the aspects and survey responses.

In general the participants understood the changes that were presented to them, but there were three that were left open or answered with “Don’t know” relatively often and these require further explanation. First, “e. Establish an Office for Resource Stewardship (OfReS) that collects data on waste and resource flows, formulates policies for- and enables investment in circular economy”; this is an office that has been suggested regularly by multiple actors over the past years with the aim to

improve policy integration, facilitate collaboration across government department and levels, and keep an overview in terms of monitoring material flows linking upstream and downstream parts of the production-consumption system (e.g. Material Security Working Group 2015, Allen et al. 2015, Velenturf 2016, Purnell 2017, Velenturf et al 2018a); an overview of the tasks for this office can be found in Velenturf and Purnell (2017b). The second aspect is "a. Move from waste to resource productivity" and this refers to the change in thinking aimed for by the Government Office for Science to go from creating- and consequently having to deal with issues around waste to creating value from waste prevention and resource recovery instead (Walport and Boyd 2017). The third "j. Government funds innovation, instead of production" indicates a change in government mind-set and priorities to direct resources at driving radically different production practices instead of helping essentially unsustainable existing practices become less bad.

Participants commented on the following aspects:

- Resource productivity (a): should not replace resource efficiency and the two terms need to be considered complementary.
- Climate change interactions (c,o): recovering resources can be carbon intensive and in some cases this may outweigh the benefits of recovery, the impact of recovery may vary between materials and this needs to be taken into account when developing policy.
- GDP+ (d): need for developing metrics and targets other than purely financial ones, preferably through international agreements; however, arguably companies are only driven to voluntarily adopt recovery processes if money can be made.
- Office for Resource Stewardship (e,q): was considered a useful way of improving the quality of leadership, policy and regulation; as long as it is open to wider opinions, truly integrated and relations to government department and committees are clear.
- Eradicate waste (m): pointing out that waste elimination may not be the most sustainable option in all cases.
- Fund innovation (j): also via SMEs and organise competitions to recycle the currently unrecyclable materials.

The proposed changes that scored the highest were (average value in brackets):

1. (b, 4.8)Design for durability, reuse and recyclability becomes embedded in supply chains.
2. (l, 4.7) Educate general public to normalise resource recovery behaviour, including programmes at schools.
3. (d, 4.5) Progress is redefined beyond GDP and purely financial values, to include environmental and social benefits & (a, 4.5) Move from waste to resource productivity.
4. (t, 4.4) Government and industry collaborate to improve the mapping of resource availability.
5. (s, 4.3) Penalise bad behaviours of consumers and producers that reduce recycling, and incentivise good behaviours that increase recycling.

The prioritised aspects were generally also the ones where the least variation existed in the scoring, indicating that there is likely to be consensus on the importance of the proposed change with a variation from moderately important/ important up to very important.

The following changes were considered the least important (average value in brackets):

1. (k, 2.8) Appoint "celebrity champion" to inspire consumers to change consumption and recycling behaviour.
2. (m, 3.4) Eradicate waste by 2050.

3. (g, 3.6) Introduce circular business models such as products-as-service & (j, 3.6) Government funds innovation, instead of production.
4. (e, 3.7) Establish an Office for Resource Stewardship (OfReS) that collects data on waste and resource flows, formulates policies for- and enables investment in circular economy & (f, 3.7) View the transition towards a circular economy as an economic- rather than an environmental policy task.
5. (I, 3.8) Introduce regulation for consumer responsibility.

In all the ranking of the proposed changes it should be born in mind, however, that the differences between the highest and lowest are small and an average value of 3-4 is still moderately important up to important i.e. even these "least important" changes were still valued by industry as reasonably important and need to be acted upon.

Other changes that were suggested include:

- More attention for remanufacturing including the commissioning of required infrastructure and development of new business models to realise the economic and environmental potential of remanufacturing. This is similar to suggestions made in the preceding stages of the co-creation process (Velenturf and Purnell 2017a, Purnell 2017, Velenturf et al 2018a).
- Policy and support is predictable and consistent, enabling planning and investment. This is a recurring recommendation in RRfW outcomes (Velenturf et al 2018a,b).
- Waste permitting regulations are updated to promote reuse and recycling and enable end-of-waste. This too is a recurring recommendation within RRfW (Deutz et al. 2017, Velenturf et al 2018b).
- Separate food waste collections for households and businesses are mandatory. This is a timely recommendation given recent debates around Defra policy in this matter (e.g. Letsrecycle 2018). https://www.letsrecycle.com/news/latest-news/mandatory-food-waste-collections-unlikely/
- Government supports circular economy through procurement. This is a much heard recommendation and HM Treasury guidelines need to be updated to enable this (Marshall et al., forthcoming).
- Decisions regarding circular economy strategies are made based on whole systems thinking and assessment of lifecycle impacts. Similar to arguments formulated within RRfW (see for example Velenturf and Purnell 2017a, Iacovidou et al 2017a, Sadhukhan et al 2017).

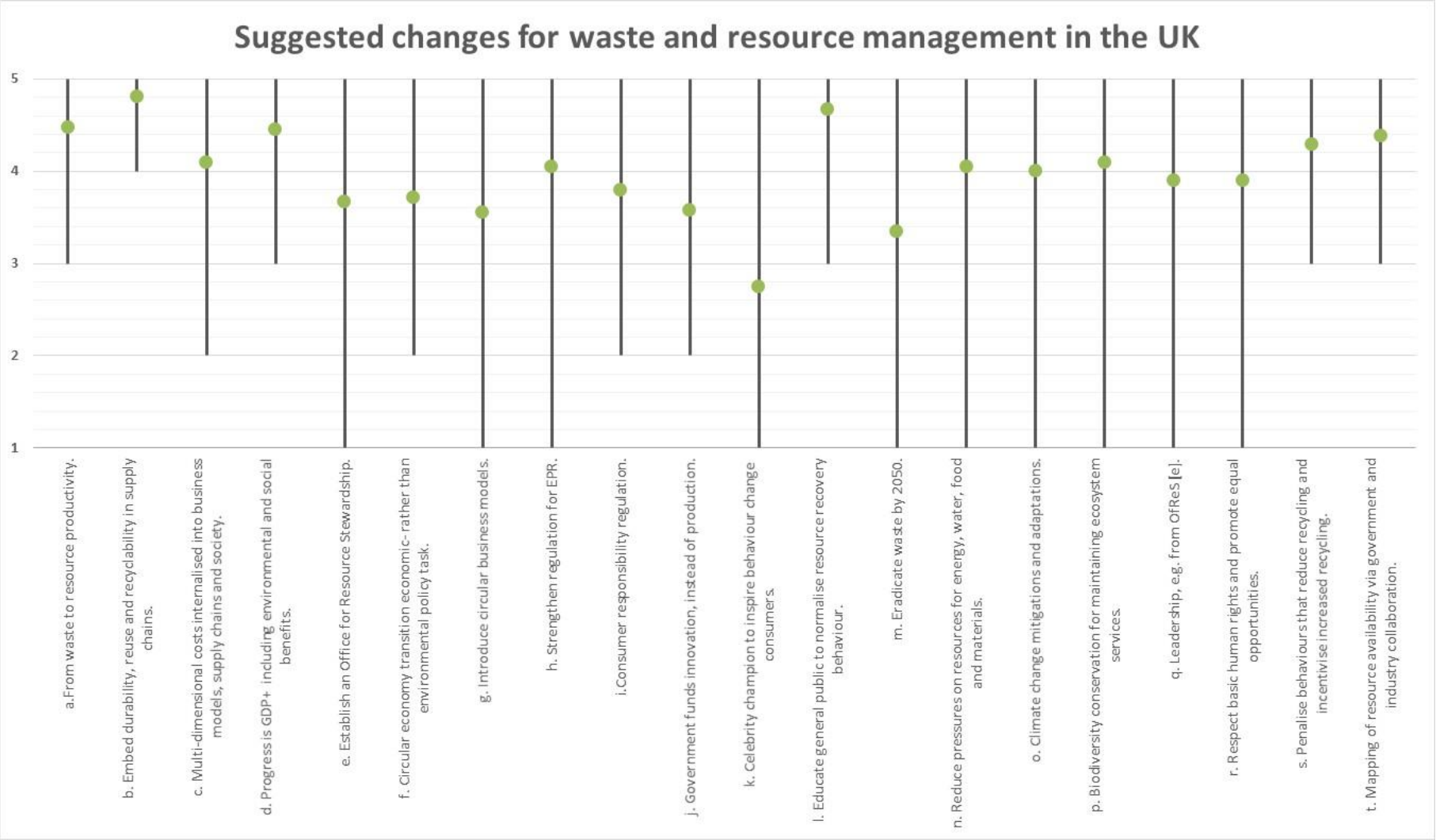

Figure 5: Changes suggested in the workshop were rated in the survey ranging from 1=Unimportant; 2=Of little importance; 3=Moderately important; 4=Important; to 5=Very important; or "Don't know" (excluded from figure). The figure shows the range of lowest and highest values allocated and the mean.

3.2 Barriers

A number of barriers were identified at the workshop in 2016, and these were valued in the online survey to get a better understanding of their relative importance:

a. Market failures such as lack of information, externalities including carbon emissions etc., and pricing of primary and secondary materials.
b. Lock-in of waste streams into long-term contracts, which constrains innovative resource recovery solutions reaching full market scale.
c. Time constraints to identify and adopt innovations.
d. Poor supply chain connections.
e. Political barriers including poor regulation and transfer of liabilities, clashes between the motivation and action of government departments, and political inertia and dogma.
f. Focus on increasing GDP instead of a more balanced, integrated approach addressing environmental, social and economic issues at national and global scales.
g. Lack of long-term government vision and planning and a centralised government approach to achieve zero waste.
h. Lack of standardised data collection on resource flows.
i. Lack of public engagement by government and industry.
j. Addiction to consumption.
k. Consumer perception of products made from secondary resources.

Figure 7 gives an overview of the barriers and survey responses. Most barriers were described clear enough for participants to value them, but there were three that attracted a relative high number of "Don't know" answers and hence may require further explanation. "e. Political barriers including poor regulation and transfer of liabilities, clashes between the motivation and action of government departments, and political inertia and dogma" refers to a collection of constraints caused by government. "d. Poor supply chain connections" intended to represent that the supply chain may not be well interconnected, and innovations in one part of it may not be integrated with other parts e.g. changing a product design to use a material that the (local) waste management infrastructure has no processing capacity for. "c. Time constraints to identify and adopt innovations" expresses the limited financial resources to pay for staff capacity, and thus have time, to develop, search or adopt innovations.

Comments on the listed barriers included:

- Lock-in waste streams (b): constraining innovation is particularly the case with broad feedstock energy-from-waste.
- Consumer focused barriers (i,k): are important and need to distinguish perception from real risk, and educate consumers with the right information to increase acceptance.
- Long-term policy (g,e): indicating the strategic direction of travel in the UK is needed to enable infrastructure investment.

The most important barriers are (average value in brackets):

1. (e, 4.5) Political barriers including poor regulation and transfer of liabilities, clashes between the motivation and action of government departments, and political inertia and dogma.
2. (g, 4.3) Lack of long-term government vision and planning and a centralised government approach to achieve zero waste.

3. (a, 3.9) Market failures such as lack of information, externalities including carbon emissions etc., and pricing of primary and secondary materials & (h, 3.9) Lack of standardised data collection on resource flows.

Similar to the changes discussed in Section 3.1, most consensus was observed on barriers that also received the highest scores i.e. “e. Political barriers including poor regulation and transfer of liabilities, clashes between the motivation and action of government departments, and political inertia and dogma” and “a. Market failures such as lack of information, externalities including carbon emissions etc., and pricing of primary and secondary materials”. Conversely, opinions on the importance of the lack of governance visions (g) varied from unimportant up to very important.

The least concerning barriers are (average value in brackets):

1. (b, 3.4) Lock-in of waste streams into long-term contracts, which constrains innovative resource recovery solutions reaching full market scale & (c, 3.4) Time constraints to identify and adopt innovations.
2. (d, 3.6) Poor supply chain connections & (j, 3.6) Addiction to consumption.
3. (f, 3.7) Focus on increasing GDP instead of a more balanced, integrated approach addressing environmental, social and economic issues at national and global scales & (i, 3.7) Lack of public engagement by government and industry.

However, differences in average values for the most and least important barriers are small. All barriers were considered at least moderately important on average.

In addition to the barriers identified in the workshop, participants of the survey suggested the following – all referring to government:

- Incomplete implementation of polluters pays principle in the UK and this is a barrier to behaviour change in households.
- The balance between keeping regulatory control and granting end-of-waste relies too heavily on the former.
- Lack of international coordination causes risks for national interest, yet insufficient focus on becoming self-sufficient in terms of water, energy, food and other basic materials.
- Public funding unavailable where it is needed due to local councils having to prioritise other responsibilities.
- Investment in technology and innovation is lacking, especially to effectively support innovation in smaller businesses.
- Not promoting new waste conversion technologies.
- Difficulties in communicating the message about sustainability.

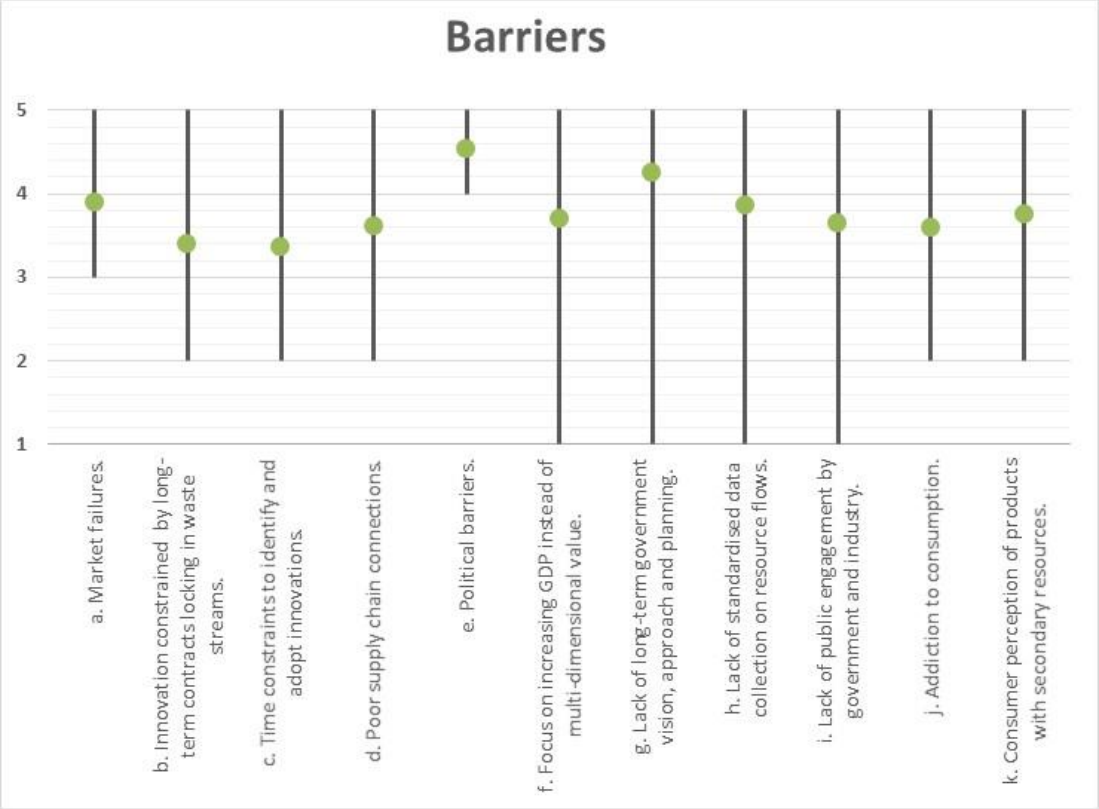

Figure 6: Constraints to realising radical changes in waste and resource management in the UK, valued from 1=Unimportant; 2=Of little importance; 3=Moderately important; 4=Important; to 5=Very important; or "Don't know" (excluded from figure). The figure shows the range of lowest and highest values allocated and the mean.

3.3 Drivers

A number of drivers were identified at the workshop, many of which significantly overlapped with the envisioned changes (Section 3.1). To prevent duplication of efforts, only the additional entries were included as drivers in the online survey to get a better understanding of their relative importance. Drivers were rated by participants with answers ranging from unimportant (value 1) up to very important (value 5).

a. The UK government legally binding carbon budgets.
b. Regulation as a driver for innovation.
c. Increase resource security including for water, energy, food and the associated infrastructure.
d. Demographic changes, such as global population growth and urbanisation.
e. Changing attitude of consumers towards resources, increasingly valuing sustainable products and services.
f. Pricing of environmental costs such as carbon emissions.
g. Growing availability of alternative economic and business models.

Overall the drivers were answered in completeness. Figure 8 gives an overview of the aspects and survey responses. Participants made very few comments regarding the drivers. In response to b "Regulation as a driver for innovation" it was suggested that regulation needs to be based on whole

life cycle impact. As a general comment, one participant proposed to distinguish national- and global drivers because they are different and this causes problems.

Similar to the barriers, the differences in average values allocated to the drivers are very small. The highest values were allocated to:

1. c (4.3) Increase resource security including for water, energy, food and the associated infrastructure
2. g (4.1) Growing availability of alternative economic and business models.

Most consensus was reflected in the importance of three drivers on increasing resource security (c), changing consumer attitudes (e), and growing availability of alternative economic and business models (g) varying from moderately important up to very important.

The lowest value went to:

1. d (3.7) Demographic changes, such as global population growth and urbanisation
2. a (3.8) The UK government legally binding carbon budgets

In addition to the drivers identified at the workshop, a participant identified the ability to invest and innovate as a driver. However, the barriers suggested that support for innovation, and actual innovation, is in some cases still insufficient in the UK.

Figure 7: Drivers for radical change in waste and resource management in the UK, valued from 1=Unimportant; 2=Of little importance; 3=Moderately important; 4=Important; to 5=Very important; or "Don't know" (excluded from figure). The figure shows the range of lowest and highest values allocated and the mean.

3.4 Actions

The survey asked specifically for the most important actions that should be taken by companies, government and academia in support of resource recovery as part of a circular economy. There was also space to suggest actions for other types of actors.

3.4.1 Companies

Actions were suggested for companies to take responsibility, both in terms of Extended Producer Responsibility (EPR) and Corporate Social Responsibility:

> *"Companies must take economic and environmental responsibility for the manufacture of their products and for the ability of their products to continue to be used as resource at the end of their working life."*
>
> *"Companies should take total responsibility for all the products their processes produce and design out waste wherever possible and if waste is necessary ensure it is reusable thereafter, either on or off site."*
>
> *"Think whole life cycle, particularly what happens to products at end-of-life. Develop supply chain partnerships to optimise material efficiency. Avoid specifying inappropriate metrics such as recycled content."*

The comments above regarding EPR already hinted at working in accordance with the waste hierarchy, and more specific actions pertained to minimising waste streams and even adopting a formal waste reduction policy, and taking into account which level of the waste hierarchy offered the best solution for a particular resource/ waste from more than just a financial perspective. The BS8001 standard on circular business model innovation was suggested as a support tool.

Companies need to innovate their business models and *"be more bold and embed circular economy approaches"*. Similarly, companies should *"take climate change and resource efficiency more seriously"* and instead of just ticking boxes of accreditations, switch more to a circular economy mindset. Business model innovation needs to cover design *"though not at the cost of resource efficiency"*, waste reduction, reuse, remanufacturing, products as services, and industrial symbiosis (requires government support). The oil & gas sector was highlighted as an area of high potential for remanufacturing.

In general companies need to innovate more both in terms of business models and production processes *"exploring alternative production processes or business opportunities from their waste"*. In addition to seeking potential outlets for any unavoidable wastes produced, companies also need to consider alternative sources for their input materials. It is important to be more proactive regarding *"continued access to critical resources within and between supply chains"* from the point of view of availability, affordability, acceptance, lifecycle awareness, regulation etc. Supply chain integration and the accompanying necessary collaboration and data/ information provision also need to be actioned. In this way collective, industry-wide environmental benefits can be realised.

All of the above may require continued professional development of staff.

Finally, *"SMEs should engage actively in policy development via their sector bodies and directly where possible"*.

3.4.2 Government

A number of entries were made calling for a long-term (multi-generational) strategy that sets a clear, joined up direction of travel and that does not keep changing. This was suggested as a form of leadership, setting clear priorities for the long-term social good, in line with climate change mitigation targets. Such strategy forms *"the basis to implement unambiguous long term consistent policies and regulatory frameworks to achieve the required change"*. This does require some flexibility and, perhaps contradictory, openness to change waste policies. Particularly, whole life-cycle thinking should be integrated into legislation, covering energy, food, water, basic materials and end-of-life management of wastes. Any policies, as well as public information, needs to be *"derived from scientific fact not popular myth"*.

Government priorities that were suggested include:

- Promoting design for sustainability *"in all its dimensions"*.
- Education on redesign, reuse and recycling.
- Investment in- and support for innovation, including easily accessible capital schemes for SMEs.
- Waste minimisation through positive encouragement, financial incentives, acting upon "Duty of Care", and stronger EPR including eco-design and rewarding sustainable, low-carbon businesses.
- Enforcement of consumer responsibility legislation such as fines for littering.
- Clarify legislation on End-of-Waste and reuse (linking into comments around need for more regulation and support below).
- Carbon taxing, preferably via international agreements.
- Support industrial symbiosis.
- Include recycled content in government procurement criteria.
- Promote bioeconomy and green spaces.
- Invest in better data collection on resources and wastes.
- Standardise waste collection systems across the country and ensure infrastructures are in place to process materials.
- Ease import of wastes, referring to the "Trans Frontier Shipment of Waste regulation", if it can be demonstrated that such materials can be effectively reused or recycled in the UK and not in their country of origin.

There was a call for stronger global agreements. Overall, participants suggested more regulation is necessary for resource recovery and waste to drive zero waste to landfill and support regulatory activities *"to help resource recovery operators raise standards"*. The regulator and related agencies and bodies *"used to provide a lot of easily accessible technical support to businesses in respect of resource and wider environmental management but no longer appear to have the resources to do this"*.

3.4.3 Academia

Academics should carry out blue sky-, quantitative-, problem-oriented-, transdisciplinary research involving industry. Pathways between fundamental- and applied research need to better linked. Industry state-of-the-art should be taken into account in scientific studies. The scope of research projects should be expanded to cover commercialisation stages, and an understanding of scaling up needs to inform basic research. In some cases new methods need to be developed to address the challenges at hand, and catapult centres could potentially help with this.

A few concrete research ideas were put forward:

- Identify processes where wastes arise and investigate how wastes can be designed out of the system where possible, or reuse or recycling possibilities.
- Objective investigation of the most effective collection system for materials.
- Develop novel products from waste or waste treatment processes, and develop industrial applications in collaboration with companies.

Collaboration is important *"to ensure that the scientific/business case for a circular economy remains relevant to the key/dominant players in a given supply chain or resource cascade"*. Academia should collaborate with small, medium and large businesses to innovate. Academia can help to fill knowledge gaps and be more focused on the future, and play a particular role in bridging gaps between parts of industry and commerce. However, barriers around legal issues and IP should be removed to enable more collaboration.

In addition to research, academia also needs to *"provide a stream of motivated and well-qualified graduates and post-graduates"*. These graduates needs to be equipped with an understanding of business drivers.

Finally, academia should influence government policy and communicate better with the general public.

3.4.4 Other organisations

Actions were suggested for NGOs, professional bodies and education providers alongside the observation that everyone has to act.

WRAP was recommended to act upon end-of-waste and reuse, alongside the EA and Defra. However, there were also concerns regarding WRAP's credibility to report objectively.

NGOs should educate the general public and support value creation from wastes. However, again concerns were voiced around the willingness of NGOs to consider reuse and recycling due to an anticipated necessity to change operations; a new body was proposed both for NGOs and governmental organisations for whistleblowing in case these organisations do not take appropriate responsibility.

Professional industry bodies should try to find more consensus between them to put pressure on government and private sector *"to initiate/ drive change from a unified platform"*. However, it was also suggested that trade associations and professional institutions needed government support; this could create a conflict of interest regarding keeping government to account. Similar to NGOs, trade- and professional organisations have a role to play in education and encouraging change, in this case for companies in sustainable business principles, dissemination of best practice and new ideas/ models.

Finally, education providers should equip people with the knowledge that they need to take responsibility and enable critical thinking. *"Key aspect in this context is the effect of humans on planet earth and how we can change to a more responsible stewardship of the planet."*

4. Discussion

4.1 Reflections on the results

Industrial views on the future changes required in the waste and resource management landscape were largely consistent with previous analyses from academic and governmental viewpoints (Velenturf and Purnell 2017a, Velenturf et al 2018a) with the exception that issues pertaining to social wellbeing and human rights aspects of RRfW were considered rather less important, presumably because this is not seen as a problem to be tackled by the industry but by government actors. Similar to the academic and government narratives (Velenturf and Purnell 2017a, Velenturf et al 2018a), industry was a strong advocate for taking a holistic, multidimensional – i.e. wider than financial – approach to the evaluating costs and benefits of proposed actions, in particular for interventions intended to design waste out of the economy. It was felt that the push for this needs to come via government regulation rather than purely voluntary measures, and that the potential impact of public education in the benefits of engaging with RRfW processes was high (similar to RRfW business case, see Velenturf and Jopson, 2018). A small section of the participants continued to promote EfW as a key aspect of a future circular economy, particularly for materials and products that cannot be reused or recycled, rather than promoting a focus on 'designing out' such materials and products from supply chains.

Several barriers were identified with very little difference in their scores, indicating that the industry sees a wide and equally important range of issues that must be tackled. It was striking that almost all of these were associated with government and regulation i.e. that it was seen as the government's job to regulate to remove these (mainly medium- to long-term) barriers, and/or the economic incentives for companies to act individually or collectively to remove these barriers is either not there, or poorly communicated. The power of regulation in circular economy is obviously perceived as being very strong, particularly to help correct market prices that do not reflect the full multidimensional costs (and values) of materials and to help collect better data about primary and secondary material flows that would help support functioning markets. Nonetheless, it was noted that a balance between government control and the regulatory freedom to innovate must be preserved. Industry was least concerned (compared to other stakeholders) about locking waste-streams into long-term, sub-optimal processes, previously often quoted as a major barrier to change. Presumably this is because local authority waste management contracts have recently changed from being typically 20-25 years to ca. 10 years (Biffa, pers. comm.).

In common with our previous analyses (Velenturf et al 2018a), regulation and resource security were seen as the key drivers of change in RRfW systems. As traditional TMUDR ('take – make – use – dispose – repeat') supply chains are projected to become more fragile, indirect economic factors such as developing alternative ways of protecting materials supplies through e.g. recycling, refurbishment, buy-back of used products is seen as a more compelling driver to move towards a circular economy than straightforward direct economic factors. This chimes with other analyses (Purnell et al 2018, Velenturf and Jopson 2018). Unlocking the potential for innovation and investment – presumably through the appropriate set of regulatory instruments – is seen as an important driver towards more sustainable resource and waste management.

Actions that industry proposes should be taken are similarly widespread to the barriers identified. There appears to be an aspiration towards taking a more proactive approach both towards more sustainable business models and towards shaping the regulation and governance required to initiate these. Industry requires government to signpost a stable long-term direction of travel (i.e. programme of policy and investment in RRfW) in order to provide investors with confidence; a theme repeated in many industries in which the government is a major client, see e.g. the National Infrastructure Pipeline which provides the same for the construction industry[1]. As previously noted however, flexibility needs to be maintained in terms of adapting regulations to cope with new technologies, particularly when these have the potential to help a waste stream achieve 'end of waste' status. What this pipeline of policy should include was less clear. Specifics focussed on waste management and end-of-use issues. Yet the problem as expressed by the industry is that the cost of primary materials does not reflect the environmental and social impacts of their extraction, while the relative cost of secondary materials is high and/or volatile; exacerbated by practices designed to boost consumption and economic growth rather than preserve materials and environments (Velenturf and Jopson 2018). Government needs to act upon those issues, that pertain to a deeper cultural change, in order to not just promote resource efficiency within our industrial system and society but also resource effectiveness.

The role for academia, as envisaged by some industry commentators, was to be the most forward-looking stakeholder and to develop radical solutions; this was contradictory to other industrial commentators who suggested academia should be working with more realistic response that are closer to market. To an extent, academia can do both but the former is better suited to its talents than the latter. In either case, industry needs to accept that many research pathways turn out to be dead ends – this is the nature of research risk – and a wider view of the benefits of engaging with academia in research needs to be taken. Education, both by academia and NGOs, trade bodies, professional associations etc. is seen as a key action in enabling change, as has been noted in virtually all RRfW publications (e.g. Velenturf et al 2018a, Velenturf and Jopson 2018, Velenturf et al 2018b). Both consumers and companies (and arguably, government bodies too – see Velenturf et al 2018b) need to be educated not only in what a sustainable circular economy is, but also what the pathways are that will constitute the transition thereto.

Overall very few changes, barriers and drivers scored coherently during the analysis and most were given roughly equal weightings, indicating that the industry considers the issues facing the transition towards a more circular economy are diverse and numerous. This makes it difficult to identify key interventions and perhaps hints at why the industry (or perhaps more correctly, individual industries) find it difficult to find consensus among new and existing supply chains regarding sustainable solutions. Industry perceives that concerted action is required across all fronts and stakeholders, which is why it sees government intervention, policy and regulation as the most effective means of implementing change. Transitions towards new ways of operating must happen one step at a time and be presented as such in order not to appear insurmountable. Further research will need to concentrate on a framework that can agree on a common vision for a sustainable circular economy, and guide manageable, consecutive and coherent actions towards this vision reinforced by a stable policy framework that creates a level playing field for all and clearly

[1] https://www.gov.uk/government/publications/national-infrastructure-and-construction-pipeline-2017

recognises and rewards actions that increase long-term social and environmental value at the expense of short-term financial cost.

4.2 Comparison to academic and government narratives

The consensus regarding *"the necessity to transition towards a circular economy, moving away from end-of-pipe solutions and increasingly focussing on upstream supply chain changes to bring materials, components, and products to market that can easily be reused, dismantled, and recycled"* advanced in previous analyses (Velenturf and Purnell 2017a, Velenturf et al 2018a) can be extended with this analysis of industry views. Similarly, industry also agrees that concerted action is required from actors across society. The role of government (i.e. policy, regulation and enforcement) in effecting change was considered more important than in previous narratives, while the emphasis in role of academia shifted from maintaining the holistic picture and identifying key intervention points (Velenturf et al 2018a) to undertaking radical blue-sky research in close collaboration with industry. The necessity for transdisciplinary collaborations to be established was confirmed.

The technical qualities of recycled materials were barely mentioned in the results presented in this article (in common with the analysis of government actors). Yet consideration of the technical and functional characteristics of materials and products throughout their lifecycle is of crucial importance for the design and assessment of the most optimal circular supply chains in the view of the RRfW programme (Velenturf and Jopson 2018). Without a detailed knowledge of how the properties of materials and products are degraded by use and end-of-use processes (and/or restored by reprocessing) it is impossible to understand how a closed-loop system can be achieved (Iacovidou et al 2018). Similarly, data deficiencies in a more general sense played a less prominent role in the industry co-creation results; however, it was suggested that more data needs to be collected about material flows upstream and downstream of the waste generation point. This focus on data collection is similar to government priorities, and may complement academic efforts on developing tools to deal with imperfect data (Velenturf et al 2018a). Incorporating metrics that describe the technical qualities of materials and products (in particular for recovered materials) should thus form a central part of designing such data collection systems (Iacovidou et al 2017b).

Neither the industry or government participants involved in the co-creation process clearly articulated the dependency of the economy on society and the environment (i.e. they did not take a systems view), while in the academic narrative these hierarchical relations were clearly expressed through the principle of ecosystem stewardship (Velenturf and Purnell 2017a). While government was unsure about the how to incorporate environmental and social values into financial cost–benefit analyses in support of a transition towards a circular economy, industry was clear about the necessity to move beyond monetary drivers, targets and metrics; and in this sense industry is more fully in line with RRfW's vision than government which was partly in line (Velenturf et al 2018a). In a related expression of perception, both the government and industry co-creation results largely focused on waste and end-of-pipe management, rather than system redesign upstream and downstream of the waste generation point. This needs to be rebalanced with a focus on how current design and consumption patterns could be changed to minimise resource extraction and overexploitation. In all narratives, the consumption stage has been underexplored and needs to be subject to further research. Some specific insights into consumption were however discussed, and while government opinions diverged regarding the question whether "changing consumer behaviour

is a necessity before marketing products that are more amenable to recycling", industry was clear that changes in consumer attitudes are happening and more change could be catalysed through informing and educating consumers.

4.3 Implications for industry

Combining the prioritised aspects of an ideal future circular economy, barriers and drivers with the actions suggested for industry, results in the following list of actions for industry in order of importance:

1. Embed Extended Producer Responsibility into Corporate Social Responsibility policies, to meet increasingly strict regulations on design for durability, reuse and recycling aiming to minimise wastes. Make progress on waste minimisation evident by setting ambitious targets and adopt metrics to enable evaluation.
2. Engage actively in governance process to contribute to policy development, especially through the provision of data on stocks and flows of primary and secondary resources.
3. Innovate to increase resource security by exploring alternative outlets for unavoidable wastes and secondary resources as input materials, considering water, energy, food and the associated infrastructure as well as the required business model changes.
4. Educate staff (via continued professional development) and consumers (for example, to increase acceptability of using secondary resources in products and to preserve values at end-of-use) about resource recovery and circular economy.
5. Design lifecycles of products and materials with the aim to maintain economic, technical, social and environmental values for as long as possible; thereby minimising waste and limiting negative consequences for human health and the environment. Prioritise resource productivity/ effectiveness over resource efficiency.
6. Innovate business models to embed circular economy within companies, designing products and materials for circularity and adopt models that reduce waste, offer products as a service, enable reuse, remanufacturing and industrial symbiosis.

4.4 Policy implications

Government can help industry realise the envisioned circular economy. While the linkages between the suggested actions and the prioritised aspects, barriers and drivers were not as clear-cut as for industry (Section 4.3), the following implications for government could be derived in order of importance:

1. Embed design for durability, reuse and recyclability in supply chains of companies through innovation support, investment and regulation; enabling greater resource productivity. Promote design for sustainability in all its dimensions (economic, social and environmental), preserving technical values of materials and products, and facilitate associated business model innovation; strengthen Extended Producer Responsibility legislation. Increase regulatory capacity in terms of technical advice regarding resource- and wider environmental management and enforcement to raise standards in industry.
2. Overcome political barriers with evidence based policy proposals and through cross-departmental collaboration under the coordination of the Office for Resource Stewardship.
3. Influence behaviour of the general public through education about circular economy including reuse and recycling aiming to normalise resource recovery practices, and enforcement of measures around consumer responsibility such as fines for littering.
4. Prepare a long-term government vision and strategy building towards an alternative economic model based on multi-dimensional values (economic, social, environmental and

technical), indicating a clear and joined up direction of travel that provides a framework for consistent policies and regulations that can be flexible within the parameters of the long-term vision. Waste legislation, collection and management through the associated infrastructure will need to be revised in order to meet new government ambitions.

5. Correct market failures through differential tax on primary and secondary resources and lobby for stronger global agreements to ensure resource prices reflect the complete multi-dimensional costs. Initially, start with carbon tax depending on recycled contents and promote products with recycled content via government procurement.
6. Collect data about stocks and flows of primary and secondary resources in collaboration with companies.

5. Conclusions

This study has identified the key aspects, barriers and drivers for a radically difference waste and resource management landscape in the UK according to the principles of the circular economy from an industry perspective. The most important changes that were envisioned are to 1) Embed design for durability, reuse and recyclability into supply chains; 2) Change behaviour of the general public through education; 3) Redefine progress to include social and environmental values in addition to money; and Increase resource productivity. All barriers to realising a radically more valuable circular economy are within government's control to change, most importantly including the breaking down of political barriers, adopting a long-term vision and plan to realise a circular economy, correct market failures and collect better data about resource flows. The most important drivers for a transition towards circular economy are resource security, availability of alternative economic- and business models, and changing consumer attitudes.

The industry perspectives showed significant overlap with the academic- and government perspectives previously published by the Resource Recovery from Waste programme(RRfW). Across academia, government and industry there is consensus regarding the need to transition towards a circular economy more focused on waste prevention and minimisation, i.e. moving away from end-of-pipe solutions, and increasingly focus upstream from the point of waste generation in the supply chain to bring materials and products to market that are durable and that can be easily reused, dismantled and recycled. Industry did differ from preceding RRfW results by giving less priority to human wellbeing and human rights. There was agreement across the academic, governmental and industry narrative prepared by RRfW regarding the uptake of whole system thinking incorporating the multi-dimensional (economic, technical, social and environmental) costs and benefits of proposed actions including changes to supply chains.

Realising a circular economy requires concerted action from actors across society. Industry stressed the crucial role that government must play in effecting change in waste and resource management. Government actions that were prioritised in this study were: 1) Offer innovation support, investment and regulation to embed design for durability, reuse and recycling into supply chains that create economic, social and environmental benefits through the preservation of technical values of materials and products; key legislative areas to strengthen are Extended Producer Responsibility and increased regulatory staff capacity to offer enforcement and advice; 2) Launch an office to coordinate the necessary cross-governmental collaboration and lowering political barriers; 3) Steer behaviour of general public about circular economy through education and enforcement of consumer responsibility; 4) Prepare a long-term vision and strategy for a circular economy based on an alternative economic model based on multi-dimensional values (economic, social, environmental and technical) setting out a clear and joined up direction of travel that provides a framework for consistent policies and regulations that can be flexible within the parameters of the long-term vision. Revise waste legislation, collection and management through the associated infrastructure in line with new government ambitions; 5) Introduce a carbon tax depending on recycled contents and promote use of recycled materials through government procurement, and expand this tax system with a differential tax on primary and secondary resources preferably; and 6) In support of new government measures, collect data about stocks and flows of primary and secondary resources in collaboration with companies.

The most important industry actions were seen to be: 1) Embedding Extended Producer Responsibility into business policies and practices in response to stricter government regulations, set ambitious targets and measure progress towards designing wastes out of supply chains; 2) Contribute to governance process and policy development, in particular by reporting data on stocks and flows of primary and secondary resources; 3) Resource- and business model innovation to increase resource security; 4) Educate staff and consumers; 5) Design lifecycles of products and materials that maintain economic, technical, social and environmental values for as long as possible, thereby minimising waste and increasing resource productivity; 6) Adopt more circular business models to minimise wastes and increase reuse, remanufacturing, recycling and industrial symbiosis.

Government emphasised the role of academia in maintaining a holistic picture on circular economy and identifying key intervention points i.e. to carry out research close to the point of delivering solutions in practice. Conversely, in this study industry outlined more of a role for academia in undertaking radical blue-sky research which is usually further away from market, yet industry does see a role for themselves in collaborating closely with universities in such fundamental research projects.

The findings from this investigation will be communicated towards government and industry. The results will feed into the final stage of the RRfW co-creation process to produce a shared vision and approach towards a realising a circular economy in the UK with insights from the academic-, government- and industry partners engaged within RRfW.

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Appendix A: Survey "How can companies promote resource recovery in the UK?"

Page 1: Welcome

Resource Recovery from Waste is a research programme aiming to create value from waste. Resource Recovery from Waste has a vision of a high value circular economy that delivers clean growth, a better environment and social benefits such as skills and jobs. We work closely with our partners in government and business to turn this vision into action. Read more about the programme's strategy in this free publication.

This survey is designed to capture perspectives from **companies and professional bodies**, to demonstrate how radical change in waste and resource management in the UK can be delivered. It builds on an industry focused workshop and aims to clarify and consolidate the preliminary results to find out:

1. What the future waste and resource management landscape should look like.
2. Key drivers and barriers.
3. Actions from industry, government, and academia to promote resource recovery.

The results will add to government advice on policy and regulatory change, recommend how industry can adopt more resource efficient, circular economy practices, and shape academic research to ensure practical relevance. We will share the outcomes via professional publications and a policy briefing.

Participation is anonymous. The survey consists of 8 questions and takes 12-15 minutes to complete. Any questions or comments regarding this survey can be directed to Anne Velenturf, programme lead for Resource Recovery from Waste, email A.Velenturf@leeds.ac.uk.

Page 2: Introductory questions

The following questions will help us understand your role in waste and resource management.

1. In which sector(s) is your company most active? Required

Please select at least 1 answer(s).

- ☐ Mining and Quarrying
- ☐ Manufacturing
- ☐ Water supply; Sewerage; Waste management; and Remediation activities
- ☐ Wholesale and Retail trade
- ☐ Professional; Scientific; and Technical activities
- ☐ Other

If you selected Other, please specify:

2. Which material(s) does your company work with mostly? Required

Please select at least 1 answer(s).

- [ ] Metals
- [ ] Aggregates
- [ ] Bio-based resources
- [ ] Plastics
- [ ] Other

If you selected Other, please specify:

3. I am working for a... Required

- ( ) Company and/or professional body
- ( ) Governmental organisation. Please continue to final page
- ( ) University. Please continue to final page
- ( ) Other organisation. Please continue to final page

If you selected Other, please specify:

Page 3: Future waste and resource management

The next question is about the key changes needed for the transition towards a more circular, resource efficient economy in the UK. At an industry focused workshop in December 2016 our contacts suggested a number of changes when envisioning the waste and resource management landscape up to 2050. They are listed below.

This part of the survey uses a table of questions,

4. Please could you rate the suggested changes, ranging from unimportant up to very important?

Please don't select more than 1 answer(s) per row.

	1. Unimportant	2. Of little importance	3. Moderately important	4. Important	5. Very important	Don't know
a. Move from waste to resource productivity.	☐	☐	☐	☐	☐	☐
b. Design for durability, reuse and recyclability becomes embedded in supply chains.	☐	☐	☐	☐	☐	☐
c. All costs, including environmental and social externalities, are internalised into business models, supply chains and society.	☐	☐	☐	☐	☐	☐
d. Progress is redefined beyond GDP and purely financial values, to include environmental and social benefits.	☐	☐	☐	☐	☐	☐
e. Establish an Office for Resource Stewardship (OfReS) that collects data on waste and resource flows, formulates policies for- and enables investment in circular economy.	☐	☐	☐	☐	☐	☐
f. View the transition towards a circular economy as an economic- rather than an environmental policy task.	☐	☐	☐	☐	☐	☐
g. Introduce circular business models such as products-as-service.	☐	☐	☐	☐	☐	☐
h. Strengthen regulation for extended producer responsibility.	☐	☐	☐	☐	☐	☐
i. Introduce regulation for consumer responsibility.	☐	☐	☐	☐	☐	☐
j. Government funds innovation, instead of production.	☐	☐	☐	☐	☐	☐
k. Appoint “celebrity champion” to inspire consumers to change consumption and recycling behaviour.	☐	☐	☐	☐	☐	☐

l. Educate general public to normalise resource recovery behaviour, including programmes at schools.	☐	☐	☐	☐	☐	☐
m. Eradicate waste by 2050.	☐	☐	☐	☐	☐	☐
n. Simultaneous reduction of pressures on resources for energy, water, food and materials.	☐	☐	☐	☐	☐	☐
o. Climate change mitigations and adaptations are in place.	☐	☐	☐	☐	☐	☐
p. The role of biodiversity in maintaining ecosystem services is recognised and effective conservation is in place.	☐	☐	☐	☐	☐	☐
q. Leadership, e.g. from OfReS [e], by guiding R&D, investment in circular economy infrastructure, knowledge exchange, low-carbon behaviours, etc.	☐	☐	☐	☐	☐	☐
r. Respect basic human rights such as a safe, healthy, and ecologically balanced environment, and promote equal opportunities.	☐	☐	☐	☐	☐	☐
s. Penalise bad behaviours of consumers and producers that reduce recycling, and incentivise good behaviours that increase recycling.	☐	☐	☐	☐	☐	☐
t. Government and industry collaborate to improve the mapping of resource availability.	☐	☐	☐	☐	☐	☐

Are there any important changes missing? If so, please list them here.

Do you have any comments on the changes listed above?

Page 4: Drivers and barriers

The envisioned changes listed in the previous section may be enabled or constrained by a number of drivers and barriers. Our contacts already suggested a few and we would like to find out how important they are, and whether there are any other important ones we need to include.

This part of the survey uses a table of questions,

5. Please could you rate the following barriers, ranging from unimportant up to very important?

Please don't select more than 1 answer(s) per row.

	1. Unimportant	2. Of little importance	3. Moderately important	4. Important	5. Very important	Don't know
a. Market failures such as lack of information, externalities including carbon emissions etc., and pricing of primary and secondary materials.	☐	☐	☐	☐	☐	☐
b. Lock-in of waste streams into long-term contracts, which constrains innovative resource recovery solutions reaching full market scale.	☐	☐	☐	☐	☐	☐
c. Time constraints to identify and adopt innovations.	☐	☐	☐	☐	☐	☐
d. Poor supply chain connections.	☐	☐	☐	☐	☐	☐
e. Political barriers including poor regulation and transfer of liabilities, clashes between the motivation and action of government departments, and political inertia and dogma.	☐	☐	☐	☐	☐	☐
f. Focus on increasing GDP instead of a more balanced, integrated approach addressing environmental, social and economic issues at national and global scales.	☐	☐	☐	☐	☐	☐

g. Lack of long-term government vision and planning and a centralised government approach to achieve zero waste.	☐	☐	☐	☐	☐	☐
h. Lack of standardised data collection on resource flows.	☐	☐	☐	☐	☐	☐
i. Lack of public engagement by government and industry.	☐	☐	☐	☐	☐	☐
j. Addiction to consumption.	☐	☐	☐	☐	☐	☐
k. Consumer perception of products made from secondary resources.	☐	☐	☐	☐	☐	☐

Are there any important barriers missing? If so, please list them here.

Do you have any comments on the barriers listed above?

This part of the survey uses a table of questions,

6. Please could you rate the following drivers, ranging from unimportant up to very important?

Please don't select more than 1 answer(s) per row.

	1. Unimportant	**2. Of little importance**	**3. Moderately important**	**4. Important**	**5. Very important**	**Don't know**
a. The UK government legally binding carbon budgets.	☐	☐	☐	☐	☐	☐
b. Regulation as a driver for innovation.	☐	☐	☐	☐	☐	☐
c. Increase resource security including for water, energy, food and the associated infrastructure.	☐	☐	☐	☐	☐	☐
d. Demographic changes, such as global population growth and urbanisation.	☐	☐	☐	☐	☐	☐

e. Changing attitude of consumers towards resources, increasingly valuing sustainable products and services.	☐	☐	☐	☐	☐	☐
f. Pricing of environmental costs such as carbon emissions.	☐	☐	☐	☐	☐	☐
g. Growing availability of alternative economic and business models.	☐	☐	☐	☐	☐	☐

Are there any important drivers missing? If so, please list them here.

Do you have any comments on the drivers listed above?

Page 5: Actions

Talking about change in one thing, now it is time to start delivering it! The Resource Recovery from Waste network consists mainly of companies, governmental organisations and universities. We are keen to help our partners deliver change and recommend actions that they could take to promote resource recovery. We are also happy to take on board any actions that other types of actors should take.

7. What are the most important **actions** that companies, government and academia need to take to support resource recovery as part of the circular economy in the UK?

Please specify for the following types of actors:

What are the most important **actions** that **companies** should take? Required

What are the most important **actions** that **government** should take?

What are the most important **actions** that **academia** should take?

Are there any **other organisations** that need to take **action**? If yes, then please specify the type of organisation(s) and your recommended action(s):

Page 6: Final remarks

8. Is there anything else that you would like us to take on board as part of this study?