



## Resource Recovery from Waste

### Science and Implementation Plan 2012-2018

#### 1. Summary

The vision of the *Resource Recovery from Waste* programme is to lead the delivery of the strategic science needed to accomplish a paradigm shift in the recovery of resources from waste that is driven by environmental benefits (integrated across air, soil and water resources, and biodiversity) and for human health, and not by economics alone. Further, the programme will forge new thinking that goes 'beyond carbon'<sup>1</sup> to understand *waste as a resource* from the perspective of ecological not carbon outcomes.<sup>2</sup> This programme contributes to NERC's Sustainable Use of Natural Resources (SUNR) and Environment, Pollution and Human Health (EPHH) strategic themes.

The intention of this programme is to encourage applicants to bring forward innovative, ambitious, and creative research ideas and approaches for issues which look beyond 2020; and to encourage a paradigm shift such that the considerations of benefits for, and minimising impact on, the environment and human health are carried out effectively and become fully integrated into society globally. Thus, the intent is to move away from a purely economic focus for recovering resources from waste to a 'whole systems approach'; economic viability is important, but there is also the inclusion of the ecosystem service concept and of potential impacts. This incorporates the notion of 'GDP plus'<sup>3</sup> and encourages applying the principles of 'responsible innovation'<sup>4</sup>. It also means that there is understanding of benefits and dis-benefits, and trade-offs and values.

The *Resource Recovery from Waste* programme will run over five years with a total value of £6.5 million: £1 million was used for capacity building with the development of collaborative bids through a programme of Catalyst Grants (14 funded at £50-100k and running for six months from April 2013) to be carried out in advance of larger Research Grants with a budget of £5m (each being £500k-£1m and running for three years from June 2014). The Research Grant phase also has up to an extra £1 million available from the Economic and Social Research Council (ESRC) to support these aspect of the programme.

This *Science and Implementation Plan* details the science and method of execution of the *Resource Recovery from Waste* research programme. This plan is a 'living document' which will be updated periodically to develop the science research required and the strategy to deliver that research, as well as to address plans for programme coordination and Knowledge Exchange activities.

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<sup>1</sup> Aldersgate Group 2010. *Beyond Carbon*, 32p.

<sup>2</sup> Institute of Civil Engineers 2011. *State of the Nation: waste and resource management*, 20p.

<sup>3</sup> Where countries incorporate both traditional measures of GDP and measures of natural capital.

<sup>4</sup> Where the innovators must engage with the environmental, health and social impacts of the technologies under development, deliver benefit and identify and mitigate risks in the process.

## 2. Background

### 2.1. Importance to NERC

The *Resource Recovery from Waste* programme is designed to address the ambition in the NERC Strategy relating to waste which states: “Globally, society needs to understand how exploiting resources could affect the environment, including the impact of their waste products, and how this can be managed so as to live within the Earth’s environmental limits.”<sup>5</sup>

This programme finds its roots in the Sustainable Use of Natural Resources (SUNR) and the Environment, Pollution and Human Health (EPHH) themes. For the SUNR theme, the strategic objective is to provide the science to optimise the use of renewable and non-renewable natural resources whilst living within the Earth’s environmental limits, with this programme central to delivering against Challenge 1<sup>6</sup>. The EPHH strategic objective is to reduce the burden of human disease linked with environmental causes, and to anticipate new threats to public health before they become serious. This programme is relevant to EPHH Challenges 2<sup>7</sup>, 3<sup>8</sup> and 4<sup>9</sup>. This programme has become a priority area now because in the transition to a low carbon economy, resource recovery from waste is strategically important.

### 2.2. Subject background

In 2010, UNEP estimated 11.2 billion tonnes of solid waste from across all sectors was collected.<sup>10</sup> This figure does not take into account waste which is not collected which may be very significant, thus waste volumes are likely to be even greater. Even with this already large volume, waste produced every year is increasing and will continue to do so as global population rises. Given a growing global population that is matched by highly dynamic product development for human needs, current solutions to waste management reliant on disposal are unsustainable.

Despite recent technological advances, however, there is limited recovery of physical resources (e.g. nutrients, minerals) from waste (recovery of energy through incineration with heat and/or electricity generation, or anaerobic digestion to create biogas, conversely, is becoming commonplace in research demonstration projects and this is filtering into commercial activities). There may also be opportunities to take advantage of natural processes for resource recovery from waste which have yet to be explored. Decisions about the types of resources to recover and the processes used to manage wastes, however, rarely start from considering the best options for the health of the environment; partly because quantitative evidence on the impact of new technologies on which to base decisions is lacking at appropriate scales or across science disciplines. As a consequence, the anticipated environmental gains and their contribution to society (e.g. reduced air pollution, increased biodiversity) remain unclear.

With the encouragement of growth, GDP and jobs, there is limited knowledge about the future impacts of current practises for waste management and product production. Furthermore, new materials are entering the production cycle which means potentially significant resources are not being recovered and the residual wastes continue to change; all of which means there may be unknown biospheric feedbacks and potentially hazardous contaminants. Not only are there products now which will become the waste of the future, there are also future products which may only be in the early concept phase; there may be opportunities to anticipate future waste from these.

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<sup>5</sup> <http://www.nerc.ac.uk/about/strategy/ngscience.asp>

<sup>6</sup> “predicting environmental impacts of the whole lifecycle of resource exploitation”

<sup>7</sup> “Improve knowledge of processes and models of the dynamics of transport and transformation of pollutants and pathogens in the environment”

<sup>8</sup> “Improve assessments of pollutant and pathogen exposure and risk to humans”

<sup>9</sup> “Understand the impacts of waste management activities on the environment and human health”

<sup>10</sup> [http://www.unep.org/greeneconomy/Portals/88/documents/ger/ger\\_final\\_dec\\_2011/Green%20EconomyReport\\_Final\\_Dec2011.pdf](http://www.unep.org/greeneconomy/Portals/88/documents/ger/ger_final_dec_2011/Green%20EconomyReport_Final_Dec2011.pdf)

Beyond the drivers listed, there may also be currently unimagined future challenges (political, economic, social, technological, legal, environmental) which could further exacerbate issues. For example, if there were a ban on biodegradable waste being sent to landfill, there may be a driver to recover further resources from such a waste.

NERC aims to drive *innovation for the green economy* but resource scarcity is an increasing threat to future economic development globally and, in particular, a real challenge for the manufacturing industries. Resource scarcity also sits in the context of changing climates and increasing issues surrounding food, energy and water security for the human population.<sup>11</sup> Meeting global challenges on natural resource use depends on a twin-track approach that finds new ways to use existing natural resources coupled with new approaches to extract further use from waste materials.

Globally, the waste management sector produced 3-5% of total anthropogenic greenhouse gas emissions in 2005 from treatment and disposal, a relatively minor contribution. However, this sector is in the position to have the opportunity to move from being a minor source to a major saver by preventing and recovering of resources from waste which would avoid emissions from all other sectors.<sup>12</sup> This could be a very positive output of a change in thinking where waste is a resource.

The health of humans is intrinsically linked to the health of the environment and the services provided from it. Use of waste as a resource can present the opportunity for contaminants, including persistent chemicals, to pass into the ecosystem and subsequently into the human food chain or through the contamination of land and air. For example, changes to current practise such as disposal of sewage sludge to agricultural land is suggested to lead to both the promotion of antibiotic resistance in bacterial populations and to human exposure to pathogenic organisms through the food chain.<sup>13</sup>

There are a number of conceptual starting points of relevance to the *Resource Recovery from Waste* programme, including the ‘waste hierarchy’<sup>14</sup>, ‘industrial ecology’<sup>15</sup>, ‘circular economy’, ‘closed-loop’ and ‘zero waste’<sup>16</sup>, amongst others. Although progress has been made in researching these areas, much remains a theory and advances in science are needed because the current conceptual framework fails to account fully for emissions to the biosphere during the process which might have major implications for the environment and health.

### 3. Programme details

#### 3.1. Vision

The vision of the *Resource Recovery from Waste* programme is to deliver the strategic science needed to accomplish a paradigm shift in the recovery of resources from waste that is driven by environmental benefits (integrated across air, soil and water resources, and biodiversity) and for human health, rather than by

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<sup>11</sup> Throughout 2008 and 2009 Professor Sir John Beddington, the Government Chief Scientific Advisor, raised the concept of the “Perfect Storm” of food/water/energy security in the context of climate change, gaining considerable media attention and raising this as a priority in the UK and internationally.

<sup>12</sup> <http://www.unep.org/ietc/Portals/136/Publications/Waste%20Management/Waste&ClimateChange.pdf>

<sup>13</sup> <http://thewatchers.us/myths/Myth-4-antibiotic.pdf>

<sup>14</sup> The waste hierarchy (in priority order): (a) prevention; (b) preparing for re-use; (c) recycling; (d) other recovery, e.g. energy recovery; and (e) disposal. See <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:312:0003:0030:EN:pdf>

<sup>15</sup> Collier & Alles 2010. Materials Ecology. Science 330: 919-20. Clift 2001. Clean Tech. & Industrial Ecology. In: Pollution: Causes, Effects & Control, Harrison (Ed), RSC.

<sup>16</sup> Coined by the company Zero Waste Systems Inc. (ZWS)

economics alone. The programme will also forge new thinking that goes ‘beyond carbon’<sup>17</sup> to understand *waste as a resource* from the perspective of ecological rather than carbon outcomes.

### **3.2. Philosophy**

Although the term ‘waste’ is in the title of the programme, the aim is to think more about ‘resources’ from waste, and changing thinking to consider potential new resources. The concept of the programme is encompassed by broader terms such as ‘resource efficiency’, ‘sustainability’, ‘circular economy’, but this programme should have an explicit focus on reducing pressure on natural resources by recovering resources from ‘waste’ in a way that benefits the environment.

The programme encourages a ‘whole systems approach’ to thinking about the emissions to the environment that occur during these processes, in order to understand the risks and benefits and trade-offs. Taking crop residual straw as an example: it can be ploughed back into the ground; it can be used as an energy source through incineration or co-digestion; and it can be a feedstock for industrial biotechnology processes that extract valuable chemicals. In making a decision about which option to pursue, a systems approach would consider the land, water, energy, nutrients and resources used in growing the crop and the various resource-recovery process options. It would also consider the inevitable emissions to air, land and water, and aim to predict the potential transport, fate and consequences to the environment and people’s health. This is what is referred to as an ‘ecological, beyond carbon, perspective’.

The timeframe that the programme will consider is post-2020. The principles of ‘responsible innovation’ will be applied to support the development of the business models and technologies needed.

### **3.2. Anticipated outcomes**

The programme will deliver new cross-disciplinary science that advances understanding of the dissipation of waste in the environment through the consumption of natural resources. Strategically, new approaches to waste management are needed that are ‘upstream’ from the end of life of many substances if we are to move towards ‘zero waste’ without potential risk to the health of the environment and humans. Predictive science illustrating the likely positive and negative implications for the environment of future technologies is important given the value placed on technological solutions to meet pressures from population growth and climate change.

## **4. Research scope**

### **4.1. Areas in scope**

The intention of this programme is to encourage applicants to bring forward **innovative, ambitious, and creative research ideas and approaches for issues which look beyond 2020**; and to encourage a paradigm shift such that the considerations of benefits for, and minimising impact on, the environment and human health are carried out effectively and become fully integrated into society globally. Thus, the intent is to move away from a purely economic focus for recovering resources from waste to a “whole systems approach”; economic viability is important, but there is also the inclusion of the ecosystem service concept and of potential impacts. This incorporates the notion of ‘GDP plus’ and encourages applying the principles of ‘responsible innovation’. It also means that there is understanding of benefits and dis-benefits, and trade-offs and values.

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<sup>17</sup> Aldersgate Group 2010. Beyond Carbon, 32p.

There is no restriction on the habitat or ecosystem which can be investigated (terrestrial, freshwater, marine, atmospheric etc.), and the programme is not specific to a UK, Europe, international or global focus.

Applicants may choose to approach the research topic:

- through fieldwork;
- through lab work;
- through desk based approaches such as modelling (although models should be driven by specific challenges) and meta-analyses;
- by focussing on one particular country/location/habitat/ecosystem;
- by development of conceptual thinking;
- by quantifying risks and opportunities for the environment and health of exploiting a particular waste as a resource;
- by looking at one particular sector;
- by looking at links between sectors;
- by looking at new and emerging technologies;
- by making a comparison of different wastes/different potential resources/different sectors/different approaches;
- by looking at new wastes;
- by developing new metrics;

This list is not exhaustive. The approach and focus of projects are open for applicants to decide, providing they respond to the statement at the beginning of this section and are within NERC remit and for those with social science elements, these are required to be within ESRC remit, as well as within the scope of the programme. The social science elements of proposed Research Grants should constitute no more than 25% of the whole project.

The addition of social and economic perspectives to the programme gives real potential to realise the “whole system” comparison aspired to in this initiative. A socially aware perspective on the issues may increase the potential to produce research outputs that can integrate into society and be taken up by users of the research. It is therefore ESRC and NERC’s belief that integration of the social sciences, where appropriate, can dramatically improve the potential for this initiative to contribute to a real paradigm shift.

The successful Catalyst Grants set the initial scope of this programme and can be seen in annex 1. Following award of the Research Grants, this scope should become clearer.

#### **4.2. Areas outside of scope**

Municipal solid waste is not to be the *focus* of a project because there is much activity going on elsewhere and therefore more research in this area will not result in the paradigm shift which is the vision of the programme. However, lessons could be learned (e.g. applications of technology, systems, etc.) and even parts of a proposal could be included, providing that this is not the focus.

Radioactive waste has been excluded from programme because it is covered in the NERC Radioactivity and the Environment (RATE)<sup>18</sup> Research Programme.

NERC and ESRC reserve the right to exclude applications outside remit beyond this list, as appropriate.

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<sup>18</sup> <http://www.nerc.ac.uk/research/programmes/rate/>

## 5. Programme activities

The focus of the *Research Recovery from Waste* programme in the early stages is very open and broad. Therefore, it is necessary to have a series of activities which help the community, in the first instance the Catalyst Grants, which allow preparation towards the main research activity by bringing together the right interdisciplinary teams. This will also help refine the research scope for the later phase.

### 5.1. Programme timeline

|                                         |                                          |
|-----------------------------------------|------------------------------------------|
| Catalyst AO published                   | 17 <sup>th</sup> October 2012            |
| Closing date for Catalyst Grants        | 12 <sup>th</sup> December 2012, 16.00hrs |
| Assessment panel for Catalyst Grants    | February 2013                            |
| Catalyst Grant awards offered           | February 2013                            |
| Catalyst Grants begin                   | April 2013                               |
| End of Catalyst Grants                  | October 2013                             |
| Invitation to Research Grant submission | 4 <sup>th</sup> October 2013             |
| Closing date of Research Grant call     | 28 <sup>th</sup> November 2013           |
| Moderating panel of Research Grant call | March 2014                               |
| Research Grants offered                 | March/April 2014                         |
| Research Grants begin                   | June 2014                                |
| Research Grants end                     | June 2017                                |
| End of programme activity               | June 2017 – March 2018                   |

### 5.2. Catalyst Grants

As with many of the environmental challenges facing society, resource recovery from waste will require researchers to collaborate across disciplines and will probably need a degree of capacity building. The Catalyst Grants will bring researchers together from different disciplines to start building potential research teams. By the end of the programme, we expect to see a community from different disciplines able to sustain research in this area. NERC and ESRC have experience in bringing together such communities, as has been exhibited by the several environment and health programmes (for example, Environment and Human Health, Environmental Exposure and Health Initiative, Environmental and Social Ecology of Human Infectious Diseases) which have been successful in bringing together environmental expertise and health expertise. This community may choose to bring their expertise to the *Resource Recovery from Waste* programme.

Catalyst Grants are aimed at enabling researchers to develop realistic and relevant research partnerships across disciplines and research strategies with the potential for significant national/international impact. These grants will allow researchers to build partnerships and to develop proposals. Catalyst Grants are not intended to support research projects, but may support some preliminary research activity. Such activities are necessary in order for the Research Grants, which will follow in the next phase, to get started with minimal amounts of background work at the start of the main research activity. Thus, all Catalyst Grants are essentially a 'platform' for the Research Grants. The focus is to encourage innovative thinking so that applicants bring forward novel and creative research ideas and solutions for this topic area. Although no requirements are specified, partnerships with industry are encouraged, as are interdisciplinary collaborations (although these do not necessarily have to be from different institutions).

The Announcement of Opportunity (AO) for the Catalyst Grant call was released in October 2012 and closed in December 2012. The proposals were assessed by an expert panel, who made recommendations to the Programme Executive Board (PEB) for funding.

Projects are between £50 and £100k (80% FEC) and run for 6 months from April 2013. The budget of this round was up to £1 million. Fourteen Catalyst Grants were awarded and can be seen in annex 1.

Successful application for a Catalyst Grant will be a pre-requisite to eligibility for Research Grants. NERC reserved the right to open the call to further Expressions of Interest prior to opening the call for full Research Grant proposals if the portfolio of Catalyst Grants failed to cover sufficiently the high priority areas for the programme. However, in April 2013 the Science Advisory Group (see below) discussed whether this was necessary and concluded that within the constraints of the funding available and considering the programme is driven by environmental and health benefits, there was sufficient science within the breath of the funded Catalyst Grants and therefore it was not recommend that the Research Grant stage be opened to further Expressions of Interest.

### **5.3. Research Grants**

The call for the main Research Grants is a “closed” call, i.e. open only to those with funded Catalyst Grants.

Funds available for the main Research Grant round will be £5 million with up to an additional £1m available from ESRC. Individual awards are expected to be in the range of £500k and £1.2m at 80% FEC. Projects will be no more than three years in duration and should begin by June 2014. There will also be a central fund of money for programme level KE and coordination (see section 8.).

Inclusion of social science research content is not a pre-requisite of this call, and applicants who chose not to further develop the social science elements of their Catalyst project will not be penalised.

The Research Grant applications will be externally peer reviewed, including an applicant response stage and moderating panel. The moderating panel will make recommendations for funding to the PEB.

## **6. Programme management**

The roles and responsibilities of the groups are detailed below.

### **6.1. Programme Executive Board**

The *Resource Recovery from Waste* programme will have a Programme Executive Board (PEB). The PEB is the executive decision making body for the programme and provides the overall strategic direction. In the execution of this role, it is advised by the Programme Advisory Group initially and then the Science Advisory Group, and during the Research Grants phase, the KE and coordination team. The membership of the PEB includes NERC management, ESRC management and the Chair of the Science Advisory Group and can be expanded to include other funders if they choose to join the programme.

### **6.2. Programme Advisory Group and Science Advisory Group**

A Programme Advisory Group (PAG) advised the PEB on the delivery of the *Resource Recovery from Waste* programme during the development prior to the Catalyst Grant phase. The PAG consisted of experts, including representation from end users and linked programmes (the NERC Mineral Resources Research Programme, the EPSRC Resource Efficiency Sandpit). The PAG worked closely with the PEB and the Management Team. The PAG was appointed by NERC by Q3 2012/13.

The key responsibilities of the PAG were to:

- advise on setting programme scope and objectives in a Science and Implementation Plan, and how to ensure their execution;

- advise on the strategic direction of the programme, including specification of the scientific content of published announcements of opportunity;
- advise on the development of collaborative activities including emerging and future opportunities in the UK and internationally;
- advise on the development of user engagement;
- advise on appropriate ways to monitor and evaluate the progress of the programme towards its purpose and goals;
- advise on the progress and success of the programme in meeting its purpose and goals;
- via the Chair, report as required to NERC.

The Terms of Reference for the PAG can be found in annex 2.

Members of the PAG may also participate in the assessment and moderating panels for review of applications.

At the Catalyst Grant phase, the remit of the programme was very broad and the call for these grants avoided prescription and looked for the community to respond with novel ideas. Due to this wide scope, expert scientific advice was also required to advise on the direction of the programme. The PAG provided this in the very early stages of the programme, but a smaller and more focussed Science Advisory Group (SAG) was called on for this particular function during the Catalyst Grant phase and prior to the start of the Research Grants. The membership of the SAG is a minimum of four individuals which represent key expertise and include cross over with the PAG membership (but avoids conflict of interests with Catalyst Grants). Membership will be assessed during the lifetime of the SAG and additional members may be invited if thought necessary. The SAG was appointed by NERC by Q1 2013/14. Specifically, the SAG advised on the scope of the Catalyst Grant proposals; the Catalyst Grant proposal fit to the programme; the best way to draw the programme together; how best to bring in users of the research; specifications of the Research Grant phase; and appropriate ways to monitor and evaluate the progress of the programme towards its purpose and goals. They aid the MT in carrying out activities to achieve these aims. The SAG will remain in place until the award of the Research Grants so that they may make final recommendations to the PEB for requirements and mechanisms for the KE and Coordination funds. Individual SAG members may be invited to additionally serve as reviewers or on moderating or selection panels to evaluate Research Grant proposals. The Terms of Reference for the SAG can be found in annex 3.

### **6.3. Management Team/Programme coordination**

The Management Team (MT) will be responsible for administering the programme. This group is run from NERC Swindon Office. Activity will involve: coordinating the production and publishing of a Science and Implementation Plan and Announcement of Opportunities; administration of the grants process; coordinating the PAG; day-to-day management of the programme. This group will report to the PEB. The MT may seek advice from others, including the Environmental Sustainability Knowledge Transfer Network (ESKTN), the Chemistry Innovation KTN (CIKTN) and the NERC Knowledge Exchange team, as appropriate.

### **6.4. Programme and Knowledge Exchange coordination**

During the Catalyst Grant phase (June 2013), the successful grants were brought together at a workshop. The purpose of this workshop was:

- 1) to provide information to Catalyst Grant holders about what will be required and what expectations are for the full Research Grants stage;
- 2) to allow grant holders to ask NERC questions about the specifics of the Research Grant stage;
- 3) to facilitate networking between individual Catalyst Grants for opportunity to join up between grants with cross over in activities;

- 4) to allow grant holders to hear a view from key stakeholders' on recovering resources from a variety of waste streams so that they may understand where their research may add value and identify translation opportunities; and
- 5) to enable stakeholders and grant holders to network and work together as part of the Resource Recovery from Waste programme and beyond.

A wider group of stakeholders and funders were also engaged throughout the Catalyst phase by the MT.

Once the Research Grants have been funded, the successful teams will be brought together to develop plans for programme-wide coordination and KE activities. There will be a separate budget for these coordination and KE activities, and Research Grant holders will be required to participate in these centralised programme activities. The SAG will advise on the best method to deliver this following award of the Research Grants. Note that individual projects will still be required to have their own Pathways to Impact plans which are separate to this centralised activity.

### **6.5. Assessment panels**

Assessment panels will be assembled to undertake the assessment of the Catalyst Grant proposals and to moderate the external reviews of the Research Grant proposals. They will consider both quality of the proposed activity and their ability to deliver the requirements of the *Resource Recovery from Waste* programme. These groups will consist of national and international experts in the field, representatives from the PAG and a member of the NERC Peer Review College for benchmarking. These assessments will inform the PEB's decisions on the award of funding to deliver the programmes vision. There will be a separate panel for the assessment of the Catalyst Grant applications and the Research Grant applications, but overlap in membership is likely.

## **7. Key opportunities**

### **7.1. Multi- and interdisciplinary working**

Promoting interdisciplinary working between different research and end-user communities will be fundamental to the programme's success. There are clear opportunities for innovation, as an example of one element of this programme, through the academic, government and industrial partnerships.

There is the opportunity to interact with activities in other Research Councils, as well as with other research programmes (see section 7.2.) and bring environmental expertise to these other initiatives. This is something which will be sought both at the programme level and for applicants in individual projects.

Furthermore, industry and agency partnerships will be essential to the development and success of the programme leading to conceptual and technological advance with measurable environmental benefits. It is envisaged that these groups may have interest in individual project participation and seeking these partnerships is something which is actively encouraged for applicants. In addition to financial partnership, assistance could also be in the form of providing access to data, materials or a research sites. These partnerships must be meaningful to enable those who have the influence to change policy and practice around resource management in government and the private sector.

### **7.2. Other investments**

It is recognised that there are a number of initiatives in this area already underway or in planning and it is not intended that this programme will duplicate these efforts. Moreover, as a NERC and ESRC funded programme, the focus of projects should clearly be within NERC and ESRC remit, although NERC and ESRC

recognise the added value of interacting with other initiatives. Therefore, if there is an opportunity to add value to a project, either by bringing environmental disciplines to existing activity or by identifying gaps of relevance to NERC/ESRC, or for the numerous NERC/ESRC programmes, providing interfaces and expertise of relevance to projects, then this needs to be clearly articulated by applicants. Furthermore, there may be an opportunity for these interactions and interfaces at the programme level and this will be clearly articulated in the forward plan once it becomes clear following Research Grant awards. Some identified initiatives include (this list is not necessarily comprehensive):

- EPSRC Engineering Solutions for Resource Efficiency<sup>19</sup> programme
- EPSRC Waste, Water and Land Management cluster<sup>20</sup>
- EPSRC Resource Efficiency<sup>21</sup> research area
- Waste and Resources Action Programme (WRAP)<sup>22</sup> funded by Defra
- The Waste, Resources and Sustainable Consumption Evidence (WReSCE)<sup>23</sup> programme (a collaboration between Defra, the Environment Agency, WRAP and Welsh Government)
- ESRC's The Waste of the World<sup>24</sup> research programme
- BGS Minerals and Waste<sup>25</sup> theme/programme
- The Environmental Sustainability Knowledge Transfer Network (ESKTN)
- TSB competition "The Great Recovery"<sup>26</sup>
- TSB's Future Cities Catapult<sup>27</sup>
- BBSRC/TSB's Networks in Industrial Biotechnology and Bioenergy (NIBB)<sup>28</sup>
- Global Food Security<sup>29</sup> programme Resource Efficiency research theme
- RCUK Energy Programme<sup>30</sup>
- NERC Security of Supply of Minerals<sup>31</sup> (SoS Minerals) research programme and the associated ESKTN run Minerals Network<sup>32</sup>
- NERC Macronutrient Cycles<sup>33</sup> research programme
- NERC Valuing Nature Network<sup>34</sup>
- NERC Environmental Nanoscience Initiative<sup>35</sup> research programme
- NERC Environment and Human Health<sup>36</sup> research programme
- NERC Environmental Exposure and Health Initiative<sup>37</sup>
- MRC Environmental and Social Ecology of Human Infectious Diseases<sup>38</sup>

There are likely to be other investments which can be built upon beyond this list, both in the UK and internationally. These could be considered by applicants, and the PEB, SAG and MT will discuss any other initiatives where links might be needed at the programme level.

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<sup>19</sup> <http://www.epsrc.ac.uk/funding/calls/2012/Pages/engineeringsolutionsforresourceefficiency.aspx>

<sup>20</sup> <http://www.epsrc.ac.uk/ourportfolio/themes/engineering/activities/sue/Pages/waste.aspx>

<sup>21</sup> <http://www.epsrc.ac.uk/ourportfolio/researchareas/Pages/wasteandpollution.aspx>

<sup>22</sup> <http://www.wrap.org.uk/>

<sup>23</sup> <http://www.defra.gov.uk/publications/2011/06/14/pb13543-collaborative-waste-resources/>

<sup>24</sup> <http://www.thewasteoftheworld.org/>

<sup>25</sup> <http://www.bgs.ac.uk/research/minerals.html>

<sup>26</sup> <http://www.greatrecovery.org.uk/>

<sup>27</sup> <https://connect.innovateuk.org/web/future-cities-special-interest-group>

<sup>28</sup> <http://www.bbsrc.ac.uk/IBnetworks>

<sup>29</sup> <http://www.foodsecurity.ac.uk/>

<sup>30</sup> <http://www.rcuk.ac.uk/research/xrcprogrammes/energy/Pages/home.aspx>

<sup>31</sup> <http://www.nerc.ac.uk/research/programmes/minerals/>

<sup>32</sup> <https://connect.innovateuk.org/web/security-of-supply-of-mineral-resources>

<sup>33</sup> <http://macronutrient-cycles.ouce.ox.ac.uk/>

<sup>34</sup> <http://www.valuing-nature.net/>

<sup>35</sup> <http://www.nerc.ac.uk/research/programmes/nanoscience/>

<sup>36</sup> <http://www.nerc.ac.uk/research/programmes/humanhealth/>

<sup>37</sup> <http://www.nerc.ac.uk/research/programmes/eehi/>

<sup>38</sup> <http://www.nerc.ac.uk/research/programmes/esei/>

## 8. Knowledge Exchange

Knowledge Exchange (KE) will facilitate the communication of the science delivered from this programme to a variety of users including policy makers and industry, and exchange of views and knowledge from these stakeholders with a view to achieving the paradigm shift discussed above. There will be two levels of KE, at the project level through Pathways to Impact and at the programme level. KE is intrinsically linked to both the multi-/interdisciplinary partnerships and to associations with other investments (see section 7.).

For both the programme and project level KE, it will be required to **identify** the target communities/stakeholders, **consider** how these various groups/individuals are likely to benefit from (or be affected by) the research (this could include stakeholder mapping and analysis techniques to help this process), create a plan to **engage** with them which is **appropriate** (e.g. to reach industry, trade journals would be more appropriate than academic journals) and goes **beyond communication**, be **directional** (i.e. reach a specific person), **timely** (e.g. provide evidence to policy makers at a time when it is required for a specific decision) and happens **early** in the design stage. For both levels, evidence produced by this programme could potentially have the opportunity to feed into WRAP, WReSCE, Global Food Security and the RCUK Energy Programme, if appropriate, and interaction/exchange of information could help shape the programme and projects.

KE at the programme level will be combined with programme coordination during the Research Grant phase, with a budget that individual grants are required to bid into for centralised activities (see section 6.4.). These plans will be finalised once the range of topics and number of Research Grants are known. It is clear, however, that this activity should support activities to stimulate innovation and new collaborations, avoid duplication of effort and allow effective project alignment and interaction. This will foster programme integration, achieve added-value and the production of high-quality deliverables.

Individual projects will be required to submit a Pathway to Impact plan as part of the Research Grant application.

## 9. Data management

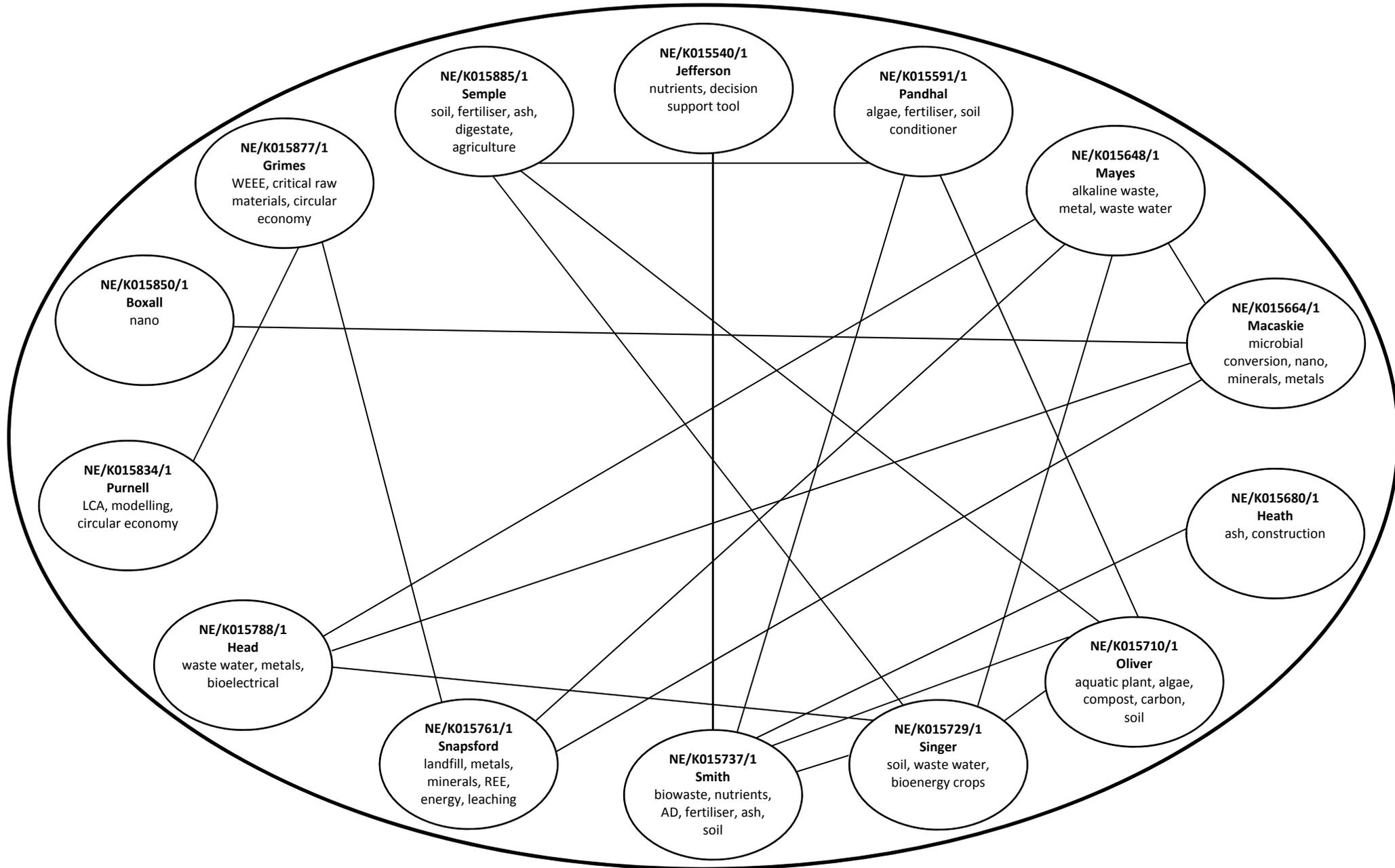
NERC requires that Research Programmes implement a data management scheme which covers practical arrangements during the programme and subsequent long-term availability of the data set. In line with the NERC data policy (<http://www.nerc.ac.uk/research/sites/data/policy.asp>), the data from the Programme will be lodged with the appropriate NERC Designated Data Centre. NERC puts an obligation upon PIs to ensure that data management is undertaken in a suitable way. A well-structured identification system is essential for data collection and experimental sample labelling.

Individual proposals should state data collection plans, staff responsibilities and data quality as part of their Data Management Plans. The funded project PIs (with assistance/guidance from the MT and PEB) will be responsible for agreeing the Programme's data management plan with the data centres and overseeing data management.

**Annex 1****Table.** Catalyst Grants funded as part of the Resource Recovery from Waste programme

| Reference    | Title                                                                                                                    | PI                                                      |
|--------------|--------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------|
| NE/K015540/1 | Nutrient recovery from waste: Identifying the path to responsible innovation                                             | Professor Bruce Jefferson, Cranfield University         |
| NE/K015591/1 | The potential to restore eutrophic freshwater systems in the UK with economic benefits                                   | Dr Jagroop Pandhal, University of Sheffield             |
| NE/K015648/1 | R3AW: Resource Recovery and Remediation for Alkaline Wastes                                                              | Dr William Mayes, University of Hull                    |
| NE/K015664/1 | Beyond Biorecovery: environmental win-win by biorefining of metallic wastes into new functional materials                | Professor Lynne Macaskie, University of Birmingham      |
| NE/K015680/1 | Bulk Use of Biomass and Co-fired Ash in Novel Binders                                                                    | Dr Andrew Heath, University of Bath                     |
| NE/K015710/1 | ReBALAN:CE - Recycling Biomass to Agricultural LAND: Capitalizing on Eutrophication                                      | Dr David Oliver, University of Stirling                 |
| NE/K015729/1 | Plant-mediated resource recovery-towards closing the waste water loop                                                    | Dr Andrew Singer, NERC Centre for Ecology and Hydrology |
| NE/K015737/1 | Recycling nutrient resources in waste for food security and environmental sustainability                                 | Professor Stephen Smith, Imperial College London        |
| NE/K015761/1 | In situ recovery of resources from waste repositories                                                                    | Dr Devin Sapsford, Cardiff University                   |
| NE/K015788/1 | Resource recovery from wastewater with Bioelectrochemical Systems                                                        | Professor Ian Head, Newcastle University                |
| NE/K015834/1 | C-VORR: Complex-Value Optimisation for Resource Recovery                                                                 | Professor Phil Purnell, University of Leeds             |
| NE/K015850/1 | Assessing the Environmental Costs and Benefits of Resource Recovery Approaches for Nanomaterials in Future Waste Streams | Dr Alistair Boxall, University of York                  |
| NE/K015877/1 | Transition of WEEE to the Circular Economy                                                                               | Professor Susan Grimes, Imperial College London         |
| NE/K015885/1 | Developing a suite of novel land conditioners and plant fertilisers from the waste streams of biomass energy generation  | Professor Kirk Semple, Lancaster University             |

Figure. Resource Recovery from Waste Catalyst Grants – subject cross over



## Annex 2



### **NATURAL ENVIRONMENT RESEARCH COUNCIL**

### **RESOURCE RECOVERY FROM WASTE**

### **PROGRAMME ADVISORY GROUP**

#### **Terms of Reference**

The purpose of the Programme Advisory Group (PAG) is to advise NERC on the strategic direction of the programme, integration of the programme science, and potential opportunities for impact. NERC will retain responsibility for how such advice is used.

In particular, the PAG is required to carry out the following tasks:

- advise on setting programme scope and objectives in a Science and Implementation Plan, and how to ensure their execution;
- advise on the strategic direction of the programme, including specification of the scientific content of published announcements of opportunity;
- advise on the development of collaborative activities including emerging and future opportunities in the UK and internationally;
- advise on the development of user engagement throughout the lifetime of the programme;
- advise on appropriate ways to monitor and evaluate the progress of the programme towards its purpose and goals;
- advise on the progress and success of the programme in meeting its purpose and goals;
- via the Chair, report as required to NERC.

#### **Vested Interests**

- NERC attaches great importance to protecting the integrity of members of Committees. All business of the PAG will be guided by Council's policy on vested interests.
- The Chair of the PAG must act in an entirely independent capacity and will not be eligible to apply for research funding from the programme.
- Members of the PAG who would ordinarily be eligible to apply for NERC funding, may submit an application to the programme as a principal investigator or as a co-investigator but will be required to leave meetings while that proposal is being discussed.

#### **Mode of Working**

NERC will determine the PAG's mode of working, its role and membership, reporting mechanisms, lifespan, etc.

- It is anticipated that the PAG will meet up to four times in the first year and work by correspondence in between meetings.
- The frequency of meetings in later years will be less, determined by NERC and the PAG as required.
- Individual PAG members may be invited to additionally serve as reviewers or on moderating or selection panels to evaluate programme research proposals.

### Annex 3



#### **NATURAL ENVIRONMENT RESEARCH COUNCIL**

#### **RESOURCE RECOVERY FROM WASTE**

#### **SCIENCE ADVISORY GROUP**

For context, Programme Advisory Group (PAG) Terms of Reference are provided. The PAG was disbanded and is to be replaced by the Science Advisory Group (SAG) as an evolved version of the PAG, with a specific and time-limited activity.

#### **Terms of Reference PAG**

The purpose of the Programme Advisory Group (PAG) is to advise NERC on the strategic direction of the programme, integration of the programme science, and potential opportunities for impact. NERC will retain responsibility for how such advice is used.

In particular, the PAG is required to carry out the following tasks:

- advise on setting programme scope and objectives in a Science and Implementation Plan, and how to ensure their execution;
- advise on the strategic direction of the programme, including specification of the scientific content of published announcements of opportunity;
- advise on the development of collaborative activities including emerging and future opportunities in the UK and internationally;
- advise on the development of user engagement throughout the lifetime of the programme;
- advise on appropriate ways to monitor and evaluate the progress of the programme towards its purpose and goals;
- advise on the progress and success of the programme in meeting its purpose and goals;
- via the Chair, report as required to NERC.

#### **Vested Interests PAG**

- NERC attaches great importance to protecting the integrity of members of Committees. All business of the PAG will be guided by Council's policy on vested interests.
- The Chair of the PAG must act in an entirely independent capacity and will not be eligible to apply for research funding from the programme.
- Members of the PAG who would ordinarily be eligible to apply for NERC funding, may submit an application to the programme as a principal investigator or as a co-investigator but will be required to leave meetings while that proposal is being discussed.

#### **Mode of Working PAG**

NERC will determine the PAG's mode of working, its role and membership, reporting mechanisms, lifespan, etc.

- It is anticipated that the PAG will meet up to four times in the first year and work by correspondence in between meetings.
- The frequency of meetings in later years will be less, determined by NERC and the PAG as required.

Individual PAG members may be invited to additionally serve as reviewers or on moderating or selection panels to evaluate programme research proposals.

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### **Terms of Reference SAG**

At the Catalyst Grant phase, the remit of the programme is very broad and the call for these grants avoids prescription and looks for the community to respond with novel ideas. Due to this wide scope, expert scientific advice will be required to advise on the direction of the programme. The PAG will provide this in the very early stages of the programme, but a smaller and focussed Science Advisory Group (SAG) will be called on for this particular function during the Catalyst Grant phase and prior to the start of the Research Grants. The membership of the SAG will be a minimum of four individuals which represent key expertise and include cross over with the PAG membership. Membership will be assessed during the lifetime of the SAG and additional members may be invited if thought necessary.

The SAG will advise on:

- the scope of the Catalyst Grant proposals;
- Catalyst Grant proposal fit to the programme;
- the best way to draw the programme together;
- how best to bring in users of the research;
- specifications of the Research Grant phase;
- appropriate ways to monitor and evaluate the progress of the programme towards its purpose and goals.

The SAG will aid the Management Team in carrying out activities (such as meetings/workshops) to:

- draw together grants;
- bring the researchers in contact with users.

### **Vested Interests SAG**

The SAG membership will not include individuals involved in any grants either in the Catalyst Grants or full Research Grants (including both successful grants and applications). This does not preclude colleagues from within the same organisation as of SAG members becoming involved as long as SAG members themselves do not become personally involved.

### **Mode of Working SAG**

NERC will determine the SAG's mode of working, its role and membership, reporting mechanisms, lifespan, etc. The SAG will report to the Resource Recovery from Waste Programme Executive Board (PEB) through the SAG Chair who will become a member of the PEB and work with the Resource Recovery from Waste Management Team.

- It is anticipated that the SAG will meet up to five times (planning meetings, workshop) and work by correspondence in between meetings.

Individual SAG members may be invited to additionally serve as reviewers or on moderating or selection panels to evaluate Research Grant proposals.

### **Timetable**

The main body of activity of the SAG will be during when the Catalyst Grants are active but the SAG will also provide advice for the Research Grant phase which can only happen once the successful Research Grants are known. Thus, the lifetime of the SAG will run until March 2014.

April 2013 – Catalyst Grants begin

April 2013 – SAG members invited and confirmed

April 2013 – First SAG meeting

June 2013 – Second SAG meeting

June/July 2013 – Catalyst Grant workshop

October 2013 – End of Catalyst Grants

October 2013 – Research Grant call opens

November 2013 – Closing date of Research Grant call

March 2014 – Moderating panel of Research Grant call

March 2014 – Research Grants offered

June 2014 – Research Grants begin

June 2017 – Research Grants end

#### Annex 4

##### Document version control

| Version | Date           | Approved by  | Reason for change                                                                                                                                                                           |
|---------|----------------|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1.1     | August 2013    | Lizzie Jones | Update changes since award of Catalyst Grants<br>Update plans for Research Grant phase<br>Update plans for programme KE and coordination<br>Add details of the Science Advisory Group (SAG) |
| 1.2     | September 2013 | Lizzie Jones | Minor edits                                                                                                                                                                                 |
| 1.3     | January 2014   | Lizzie Jones | Update following Research Grant call and ESRC involvement                                                                                                                                   |