

**SAC-WASTE (11) 01**

**14<sup>th</sup> June 2011**

# **Science Advisory Council Waste sub-group (SAC-Waste)**

## **Final Report**

**Paper: SAC-Waste (11) 01**

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**Published: 14<sup>th</sup> June 2011**

This is the final report of the SAC-Waste sub-group set up to advise and challenge the Defra Chief Scientific Adviser on maintaining and developing the evidence base underpinning waste, resources, and sustainable consumption policy.

Issues arising from this report and the work undertaken by the sub group were discussed at the SAC meeting on 17 February 2011.

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## 1. Introduction

In April 2009, the Science Advisory Council to Defra identified waste as a major area of policy, scientific interest and public concern in which it could make a useful contribution. A Sub-Group on Waste was established to examine the evidence base for Defra's Waste Strategy. The SAC-Waste Sub-Group is forward looking but does need to understand the current knowledge base in Defra so it can advise and challenge the CSA and the Department on maintaining and developing the evidence base underpinning waste, resources, and sustainable consumption policy. The terms of reference for the Sub-Group were finalised in February 2010.

In May 2010 the Sub-Group agreed a set of **objectives and actions** that needed to be followed through in order to meet the terms of reference. These are referred to throughout this document. The terms of reference, scope and objectives of the Sub-Group can be found at **Annex A**.

A list of SAC-Waste Sub-Group Members and their biographies are at **Annex B**.

## 2. SAC-Waste meetings and discussions

SAC-Waste has reviewed the evidence base for waste and Sustainable Consumption and Production (SCP) policy in Defra through a series of high-level meetings with Defra Officials and through the review of literature on waste published by Defra. This has been with a view to 'de-risking' Defra's future policies on waste. A list of meetings held and documents reviewed is at **Annex C**.

The SAC-Waste Sub-Group would like to thank Defra officials in the Waste and Sustainable Consumption and Production evidence and policy teams for the level of constructive engagement with SAC-Waste they have committed to, and for providing SAC-Waste with necessary documents.

## 3. SAC-Waste Interim Findings

This interim report is largely based on the Sub-Group's evaluation of the Government's Review of Waste Policy [call for evidence document](#) (published in July 2010), and is intended to provide evidence to this call. For ease of reference, the Sub-Group's response to this is framed in the context of the Sub-Group's objectives.

### 3.1. General comments on Waste and SCP programmes

3.1.1. The SAC-Waste group have made a series of general comments on the ways of presenting and communicating the complex scientific and technological issues underlying waste to the public. These also points are also relevant to objective 2 of the SAC-Waste Sub-Group, on behaviours.

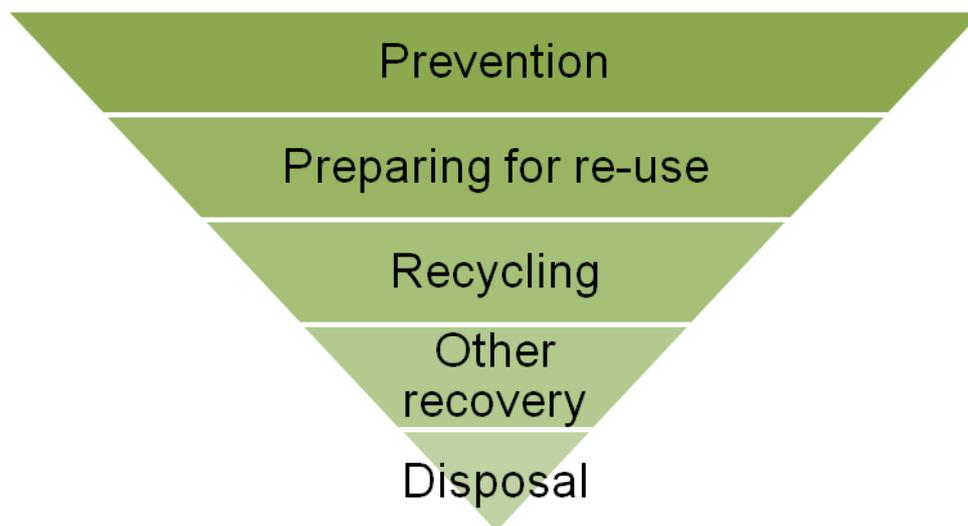
3.1.2. The call for evidence, as well as [Defra's Business Plan](#) (published November 2010) makes reference to a 'zero waste economy' – a term also used by the

Devolved Administrations - which, we understand, Defra takes to mean an economy in which no resources are wasted and where all resources are valued. The Sub-Group have noted that technically, achieving zero waste to landfill is impossible. The group has identified some risks in using the term. Firstly, it does not encompass the reality that materials get mixed and cross contaminated so that they become effectively unrecyclable after a number of cycles, and it therefore overlooks the importance of segregation of waste materials and components. Nor does it address issues of resource management and energy use. The reference to 'zero waste' creates some risk that such a target might cause achievable actions to be undervalued which might vitiate the radical action required to achieve practical reduction of waste (see also objective 2 in this document).

3.1.3. The Sub-Group considered whether, in order to develop a pathway to enable sustainable use of resources, the term 'waste' should not be in the Defra strapline. This is because the group considers the concept needs to be extended to consider the continuum of resource choice, use, reprocessing and reforming, and further use, before final disposal. This might be expressed in a more explanatory way in terms of the sustainable use of materials. However, we recognise that the term 'waste' has meaning to those Defra is trying to influence.

3.1.4. This also relates to Members' initial concerns over Defra's presentation of the Waste Framework Directive's (WFD's) waste hierarchy (Fig. 1, overleaf), where Members had suggested (1<sup>st</sup> July 2010) that rather than a focus on managing waste, focusing on preventing waste or using resources more efficiently can be more effective. The group were encouraged to see that the WFD waste hierarchy has been re-drawn to recognise that promoting waste prevention is the first step in the hierarchy, which they understand to be a reflection of the amount of attention Defra are paying to addressing and prioritising waste prevention and producer responsibility.

**Figure 1: Waste Framework Directive's Waste Hierarchy**



### 3.2. Carbon

3.2.1. Members have also noted that the call for evidence focuses heavily on carbon. SAC-Waste recognise that although describing any reduction in waste in terms of carbon saving is helpful cross-Departmental language; and picks up on the greater use by the public of terms such as “carbon footprint”; the term ‘materials security’ may be more useful as it would help the public to understand that resources are finite and should be used and managed more sustainably.

### 3.3. The Waste and Resources Evidence Programme (WREP)

**SAC-Waste Objective 1:** Identify the gaps, risks, and linkages in WREP (Waste and Resources Evidence Programme) work and the risks and uncertainties policy directions face by exploring existing data and links:

- Research commissioned by Defra (including the Environment Agency) which covers England and Wales

3.3.1. In identifying the gaps, risks, and linkages in WREP the Sub-Group were provided with a list of completed and ongoing projects from the Waste and Resources Evidence Programme (as at May 2010), and with the programmes’ draft evidence plans, which have been shared with the Department’s Chief Scientific Adviser.

3.3.2. From their investigations, the Sub-Group is reassured that the waste and SCP's programmes of research are broadly appropriate and comprehensive, but have identified some gaps and risks that they believe warrant further attention (outlined below).

#### 3.4. Research on Waste Streams

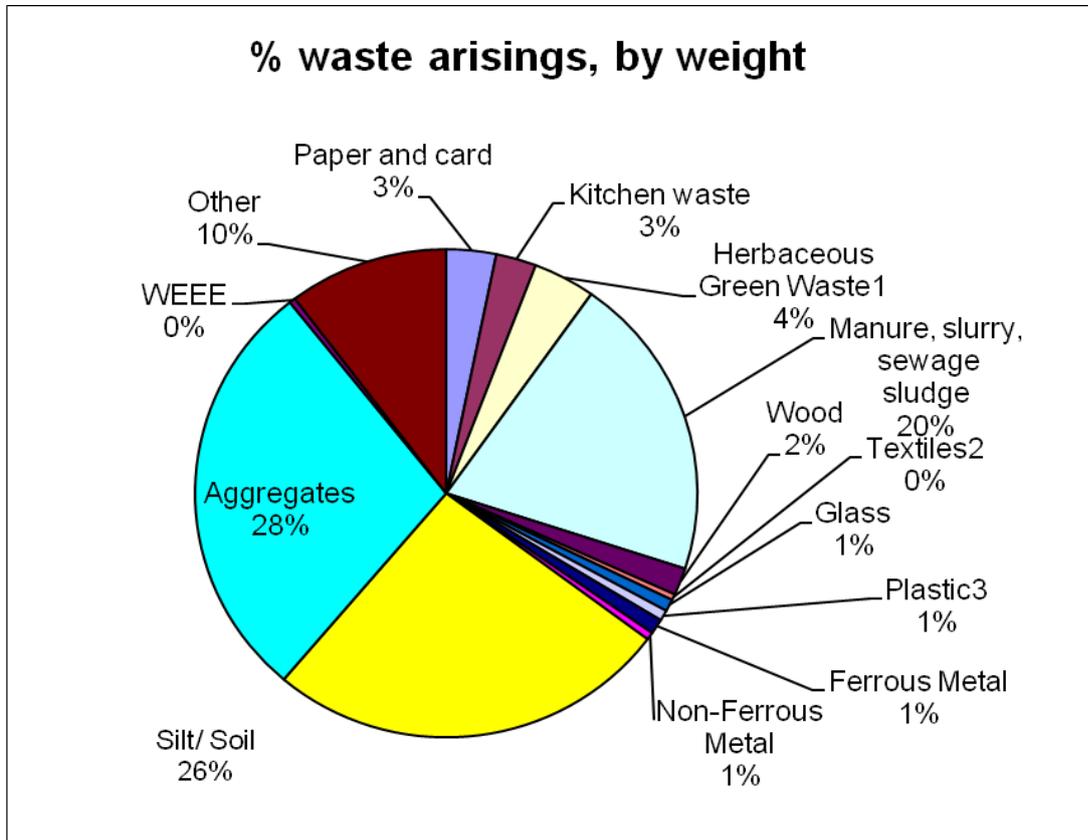
3.4.1. The sub-group observed that the standard classification of waste arisings by weight according to source suggests that undue emphasis is currently given to Municipal Solid Waste (MSW) which represents around 10% of the total. With the assistance of WRAP, Defra staff kindly prepared another representation of the data which attempts to throw light on the relative carbon impacts of different key components of the waste stream.

Taking the available waste composition data by sector (e.g. household, commercial, industrial etc.) and reclassifying it in terms of the key constituents (e.g. paper & card, food, aggregate, textiles etc.) gives the diagram presented at figure 2(a). This representation of the data excludes animal slurries (around 20% of the total) which are usually returned directly to land and a further 10% which includes end of life vehicles, fine fractions and chemicals which are usually managed separately from the 70% remaining. These percentages by weight are then expressed as global warming potential (GWP) of emissions over the whole life cycle of each constituent; the results are presented in figure 2(b). For simplicity, the analysis assumes a high cotton content for textile waste; a high polyester content would reduce the relative GWP of textile waste. No waste electrical and electronic equipment (WEEE) is included in the 70% of waste reclassified in Figure 2(b). WEEE represents around 2% of the whole life-cycle Greenhouse Warming impact of materials.

The results in figure 2(b) show that around 90% of the carbon impacts can be attributed to six main waste components: food waste, textiles, metals (non-ferrous and ferrous), paper & card and plastics. This confirms the importance of proper management of materials, including waste reduction, across all waste streams.

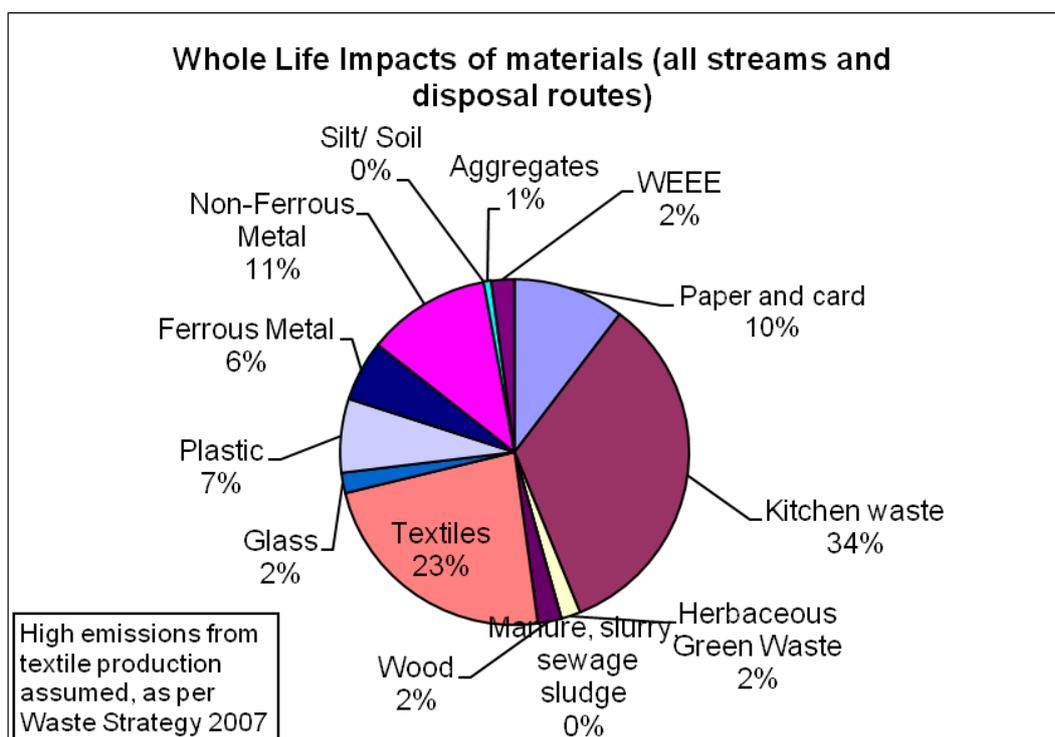
**Fig. 2: (a) Percentage of waste arisings by weight <sup>1</sup>and (b) Whole life cycle Greenhouse Warming impacts of materials (overleaf)**

**(a)**



<sup>1</sup> Data supplied from a range of research studies commissioned by WRAP and Defra between 2006 and 2010, but not taking into account the new Commercial and Industrial waste arisings figures published in December 2010.

(b)



3.4.2. The Sub-Group's view is that a more sophisticated approach to the analysis of specific material flows through the economy<sup>i</sup> is needed to provide the means for critical examination of supply chains of products and services. Once products have become waste, it would also be possible to track their fate and destination (using very low cost sensors) in a way that would not have been feasible 10 years ago. We recognise Defra's body of research on waste prevention and the fact that Defra and its partners have already identified the above need in former research plans. The time has come to progress the development of new research in these areas.

**3.4.3. Recommendation 1: Defra needs more complete and continuously updated information on the flows and fates of materials through the economy, so as to promote and plan policies for the avoidance of waste as well as for the management of future waste streams.**

### 3.5. Landfill

3.5.1. It is noted above that sustainable use of materials throughout the whole economy would require, among other things, engagement with businesses. Although landfilling tends to be regarded as inherently bad and to be avoided, there is evidence that in some instances, where materials cannot feasibly or economically be re-used or recycled, landfill may be the least environmentally, economically or

technically unsuitable option. Landfill can also be a way of storing materials that have a potential future value, and other countries already recognise the value of landfill mining. Landfill mining is already being undertaken in Israel and Sweden, and investigated in the UK. Defra could consider landfilling waste segregated by type or composition or planning landfills to be excavatable in future.

**3.5.2. Recommendation 2: Defra should consider the scope for future ‘mining’ of landfill sites for scarce materials, and for beneficial use of landfilling (possibly in segregated form) for storage materials which will become more scarce in future.**

3.5.3. One of the roles of SAC-Waste has been to question thinking and stimulate new approaches in the field of waste and SCP. The group are aware of evidence suggesting there is variable pressure on the availability of space for landfill in England. However, there has been a reduction in the amount of waste sent to landfill in recent years. The group would like to challenge whether this means that there is less cause for concern on space for new landfill sites than has been suggested, or if we are still likely to need new sites in the longer term if material consumption increases. The group recognise within this that judgements on where local authorities choose to send waste to landfill are made largely on economic grounds.

**3.5.4. Recommendation 3: Given the reduction in quantities of waste sent to landfill, Defra should review the need for current and future landfill sites, recognising also that some sites could be used for planned storage (see also recommendation 2).**

### 3.6. Availability of specialist expertise within core Defra

3.6.1. In terms of capacity, it has been noted that in the waste evidence plan skills table there is no mention of the need for engineering or operational research specialists in core Defra. This will reduce the scope of the evidence the Department procures and uses in support of policy-making.

**3.6.2. Recommendation 4: Defra should take the necessary steps to further strengthen in-house engineering and operational research expertise in the Waste/SCP evidence programmes, either through the recruitment of specialists to Defra (whilst recognising the staff recruitment constraints currently faced by the Department), or through the use of secondments, for example from a university or research council.** These internal experts also need to be widely networked to industry and academic colleagues.

### 3.7. Research on future technologies

3.7.1. Members noted with concern that the call for evidence document does not acknowledge that technologies will change dramatically during the period to 2050, possibly along with the composition of waste streams. This will have implications in particular for the technical capability of separating waste streams and, therefore, for the behaviour of industries and consumers (see also SAC-Waste objective 2).

3.7.2. It is highly likely that technology in future will be so effective at separating waste (in particular industrial and municipal solid waste) that efforts to persuade industries and the public to separate waste streams themselves would be less effective. This brings with it enormous implications around perception, particularly after so much work has been done to change behaviours in the public mind. Nevertheless if there are more efficient ways of achieving the separation of waste, it might be risky not to consider them.

3.7.3. Members have been encouraged by the work Defra is undertaking to develop future waste scenarios to 2020, 2030 with a view to 2050 (project WR1505), and have welcomed the chance to influence the development of this work, through attendance at a workshop (12 November 2010) and participation in the review of the draft scenarios. The Sub-Group invite Defra to reassure them that, as the work progresses, technological advances will be adequately accounted for in the development of these scenarios.

**3.7.4. Recommendation 5: Defra should commission a comprehensive prospective review of possible developments in waste arisings and relevant technologies, in order to ensure that decisions taken in the short term do not preclude policies and actions which could be desirable in future.**

### 3.8. Behaviour change – where to intervene in order to reduce waste

**SAC-Waste Objective 2:** Explore work on behaviours: past, present and future including attitude to risk (including commercial risk associated with using waste materials); separation for recycling.

3.8.1. There has been a major research focus within Defra on behaviour at individual and household levels, including some work at community level, but rather less within the supply chain or institutions. The work that has taken place tends to take a social psychological approach to behaviour. Causal factors of pro-environmental behaviours identified in work for Defra can be summed up as:

- Attitudinal factors such as values, beliefs, and norms
- Contextual factors such as external barriers and constraints

- Personal capabilities such as behaviour-specific knowledge and skills
- Habits and routines

3.8.2. The Sub-Group noted that Defra has established a joint research initiative with the Economic and Social Research Council (ESRC) on Sustainable Behaviours. The commissioning process was completed in March 2010 with contracts awarded for two Research Groups – one based at University of Surrey (SLRG), and one based at University of Manchester (SPRG). Additionally, there is another strand of work (not funded by Defra) being undertaken in Manchester at the Sustainable Consumption Institute. In some ways, and at the risk of some simplification, we feel that the two programmes of the two groups reflect different approaches to behaviour: the Surrey programme tends to be social psychological in orientation and the Manchester programme more sociological. Lessons can and should be learned from both and interactions between the two programmes are important to Defra’s evidence needs. In fact neither programme has a strong emphasis on waste per se, and we have been advised that work at Manchester in the Sustainable Consumption Institute on waste may be of greater direct relevance to Defra’s waste programme.

3.8.3. Overall, the Sub-Group has been encouraged by the investment Defra have made in the area of behaviours, and recommend:

**3.8.4. Recommendation 6: Defra should move beyond understanding behaviour in general terms to a focus on the effectiveness of specific schemes to increase recycling and reduce wastage.**

**3.8.5. Recommendation 7: Defra need to examine behaviours around supply and demand across the various supply chains for particular products, covering both public and private sector actors including organisations, to understand where and how waste is generated and identify possible points of intervention to reduce generation or promote re-use of waste by manufacturers and producers.**

**3.8.6. Recommendation 8: Defra should ensure that research on behavioural change is undertaken with a view to identifying policy implications and developing policy recommendations.**

**3.8.7. Recommendation 9: Defra should ensure that social psychological approaches to behaviour are complemented by other approaches, particularly sociological approaches which put more emphasis on the structural and institutional contexts of behaviour;** in other words rather more emphasis on the societal and political-economic context, linking to the ‘big society’, rather than the individual.

### 3.9. Anaerobic digestion (AD) and Mechanical Biological Treatment (MBT)

**SAC-Waste Objective 3:** Consider the science that may not be available currently but could be in the future and the impact this could have on e.g. the form and content of contracts:

- What is the risk from the output from Mechanical Biological Treatment (MBT)?
- What is the value of anaerobic digestion (AD)?

3.9.1 The concern behind this objective is to ensure that Defra can be sure that any contracts entered into are for technologies which will be viable for the duration of the contract. The Sub-group met with Defra policy officials to discuss these two approaches to waste management on 6<sup>th</sup> January 2011, and at the meeting were provided with a specially prepared document summarising evidence and current research on Mechanical and Biological Treatment (MBT) and Anaerobic Digestion (AD). We also note that Defra are represented on the cross-Whitehall steering group for AD Strategy and are funding a “gap analysis” on the evidence base, to include examples from research and experience elsewhere in the world. We support this approach, noting that there is much more experience elsewhere, notably in the EU, than in the UK, particularly with AD.

#### *Mechanical Biological Treatment (MBT)*

3.9.2 MBT depends on separating MSW into recyclables; constituents which can be processed into a solid fuel, Solid Recovered Fuel (SRF); compost-like output (CLO) and stabilised waste which is usually disposed to landfill. In some applications, organic waste is then treated by AD. The value of the recyclable components depends on their quality – usually mainly purity – and on the market for secondary materials which depends in turn on the incentives and barriers to re-use of wastes. Recommendation 7 of this report is therefore also relevant to MBT.

3.9.3 Efforts to develop markets for SRF have achieved some notable success, particularly in applications with combustion equipment which can accept a range of fuels; examples are cement kilns and some forms of CHP plant. Expansion of MBT will require further expansion of demand for SRF, and this in turn is likely to depend on construction of new plant. As a waste, SRF must be burnt in a WID-compliant facility. Even though the emissions from such plants are lower than from, for example, coal-fired plant, there is still some resistance to its use, just as there is to mass-burn of MSW, arising from these concerns and from a view that energy-from-waste represents a “lock-in” which inhibits waste reduction and recycling. Unless the market for SRF develops to accommodate the output from new MBT plant, some SRF may end up in landfill (as has happened elsewhere in Europe). Efforts therefore need to continue to develop markets for SRF to ensure that expansion of MBT does not outstrip demand.

3.9.4 CLO, the residual organic fraction from MBT, may be contaminated, most significantly with heavy metals, and by organics (most notably triclosan). The extent to which this limits its use as a true substitute for compost is a subject of current research. If there is no market for CLO, then it may merely go to landfill.

3.9.5 The Sub-Group thus considers that there may be technical and economic limits to the expansion of MBT. A particular route to be explored to avoid these limits may lie in co-firing of SRF with biomass, as a way to avoid the criticism of lock-in. This area lies within the concerns of both Defra and DECC.

**3.9.6 Recommendation 10: We recommend that efforts to develop markets for the output from MBT plants be continued together with the Department for Energy and Climate Change (DECC), in particular to promote solid recoverable fuel (SRF) along with biomass as complementary solid fuels. Markets also need to be identified and developed for compost-like output (CLO).**

#### *Anaerobic Digestion (AD)*

3.9.7 AD is a microbiological process which yields biogas, a fuel whose principal constituents are methane and carbon dioxide, and an organic residue with much in common with CLO. It is potentially applicable to food waste and other forms of organic waste including agricultural and abattoir residues. Defra has supported out a significant body of research on AD, including economic assessment and the behaviour of specific materials, and has set up an Anaerobic Digestion and Composting Research network to collect and disseminate information. Defra has also drawn up an AD Framework Document which will lead to an evidence based AD strategy. LCA studies have confirmed that the energy balance can be attractive, especially if the biogas is used as a fuel for Combined Heat and Power (CHP) generation; however, the viability of CHP depends on developing the market for low-grade heat. An additional area of concern is the resilience of AD to variations in feed compositions and consistency, although Defra research has found solutions to this resilience.

**3.9.8 Recommendation 11: We recommend that work initiated by Defra to explore the evidence for the pathways to the development of viable and sustainable technologies for AD is continued, to deliver an increasingly sound base for making decisions which have long term implications.**

#### 3.10 Links from the waste/SCP programmes to other programmes in Defra

**SAC-Waste Objective 4:** Explore the links to other programmes (e.g. energy and food and farming) and industry to establish where impact has been assessed.

3.10.1. The group were keen to hear about the work that has been tendered or is in the process of being tendered in support of the 'Sustainable use of energy in products' theme.

*NERC programme - 'Resource Recovery from Waste: Challenges for the Health of the Environment'*

3.10.2. The Sub-Group heard about the work being undertaken to establish 'actions' (projects) under this new programme at their meeting on 1<sup>st</sup> November 2010, from NERC champions Professors Louise Heathwaite and Roy Harrison. The group believes that this programme could be crucial in developing a longer term view of waste management in the context of changing practices with respect to waste management, the need for more resource recovery, the environmental consequences of energy recovery from municipal waste management, the treatment of wastewater, and how the paradigms of 'clean technology' and 'industrial ecology' influence process design.

**3.10.3. Recommendation 12: The SAC-Waste Sub-Group is strongly supportive of the work being initiated under the NERC programme on *Resource recovery from waste*. They recommend that, having assisted NERC scope this programme, Defra support the NERC champions in establishing the programme, which has the potential to yield useful insights on the environmental consequences of waste management in the longer term.**

3.10.4. The Sub-Group were surprised that the call for evidence document did not refer more explicitly to the links between waste and water and food both within Defra and between Defra and other Government Departments, and thought that this was something of a missed opportunity. Discussions with waste and SCP officials have reassured the Sub-Group that these links do exist, but are perhaps not being articulated clearly enough. The call for evidence made no reference to the role that technology and innovation could also play in the reduction of waste and promotion of SCP.

**3.10.5. Recommendation 13: In view of the cross-cutting nature of waste and sustainable consumption and production, SAC-Waste recommend that links to other Government Departments with responsibility for waste should be more clearly articulated in the development of future calls for evidence.**

## Terms of Reference (ToR), Objectives and Scope of the SAC-Waste Sub-Group

The SAC-Waste Sub-Group will advise and challenge the CSA on Defra's waste strategy by:

**ToR1:** *Reviewing and comparing the use of a range of evidence, including science, economics and social research, to support policy-making on material flow management, waste, resources and sustainable consumption;*

**Objective 1:** Identify the gaps, risks, and linkages in WREP (Waste and Resources Evidence Programme) work and the risks and uncertainties policy directions face by exploring existing data and links:

- Defra commissioned research (including Environment Agency) which covers England and Wales
- research commissioned by the Scottish Government (including SEPA)<sup>2</sup>

**Objective 2:** Explore work on behaviours: past, present and future including attitude to risk (including commercial risk associated with using waste materials); separation for recycling.

**ToR2:** *Acting as a challenge to Defra on maintaining and developing the evidence base and consideration of how this can be planned into future programmes, including the next Waste Strategy;*

**Objective 3:** Consider the science that may not be available currently but could be in the future and the impact this could have on e.g. the form and content of contracts:

- What is the risk from the output from Mechanical Biological Treatment (MBT)?
- What is the value of anaerobic digestion (AD)?

**ToR3:** *Considering the potential impacts across multiple policy areas (for example, environmental management, climate change, resource efficiency, sustainable consumption, construction, retailing and food and farming), recognising the context set by EU policy.*

**Objective 4:** Explore the links to other programmes (e.g. energy and food and farming) and industry to establish where impact has been assessed.

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<sup>2</sup> In the event, the group did not have time to examine research commissioned by the Scottish Government (including SEPA).

### Scope of the SAC-Waste Sub-Group

- The focus of the Sub-Group is to review the scientific basis of waste management policy in Defra. Although much of the technical knowledge may exist in Defra, the wider Defra network and elsewhere, the objective of the SAC-Waste Sub-Group is to examine how Defra makes use of all the available expertise and evidence to inform policy decisions.
- The Sub-Group seeks to gain a deeper understanding of EU (and more widely if relevant) legislation, policy in the making and targets that relate to Defra's waste strategy. Where possible the Sub-Group will seek to engage with all relevant groups within Defra including climate and environmental change, sustainable consumption, food and farming, economics and social research. It is also envisaged that the Sub-Group would seek to engage with regulators and with representatives of the industry, and thereby examine the interactions of the all the partners, including the Devolved Administrations as appropriate.

## **SAC-Waste Sub-Group Members and Biographies**

### **Professor Roland Clift CBE FREng (Co-Chair of SAC-Waste)**

Emeritus Professor of Environmental Technology and founding Director of the Centre for Environmental Strategy at the University of Surrey; previously Head of the Department of Chemical and Process Engineering at the University of Surrey. He is Visiting Professor in Environmental System Analysis at Chalmers University, Göteborg, Sweden, Adjunct Professor in Chemical and Biological Engineering at the University of British Columbia, Vancouver, Canada and Executive Director of the International Society for Industrial Ecology. He is a member of Rolls-Royce' Environmental Advisory Board and of the International Expert Group on application of Life Cycle Assessment to waste management. From 1996 to 2005 he was a member of the Royal Commission on Environmental Pollution (RCEP). In 2004-5, he acted as Expert Adviser to a House of Lords enquiry into energy efficiency. He is a past member of the UK Eco-labelling Board and of the Royal Society/Royal Academy Working Group set up at the instigation of DTI to examine the risk and regulatory issues raised by nanotechnology. His research is concerned with system approaches to environmental management and industrial ecology, including life cycle assessment and energy systems.

### **Professor Peter Guthrie OBE (Co-Chair of SAC-Waste and Deputy Chair SAC)**

Peter is Professor of Engineering for Sustainable Development at the University of Cambridge. He took up this post in September 2000, after 30 years in professional practice in civil engineering in UK and internationally. The research he leads is focused on the integration of sustainable development into decision making in large infrastructure projects such as regeneration schemes, renewable energy projects, buildings and mining projects, worldwide. Research has concentrated on waste in construction and demolition, methods of measurement and assessment, and ways to systematise decisions towards sustainable development.

A civil engineer with geotechnical specialisation by background, Professor Guthrie has worked in diverse environments including countries such as Nigeria, Lesotho, Sudan, Philippines, Ethiopia, and Botswana, and on major infrastructure projects such as Channel Tunnel Rail Link, CrossRail, West Coast Mainline Route Modernisation and Birmingham, and Manchester Airports, and major building projects such as Eden Project Phase 4, and large scale schemes for the Prison Service and the Ministry of Defence. He has advised on policy matters related to

waste and environment in Russia, Mauritius, Seychelles, Romania and Portugal. He was involved in the founding of RedR, a charity that provides engineers and other personnel to relief agencies in disasters and is Vice President of the organisation. He was awarded the OBE in 1994.

### **Professor Alistair Hetherington**

Professor Hetherington holds the Melville Wills Chair of Botany at the University of Bristol. His main research interest is in understanding the ways that plants adapt to changing environmental conditions. To investigate this, the members of his research group employ molecular and physiological approaches. He has major research interests in understanding how plants respond to elevated concentrations of atmospheric carbon dioxide and improving crop tolerance to reduced water availability.

Alistair Hetherington has served the BBSRC in various capacities since the mid-1990s and most recently chaired the Strategic Review of research into Environment Change. He is a Trustee of the National Botanic Garden of Wales and The John Innes Centre and also a Visiting Professor at University College Dublin.

### **Professor Michael Winter OBE**

Professor Winter is Director of the Centre for Rural Policy in the Department of Politics at the University of Exeter. He is a rural policy specialist and a rural social scientist with particular interests in applying inter-disciplinary approaches to policy-relevant research and in direct engagement in the policy process. Within the University he is a member of the Climate Change and Sustainable Future Core Theme Team, and of management boards for both the Sport, Leisure & Tourism and the Egenis research centres. He chairs the Science Advisory Board and is a trustee of the BBSRC North Wyke Research centre; is a Commissioner for the Commission for Rural Communities, a former Chair of the South West Rural Affairs Forum, and President of Devon Rural Network.

In 2000, he was a member of the Committee of Inquiry into Hunting with Dogs in England and Wales chaired by Lord Burns. He is on the editorial board of the International Journal of Sustainable Agriculture. His current research interests, among others, focus on rural policy analysis and governance with a specific focus on regionalism; sustainable agro-food systems and food security; climate change and rural land use; the historical and contemporary sociology of west country agriculture; & farmer environmental attitudes and decision-making, particularly in the context of diffuse pollution and water quality.

**Mr Chris Lea (Observer, representing the Welsh Assembly Government)**

Chris studied Agricultural Economics and Food Marketing at the University of Wales in Aberystwyth and went on to undertake a Post Graduate Diploma in Rural Estate Management at the Royal Agricultural College in Cirencester.

Chris joined ADAS and studied to become a Member of the Royal Institute of Chartered Surveyors and undertook Business Management and Rural Economy Consultancy work. Chris joined the Farming and Rural Conservation Agency and subsequently took up position as Head of Technical Unit for the Department of Environment, Planning and Countryside in August 2001 within the Welsh Assembly Government. In 2005 Chris became Head of Sustainability and Environmental Evidence Division ( SEED ) formerly known as Technical Services Division, providing Technical advice to Ministers and Senior Civil Servants on a range of subjects including Environmental issues, Climate Change, Food, Farming, Research and Evaluation. The Division is comprised of 70 technical specialist staff located throughout Wales.

**SAC Research and Delivery Team:**

Laura Eden

Jerome Moulin

Amanda Roper

### SAC-Waste Meetings

- 25 January 2010
- 17 February 2010
- 1 July 2010 (with Defra policy officials)
- 28 September 2010
- 1 November 2010 (with Defra policy officials)
- 6 January 2011 (with Defra policy officials)

### Documents reviewed

- Data from Defra (supplied to them by WRAP) on UK waste arisings by weight and by whole life impacts (CO<sub>2</sub> equivalent)
- List of completed and ongoing projects from the Waste and Resources Evidence Programme, at May 2010
- Evidence Plans (not published documents) – Waste and SCP Programmes
- The Defra Waste and Resources Evidence Programme - Policy Priorities and Requirements
- Defra Waste Strategy Annual Report 08/09
- List of Defra R&D projects 'Sustainable Use of Energy in Products' 2010/11

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### References

<sup>i</sup> See also paper: Allwood, J.M., Cullen, J.M. and Milford, R.L. (2010). Options for achieving a 50% cut in industrial carbon emissions by 2050. *Environ. Sci. Technol.* **44**: 1888-1894.