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Working together for
a world without waste

Building Insulation Foam Resource Efficiency Partnership

A Resource Efficiency Action Plan

Delivering targets towards the joint Government and industry strategy for sustainable construction.

construction products association

bretrust

Foreword

I am delighted to present to you this Building Insulation Foam Resource Efficiency Action Plan. The work has involved extensive collaboration and consultation of industry stakeholders. The project has also enjoyed and benefited from support from WRAP, the government-funded delivery body dedicated to reducing waste and increasing resource efficiency, and the BRE Trust, the UK charity dedicated to research and education in the built environment. Given this collaborative approach, I am confident it will be implemented to the fullest extent by the industry. It includes practical recommendations, actions and targets that I firmly believe will directly benefit industry by increasing the opportunity for recycling and reusing the materials recovered, so that we can continue to reduce the amount of waste produced and the proportion that goes to landfill. Finally, it identifies a framework for the newly established Building Insulation Foam Resource Efficiency Partnership (BIFREP) that ensures its good work can continue in a forward-thinking and collaborative manner.

Jane Thornback
Construction Products Association

Supported by

Prepared by Gilli Hobbs, BRE & Paul Ashford, Caleb Management Services on behalf of the Building Insulation Foam Resource Efficiency Partnership

Version 2, Updated Sept 2013

Executive Summary

Insulation of buildings is essential to improving thermal performance and reducing carbon emissions associated with heating buildings. Over the past 30 years increasing amounts of insulation have been put into new and existing buildings. One of the main types of insulation is Building Insulation Foam. These products range in chemical composition but are essentially foamed and rigid products that can be used for a wide range of insulation applications.

This Action Plan is directed at all those whose activities produce, handle or influence building insulation foam waste from the construction sector, either directly or indirectly, as well as interested stakeholders. The main objective of the Plan is to achieve higher levels of diversion of these wastes from landfill and greater efficiency in resource use across the construction supply chain. This document summarises the actions identified to improve waste management performance, timescales (where practicable) and lead organisations for the actions.

Resource Efficiency Action Plans are vital in achieving the target of a 50% reduction of construction, demolition and excavation (CD&E) waste to landfill in 2012 compared to 2008. They set out specific actions to improve resource efficiency for a particular construction product group and feed into this overarching target set by the 2008 joint Government and Industry Strategy for Sustainable Construction.

Before this Action Plan was drawn up, a scoping study on building foam waste arisings and current waste and resource management practices was conducted. This study concluded that the amount of waste would increase considerably over the next 20 years. A stakeholder group, made up of organisations representing different stages of the construction supply chain and different types of building insulation foam, came together to set out and implement actions that will have a significant impact in reducing waste production and diverting waste from landfill over the coming years. This stakeholder group is called the Building Insulation Foam Resource Efficiency Partnership (BIFREP).

An estimate has been provided of waste arising from products removed from buildings – either during their demolition or fit-out. Whilst it is difficult to derive an accurate figure for waste generation, all the studies generally conclude that the amounts will increase continually in the foreseeable future as greater quantities of insulation have been, and continue to be, installed, and will eventually end up as demolition waste.

The policy context is presented as this will have an impact on the drivers and costs of managing these types of waste. Relevant policies range from construction-specific legislation, such as Site Waste Management Plans, to European Directives such as the revised Waste Framework Directive, which covers all waste streams.

There are a number of generic issues relating to resource efficiency that are relevant for all insulation product types. For example, the scope to design out waste arising from the installation of board products relates more closely to the way the building is designed than to the product used. In terms of site practices, it is important that the conditions to facilitate segregation and collection of all the waste types are conducive to maximising the opportunities to recover these resources. There are also schemes in place that make it easier for sites to recycle their off-cuts, such as the Kingspan take-back scheme, for which a Willmott Dixon case study is provided (see Section 8).

Each product type is then considered in terms of its composition and use, current ways to manage waste along with existing and potential waste reduction, reuse, recycling and recovery options. The stakeholders have considered specific actions that could be taken to reduce waste production and increase waste recovery. These actions are then summarised for each product type, including polyurethane-based building foam, polystyrene-based building foam, phenolic-based building foam and insulated panels and boards.

This Action Plan will be implemented and monitored mainly by BIFREP, which will meet regularly to maintain momentum, and will also be reviewing actions to see if they have been delivered, are still relevant, or whether additional actions are needed. A summary of all the actions listed in this Resource Efficiency Action Plan are thus provided in the Appendix to help with the ongoing implementation and reviewing process.

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1. Introduction

1.1. This Action Plan is directed at all those whose activities produce, handle or influence building insulation foam waste across the construction sector supply chain, either directly or indirectly, as well as interested stakeholders. The main objective of the Plan is to achieve greater efficiency in resource use across the construction supply chain and to divert higher quantities of these wastes from landfill. This document summarises the actions identified to improve waste management performance, timescales (where practicable) and lead organisations for the actions.

1.2. In 2008, the Strategy for Sustainable Construction was published jointly by Government and Industry. Within the waste chapter, an overarching target was set:

By 2012, a 50% reduction of construction, demolition and excavation (CD&E) waste to landfill compared to 2008.

The responsibility for this target lies with the Strategic Forum for Construction, which is the Industry signatory to the Strategy. An overarching Action Plan[1] for waste was published in 2011 to set out actions across the construction supply chain to help deliver this target.

1.3. Resource Efficiency Action Plans are vital in achieving the landfill reduction target. They set out very specific actions to improve resource efficiency for a particular construction product group. Action Plans for the joinery and flooring sectors have been published and a number of others are in production. The development of this action plan has been supported by WRAP and the BRE Trust.

1.4. To support industry in delivering the 50% reduction target, WRAP launched its Halving Waste to Landfill Commitment – a voluntary agreement to which all parts of the construction supply chain can sign up to play their part in helping to achieve the target.

1.5. Many of the expected results of this Plan will not take effect until after 2012, and it is envisaged that the new construction, demolition and excavation (CD & E) target to be put in place by 2013 will place greater emphasis upon reduction and environmental impact of CD&E wastes.
Proposed actions within this document apply the principles of the *Waste Hierarchy*, i.e. they prioritise waste reduction measures before focusing on reuse, recycling and recovery.

1.6. Insulation of buildings is essential to improving thermal performance and reducing carbon emissions associated with heating buildings. Over the past 30 years, this has led to increasing amounts of insulation being put into new and existing buildings. One of the main types of insulation is building insulation foam. These products range in chemical composition but are essentially foamed and rigid products that can be used for a wide range of insulation applications.

[1] *Waste: An Action Plan for Halving construction, demolition and excavation waste to landfill*, June 2011.

1.7. With increasing use comes the need to consider whether resources can be used more efficiently at the various stages of the product life cycle. This refers particularly to reducing waste when installing the products, and ensuring that any waste produced during installation or removal is recycled or recovered. For some products, this presents new issues and the solutions are not always known. Therefore, the production of this Resource Efficiency Action Plan is a major step in setting out actions to improve resource efficiency in the building foam insulation sector and identifying where further work is needed to establish the best course of action.

2. How the Action Plan was developed

2.1. A scoping study on building foam waste arisings and current waste and resource management practices was undertaken from April 2010 to April 2011. This study concluded that the amount of waste would increase considerably over the next 20 years, and the ability to divert these types of waste from landfill needed to be improved. The stakeholder group that helped with the scoping study agreed that the next step should be to set out and implement actions that will have a significant impact in reducing waste production and diverting waste from landfill over the coming years.

2.2. In developing the Action Plan, it became clear that some of the actions needed to be carried out across the range of building insulation foam products and materials (generic); whereas others were only relevant to a specific type of building insulation foam product or material (specific). Generic actions were developed and agreed by the whole stakeholder group, with specific actions developed in smaller groups made up of the stakeholders most relevant to the product/material.

2.3. The stakeholder group developed into the Building Insulation Foam Resource Efficiency Partnership (BIFREP).

3. List of stakeholders and contributors

The following people gave generously of their time to participate in discussions, provide information and comment on the development of this Building Insulation Foam Resource Efficiency Action Plan.

Table 1: List of stakeholders

Name	Company
Charlie Law	BAM Construct UK, UKCG (UK Contractors Group)
Carole Green	BMF (Builders Merchants Federation)
Dennis Jones	BOC
David Thompsett	BPF (British Plastics Federation)
Gilli Hobbs (Secretariat)	BRE (Building Research Establishment)
John Roberts (Deputy Chair)	BRUFMA (British Rigid Urethane Foam Manufacturers' Association)
Paul Ashford	Caleb Management Services, EPFA (European Phenolic Foam Association)
Peter Trew / Mark Harris	EPIC (Engineered Panels in Construction)
Philipe Marechal	EXIBA (European Extruded Polystyrene Insulation Board Association)
Bill Reilly	2G Environmental Ltd
Allan Ronald	Higgins plc
Malcolm Rochefort (Chair)	Kingspan, EPFA and BRUFMA
Howard Button	NFDC (National Federation of Demolition Contractors)
Ian Henning	NFRC (National Federation of Roofing Contractors)
Anne Dye	RIBA (Royal Institute of British Architects)
Jim Hooker	SPRA (Single Ply Roofing Association)
Richard James	Willmott Dixon
Malcolm Waddell	WRAP (Waste & Resources Action Programme)

4. Action Plan implementation

An important aspect of this Action Plan implementation will be to agree timescales by which each of the actions will be completed.

This Resource Efficiency Action Plan will be implemented and reviewed by the Building Insulation Foam Resource Efficiency Partnership (BIFREP), along with other organisations as required, to further improve the resource use and recovery of these products. The Terms of Reference for BIFREP are set out below:

BIFREP Terms of Reference

Purpose

The purpose of the Building Insulation Foam Resource Efficiency Partnership (BIFREP) is to improve the sustainability of building insulation foam by increasing awareness and understanding amongst all stakeholders of existing knowledge about the role that building insulation foam plays in the life cycle of buildings, and of sustainability issues throughout the supply chain. Furthermore, it aims to use this knowledge to develop and implement practical and coordinated strategies for sustainability.

Membership

Membership of the BIFREP is open to any company or trade association involved in the production, distribution, installation and disposal of building insulation foam as well as the relevant government departments, regulatory agencies and delivery bodies.

Chair and Deputy Chair

The Partnership will appoint a Chair and Deputy Chair from industry. The posts of Chair and Deputy Chair will be for one year only.

Secretariat

The Secretariat will be responsible for maintaining the list of BIFREP members and their contact details, liaising with the Chair to decide the agenda of meetings, and circulating relevant papers and minutes of meetings.

Communications

The Partnership will meet at minimum twice a year to discuss relevant sustainability issues relating to building insulation foam.

A website may be developed and maintained to enhance the understanding of building insulation foam issues. In the meantime, this Action Plan and any other publicly available documents will be downloadable from the Strategic forum website (www.strategicforum.org.uk/waste.shtml).

An annual review of this Action Plan will be undertaken.

5. About building insulation foam

5.1. In the UK, building insulation foams are found in a wide range of building products, applied in a variety of forms. For example, they can occur as the core material of panels in cold stores or refrigerated warehouses, or as the primary insulation materials contained within brickwork or steel, or spray-applied in retrofit internal and external insulation. Building insulation foam products are also made from different materials. In terms of the amount of product used, a recent WRAP study concluded that approximately 344,000 tonnes of building foam insulation is produced each year[2].

5.2. The following insulation materials and products are relevant in this Resource Efficiency Action Plan:

- Polyurethane rigid (PUR) foam*
- Polyisocyanurate rigid (PIR) foam*
- Expanded polystyrene (EPS) foam
- Extruded polystyrene (XPS) foam
- Phenolic (PF) foam
- Insulated plasterboard incorporating the above materials
- Insulated panels incorporating the above materials
- Structural insulated panels (SIPs)

* Note: as it is very difficult to distinguish between them, PUR and PIR are mainly considered as one product (PU) in this Action Plan.

[2] Construction Product Supply Chain Analysis, WRAP 2012

6. Building insulation foam waste

6.1. Building insulation foam waste is typically generated through:

- The manufacture of the product. This is referred to as factory produced waste in this Action plan
- Removal during demolition or refurbishment. This is referred to as 'demolition waste' in this Action Plan.
- Installation during new build construction or refurbishment. This is referred to as 'construction waste' in this Action Plan.

6.2. The above distinction is important because building insulation foam waste arising from demolition (or removal prior to refurbishment) may contain ozone-depleting substances. Building insulation foam waste arising from manufacture and new construction will not contain these substances as they have been phased out of use in the manufacture of building insulation foam since 2004. Some products never used these substances as foaming agents during manufacture, as is highlighted in the relevant sections of this plan.

6.3. The amount of building insulation foam waste generated annually from demolition is predicted to double over the next 20 years as a greater proportion of buildings constructed since the 1970s are demolished as shown in Figure 1. Currently, most buildings being demolished are older than this and do not contain building insulation foam, or have small quantities compared to the amount needed to achieve current building requirements in thermal performance. However, the increasing thermal standards in the period to 2010 means that the amount of foam in demolition waste will only begin to plateau after 2035. Assuming rates of demolition remain constant, this is predicted to amount to some 25,000–30,000[3] tonnes per year. This may seem a particularly large amount (compared to an overall construction and demolition waste arising of around 47 million tonnes in 2010[4]), but the low density of these products means that it represents a volume of waste approaching 1 million m^3.

[3] Estimate derived from the scoping study and further work under the EU project on ODS arisings.

[4] http://www.defra.gov.uk/statistics/environment/waste/wrfg09-condem/

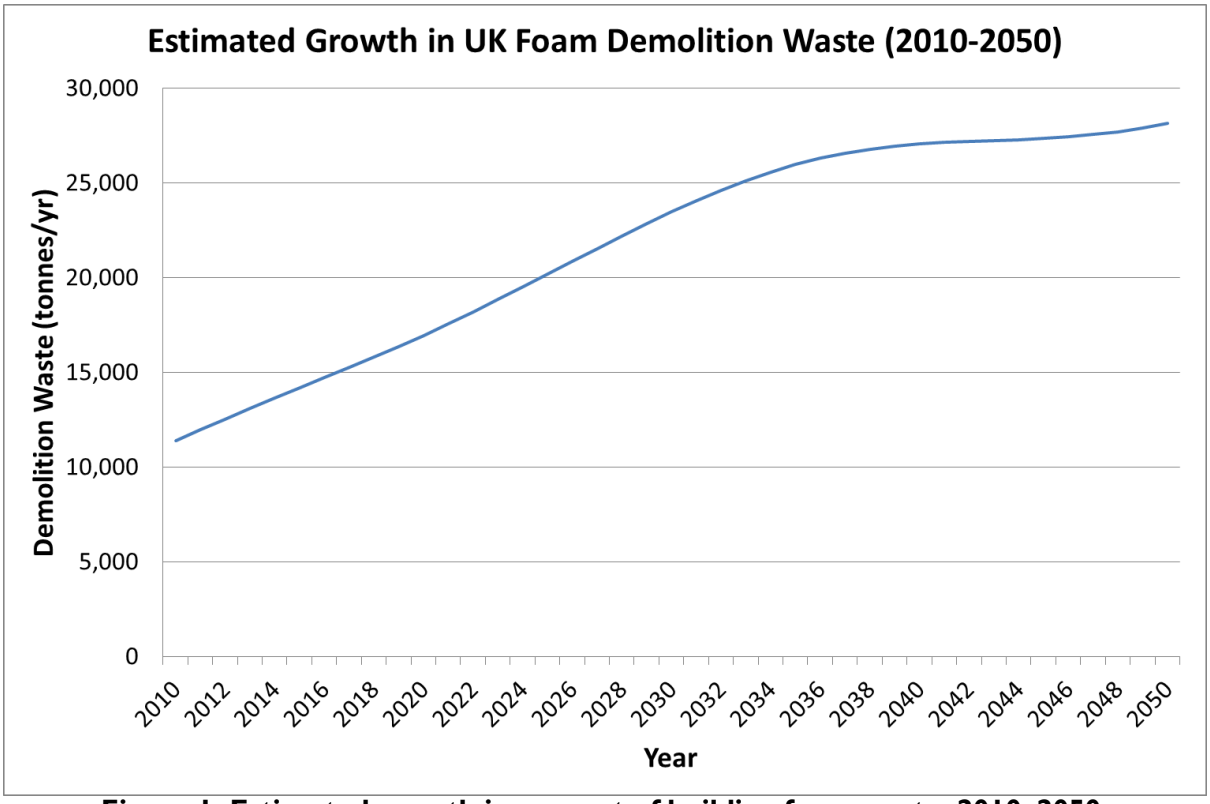

Figure 1: Estimated growth in amount of building foam waste, 2010–2050

6.4. Alongside the waste arising from demolition is waste from construction. This waste is typically created as off-cuts and as surplus materials at the end of the project. There is a range of wastage rates for the board products (4–10%) that can provide an estimate of construction waste. Assuming rates of installation remain constant, a range of 7,936–19,840 tonnes per year[5] or 254,200–635,500 m^3, of building foam insulation waste is estimated to be produced each year from installation.

6.5. It is likely that over the next few years there will be an increasing amount of building foam insulation waste produced from demolition and construction. Estimates suggest that this will exceed 1 million m^3, or 30,000 tonnes, each year, by 2020 – with the projected apportionment shown in Table 2.[6]

[5] Estimate derived from the scoping study and stakeholder group discussions.

[6] Caleb estimates

Table 2: UK construction and demolition waste estimates in tonnes for foam insulation in 2020

Insulation technology % share estimate	**Demolition waste** 59%	**Construction waste** 41%	**Total** 100%
Polyurethane (PUR/PIR) – incl. insulated plaster board & composite panels	7,085	5,040	**12,125**
EPS – incl. structural insulated panels (SIPs)	7,430	4,920	**12,350**
XPS – incl. insulated plasterboard	2,300	1,720	**4,020**
Phenolic foam – incl. insulated plasterboard	885	620	**1,505**
Total	**17,700**	**12,300**	**30,000**

7. Policy and legislative framework

7.1. **Escalating landfill tax.** In April 2012 landfill tax stood at £64/tonne for active waste. It will continue to escalate by £8/tonne a year until at least 2014, when the rate will be £80/tonne (from 1 April 2014). Landfill tax has been extremely effective at diverting waste away from landfill into increasing recycling and recovery routes. As the rate increases, so does the financial viability of sorting, collecting, transporting and processing for reuse, recycling and other recovery.

In terms of insulated plasterboard waste, it is also worth noting that plasterboard waste is restricted to single-cell landfill, i.e. it is segregated from other waste material types. This means the plasterboard waste needs to be separated from other materials prior to landfill, either at the site of production or at the waste management facility.

7.2. **Environmental permitting**. Most waste 'handling' activities require an Environmental Permit, or should comply with the conditions of an exemption. The current exemptions can be used by the construction sector to carry out reuse, recycling and use of recycled materials, though the maximum amounts that can be processed using an exemption are restricted and a permit will be required if those amounts are exceeded. Permits (or exemptions) are also required for mobile plant handling waste, such as waste shredders. The requirement for a permit, or registering for an exemption where one applies, is an important area to consider before undertaking any waste storage, handling, processing, reuse and recycling operations.

7.3. **REACH.** Materials achieving 'end-of-waste' status can fall within the REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals) Regulations which may apply to recycled substances no longer classed as waste. Guidance from the European Chemicals Agency[7] details the conditions under which recovered paper, glass, metals, aggregates, polymers and rubber would be exempt. This typically boils down to the type and proportion of impurities and whether they could fall into a category of high risk/concern. Any waste materials regarded as articles not intended to release substances would also be exempt.

[7] Guidance on Waste and Recovered Substances Version 2. ECHA May 2010. http://guidance.echa.europa.eu/docs/guidance_document/waste_recovered_en.pdf?vers=12_05_10

7.4. **Site waste management plans (SWMPs).** These regulations came into force in England in April 2008, for projects with a value over £300,000. They have a role in raising awareness of waste generated by the construction process, from the period before construction starts – when the amounts and types of wastes have to be predicted – and during the construction process, when it is necessary to record the amount, type and destination of the actual waste arising. A number of planning authorities now require evidence of a SWMP as part of the approval process, and the Environment Agency is undertaking regional inspections of SWMPs. Defra is currently reviewing the SWMP regulations and their implementation, with an industry consultation due in late 2012 as to whether they should be scrapped, kept or amended. Work is also underway on the possible introduction of SWMPs in Wales.

7.5. **Revised Waste Framework Directive.** The revised Waste Framework Directive (WFD) was transposed into the Waste (England and Wales) Regulations 2011from March 2011. There are some generic areas that are relevant to construction, such as the definition of waste. This Directive provides clarification of when something is a waste or a by-product, and when it ceases to be a waste (or end-of-waste). For example, when items are being reused they should (typically) not be defined as waste, and hence there is no requirement to apply for an exemption or permit.

The Waste Framework Directive contains specific provisions to define end-of-waste criteria. In this context, and scientific analysis has been undertaken of different waste streams that are candidates to being considered end-of-waste, with a methodology for determining end-of-waste criteria, based on a number of case studies also developed[8].

In the UK the waste protocols and quality protocols developed by the Environment Agency and WRAP are a recognised way of setting out when 'end-of-waste' status has been achieved. Materials falling into this category are not bound by the rules of environmental permitting.

The requirement to consider the Waste Hierarchy when making decisions about waste management is mandated in this Directive, for all parties from waste producers to policy makers.

The revised WFD also makes specific reference to construction-related waste and a diversion from landfill target:

Member States shall take the necessary measures designed to achieve that by 2020 a minimum of 70% (by weight) of non-hazardous construction and demolition waste (excluding naturally occurring material defined in category 17 05 04 in the List of Wastes) shall be prepared for reuse, recycled or undergo other material recovery (including backfilling operations using waste to substitute other materials.

7.6. **Construction Product Regulation and BWR 7.** Construction Products Regulation (CPR) will replace the existing Construction Products Directive (CPD) in 2013. The purpose of the Construction Products Directive is to allow construction products which have been assessed against harmonised standards to be legally placed on the market anywhere in the European Economic Area. A significant proposed change is the addition of a new seventh BWR on the sustainable use of natural resources across the life cycle of the works from design to demolition.[9] This covers recyclability, durability and use of environmentally compatible resources. The inclusion of a new BWR does not force Member States to regulate for these characteristics, though it could have the following possible implications:

- It means that when (now or in the future) Member States regulate for product sustainability, a declaration of performance on this would need to be included with the CE marking, provided that standards exist in order to be able to assess the product's performance
- It could be used as a framework for requirements, should Member States wish to use it to set regulations on product sustainability in the future.

Currently it is not certain how these changes will be implemented in practice.

7.7. **ODS regulations.** Regulation (EC) No 2037/2000 on ozone-depleting substances (ODS), which implemented the requirements of the Montreal Protocol until the end of 2009, explicitly required the recovery of ODS from certain equipment such as refrigerators and air conditioning equipment. It also required that substances in 'other' products, installations and equipment be recovered 'if practicable', but it did not define what this might mean. These provisions were reaffirmed in the recast of the Ozone Regulation (EC) No 1005/2009, although the potential now exists for the Commission to introduce additional products for control into an Annex without the need for additional primary legislation. It is possible that these requirements could include ODS in building foams in the future, but this would need to be justified accordingly: 'Any draft measure to establish such an Annex shall be accompanied and supported by a full economic assessment of costs and benefits, taking into account the individual circumstances of Member States.'

[9] CLG 2008, The European Commission's proposed Construction Products Regulation. http://www.communities.gov.uk/documents/planningandbuilding/pdf/constructionproductsconsult.pdf

8. Action Plan to reduce waste and increase recovery across the sector

Photo: Shredded insulation waste (Courtesy of 2G Environmental)

8.1. As embodied in the Waste Hierarchy, waste reduction is the most preferred option, followed by reuse, then recycling, recovery and finally disposal. The possibilities to reduce waste are mainly linked to the installation of the products. Prevention, reuse, recycling and recovery of waste can be improved at installation, refurbishment and demolition stages.

8.2. For all products, the best option to manage waste is to prevent it being produced in the first place. Actions to reduce waste can often be relevant to several product groups, particularly when related to site practices such as materials storage and use of off-cuts.

8.3. For those producing the waste, there is often a mixture of insulation waste materials to deal with on one site. Therefore, to improve the viability of certain recycling and recovery options there must be effective ways to segregate and handle these materials in line with limits on levels of contamination and the mixing of different polymers.

8.4. The low density of building insulation foam waste presents particular issues in terms of increasing levels of recovery for most of the foamed materials, mainly that of transporting waste materials from the point of production to the facility that is able to provide a recovery route.

8.5. Transporting these materials is a key issue and there are possible opportunities for volume reduction that could be explored, as detailed in Section 8.11.

8.6. Best practice on how to reduce waste and segregate it for recycling and recovery needs to be communicated effectively to those able to influence these outcomes. These will typically be those producing the waste and needing to arrange for the waste materials to be removed from site. The opportunities for recovery vary for each product group, so an important element of the guidance will be to highlight possible routes for mixed insulation waste compared to segregated insulation waste.

8.7. These common issues can be considered across the building insulation foam supply chain and for most product groups. The agreed actions are grouped in the following categories:

- Designing out waste
- Site practices to reduce waste
- Segregation of waste for recycling and recovery
- Improving the logistics of recovery
- Raising awareness of resource efficiency opportunities

8.8. **Designing out waste**

The opportunity to design out waste lies mainly with the designer of a building. Consideration of the standard size of insulation board products during design is the most effective way to reduce waste from off-cuts. Irregular room dimensions, such as curved floors, and door/window openings also require more cutting which increases waste production. One way to promote awareness of waste prevention measures to designers is to amend the specification clauses and guidance relating to insulation in the National Building Specification.

A BSI Code of Practice for Designing out Waste is also in development. Opportunities to highlight waste reduction measures for building insulation foam will be explored further. WRAP have also worked closely with the Royal Institute of British Architects (RIBA) on developing training material to be used in their continuous professional development (CPD) programme.

There may be scope to achieve waste reduction within the overall objective of improving the efficiency and reducing costs of construction, as embodied in the development of Building Information Modelling (BIM); however this is insufficiently advanced/clear in the context of materials resource efficiency to be considered in this Action Plan.

8.9. Site practices to reduce waste

There are a number of ways in which waste can be reduced on-site. These include:

- Reducing impact damage through careful loading and unloading and storage in a place where vehicle movements are limited
- Reducing damage through exposure to the elements
- Facility to dry out products that have inadvertently become wet, to enable them to be used
- Procurement of 'cut to size' boards
- Reuse of off-cuts around the site.

Over-ordering tends not to be an issue due to the cost of these products.

The UK Contractors Group (UKCG) has produced a 'Low waste site' report which includes the measures detailed above as ways of working more efficiently and reducing the cost of waste and materials. This report, or key messages from it, could be circulated more widely to anyone ordering building insulation foam products.

It is possible to reduce wastage rates of board products significantly, e.g. from 10% down to 3%, through a combination of careful design & procurement, and good storage of product to protect from moisture and impact. Reuse of off-cuts is also considered as waste prevention.

8.10. Segregation of waste for recycling and recovery

During installation it should be relatively straightforward to separate out different insulation materials to maximise recovery. This can only be done, however, if a recovery route has been identified and adopted for a particular material type. As detailed in Section 8.11 (Improving the logistics of recovery), the provision of take-back schemes is the most likely scenario for increasing recovery from construction sites. Alternatively, mixed building insulation foam and other high calorific materials could be segregated for an energy recovery route.

In the current economic climate, the price of the alternative to landfill is critical, especially if it encourages source segregation. The price for removing mixed waste in a skip ranges between £18 and £26/m^3 (prices as at March 2012) of material. It is generally cheapest in the North East and most expensive in the South East. Therefore, an alternative to this, such as a take-back scheme, would need to cost around £5/m^3 less than mixed waste to make it a viable option. As can be seen from the Kingspan Insulation Waste Collection Service described in Section 8.11, in some areas it would be economically worthwhile but in other areas it would be less so. Without this price advantage, the only realistic way to drive forward recovery for environmental reasons would be through client requirements, such as achieving a certain level of a green building standard such as BREEAM (the BRE environmental assessment method), the Code for Sustainable Homes and RICS Ska[10] for fit-out. However, using BREEAM as an example, those applying for the credits relating to the diversion of waste from landfill tend to

[10] http://www.rics.org/ska

use weight-based calculations which would not promote recycling of lightweight materials such as these. One option to explore is whether it would be possible to develop additional BREEAM credits for recycling materials that are typically landfilled. This would be best applied to demolition waste alone, to avoid the possible skewing of procurement of products that attract extra recycling credits.

Segregation of building insulation foam waste is more complicated during demolition as there is far less information about the products installed in the building and typically less time to plan for subsequent recovery. This problem stems from the difficulty in knowing which insulation product has been used in advance of the demolition. For example, wall insulation will not be uncovered unless an asbestos survey is carried out, or the client is amenable to a section of the wall being opened up to examine the composition. An approach should be developed to access this information in a consistent and minimally disruptive way, through pilot studies of demolishing buildings that may contain these products.

As a further issue, there are a number of product types where hazardous waste regulation may have a bearing on the potential for the reuse of the product. One particular question relates to whether reuse after decommissioning comes under the waste regulation at all and, if not, whether the resale of the product would fall under chemical legislation such as REACH. The matter becomes even more complex once products are genuinely recycled (i.e. by reprocessing), and one objective of this Action Plan would be to seek a Position Statement from the UK Environment Agency on these matters, for wider dissemination.

Finally, it will be important to involve the waste and resource management sector in expanding the opportunities to increase recycling and recovery of mixed insulation waste. A typical scenario is that mixed waste arrives at the transfer facility, where the materials are separated out into recyclable, recoverable and non-recyclable/ recoverable, with the latter fraction ending up at landfill. As the recovery options are developed for specific building insulation products and materials, it will be beneficial to raise awareness of these options within the waste management sector. This is an area where WRAP can help in producing case studies and evidence of cost benefit to promote recovery from waste transfer facilities.

8.11. Improving the logistics of recovery

Volume reduction is an important aspect of improving the logistics of recovery. Possible ways to achieve this include:

- Compaction or shredding. These are well established technologies for other lightweight waste streams. There may be issues in terms of flammability of blowing agents (if allowed to build up) and control of shredded material in windy conditions.
- Heat and pressure. Site-based equipment can be bought that produces briquettes of compacted material and is currently used by organisations to reduce the volume of their expanded polystyrene (EPS) packaging.
- Dissolving in a solvent. An example of this is where EPS is dissolved in orange peel essential oil (limonene). This was trialled in Japan by the Sony Corporation for polystyrene packaging.

Take-back schemes could offer the best opportunities for improving the logistics of recovering installation waste, especially where volume reduction has not been possible. Off-cuts that are too small to be reused elsewhere on site are typically collected in 1m³ bags for collection by the manufacturer, ideally when dropping off new product.

Kingspan[11] offer such a service for construction sites and factories in the UK, provided these are Kingspan products and the customer signs an insulation waste collection agreement. They will also collect the packaging associated with the product on delivery. Exclusions include insulation waste from other manufacturers, bonded boards (e.g. insulated plasterboard), contaminated insulation or other non-insulation materials or waste. The costs vary according to weight – for example, the cost of collection, transport and disposal of 1 tonne of eligible insulation waste, including 10 reusable waste collection bags, is only £180 (£18/m³)(Prices as at March 2012). In terms of what happens to the materials collected, the options are: waste to energy; reuse, downcycling (where undamaged insulation boards are cut down to be used in packaging materials, other waste insulation is processed and used to manufacture alternative products); and recycling(waste insulation materials are broken down into their constituent parts and used to manufacture new insulation boards.

Willmott Dixon completed a Kingspan 'Take-Back' trial in April 2011 on the £17.5m Landau Forte Academy in Tamworth:

- The cost of setting up the scheme including 10 reusable bags was £180 and 230kg of insulation was returned to Kingspan which equates to 83m² or 6.7m³.
- Including a factor for bulking this would comfortably have filled a 10m³ (12 yard) skip making it a cost-neutral option.

This contributed directly to Willmott Dixon's target of zero waste to landfill by 2012 and helped identify an alternative for rigid insulation – a product that has previously been difficult to divert, recover or recycle from the waste stream.

[11] Kingspan Insulation Waste Collection Service leaflet May 2011

Photo: Willmott Dixon filled 10 bags with 230kg of undamaged insulation board for Kingspan's take-back scheme (Courtesy of Willmott Dixon/Kingspan)

The other option is for mixed waste to go to a transfer facility, where the load is separated out into different material streams. Bulking up of building insulation foam into different material streams and then transportation to a reprocessing or recovery facility would reduce transport impacts and improve recovery opportunities. In these facilities the economic viability would rest upon the overall price to send materials for recovery/reprocessing versus the price of landfill. Since landfill price is set by weight (including landfill tax), costs of the alternative (including transportation) would have to be quite low to be considered at all. Exploring the current costs and benefits of different options for specific building insulation foam wastes, compared to landfill, could help identify what options are currently practical.

There is a need to characterise the logistics costs of recovery further, particularly as they relate to the segregation, collection and transport of insulation materials in general and specific product types in particular. This could be the subject of a small investigative project under the umbrella of this Action Plan.

As a particular sub-set of this work, there is substantial interest in looking at the specific costs/benefits of building services (HVAC) insulation take-back schemes. Because of its particular focus on that sector of use, this project proposal is discussed further in the section on phenolic foam, but it has potential generic implications for other insulation products.

8.12. **Raising awareness of resource efficiency opportunities**

WRAP have a remit to promote resource efficiency in the construction sector. As such, they are well placed to provide guidance and case studies to transfer best practice information to a large audience and across the construction supply chain.

One key area of work is to identify (or develop) guidance and case studies that exemplify good practice in efficient use of resources at different stages of the supply chain and across a range of products. The aim is to provide an evidence base for good practice in improving resource efficiency in the manufacture and supply of a range of construction product categories. Specific objectives of the project are to:

- identify where there is evidence of good practice in resource efficiency both in the UK and internationally and where opportunities exist for improved resource efficiency for a range of key construction product categories; and
- produce good practice examples which that be engaging to the construction sector audience and enable WRAP to promote greater resource efficiency of certain product categories across the supply chain.

Ideally, the building insulation foam sector will be able to participate in this work through helping to develop common guidance and identifying appropriate case studies for a published document. This could build upon the actions already identified to produce relevant guidance, case studies, pilot studies and cost–benefit information on improving resource efficiency.

8.13. **Summary**

Table 3 summarises the actions relating to waste reduction and recovery across the supply chain and product groups.

Table 3: Summary of actions related to waste reduction and recovery

Description/ desired outcome	Lead	Action
X1 Waste reduction during design (1)	RIBA and relevant NBS technical writer	To consider amending NBS Section P10 to promote waste reduction measures
X2 Waste reduction during design (2)	RIBA/ BSI	To consider inclusion of waste reduction of insulation measures in BSI Code of Practice – Designing out Waste
X3 Wider awareness of site practices to reduce waste	Manufacturers/ Trade Associations/UKCG	To provide guidance to installers by creating common text for inclusion in guidance and make members aware of this
X4 Create incentives to increase recovery of demolition waste	BRE	To explore the option to include BREEAM credits for 'difficult to recycle' waste types from demolition
X5 Develop common approaches to increasing the recovery of demolition waste	NFDC/UKCG	To carry out demolition pilot studies and trials to develop industry approach to identifying in-situ insulation types
X6 Better understanding of the costs and benefits of reuse, recycling and recovery	WRAP	To produce a cost–benefit spreadsheet of recovery options compared to landfill
X7 Increase awareness of recovery opportunities	WRAP/Trade Associations	To produce WRAP published guidance and case study report, widely disseminated
X8 Remove possible barriers to reuse	WRAP/Caleb/BRE	To approach the Environment Agency concerning the status of chemicals in reuse/recycling with a view to obtaining a Position Statement

9. Action Plan for polyurethane-based building foam

Photo: Flat roofing insulation boards (Courtesy of BRUFMA)

About the products

9.1. **Polyurethane foam (PUR)** is a highly cross-linked thermoset polymer. Preheated liquid chemicals, polyol (polyester or polyether) and isocyanate (diphenylmethane diisocyanate – MDI), are applied through a pressurised hose (with a blowing agent) onto a continuously moving facing material, which could be a flexible material (glass tissue, foil, paper etc.) or a rigid material such as steel sheet. The product expands to form a continuous insulating barrier (also a barrier to air and moisture). When sprayed in place, any surface can be covered, regardless of shape. It can be used for cavity-wall insulation and sprayed as 'over-rafter' roof insulation. It is also commonly used as the insulating core within structural insulated panels (SIPs). Sprayed PUR insulation needs to be applied by a specialist contractor. PUR is a combustible product. Flame retardants are introduced during foam manufacture. PUR foams generally do not have such good heat tolerance as PIR.

9.2. Rigid polyurethane foam has a closed cell structure and can be formed into prefabricated products within factories or used as liquid pre-foam mixtures for foaming-in-place/spraying (sprayed polyurethane foam – SPF). Panels and boards are generally made by a continuous lamination process. Other products can also be individually moulded into discrete shapes.

9.3. **Polyisocyanurate foam (PIR)** is also a highly cross-linked thermoset polymer. PIR is in the same family as PUR and was originally developed to give improved fire performance in those applications where this was a requirement, without the need for additional fire retardant chemicals. It is usually produced with 'facers' that are tailored for the end use (e.g. foil or glass tissue faced), which make it more durable. PIR has a closed cellular structure, is of low density, and products are usually made via a continuous lamination process. It is used in a range of products, including metal faced panels, roof boards, wall boards, flooring and pipe insulation.

Current activities

9.4 As noted in Section 6, the flow of foam products into the waste stream stems from two differentiated sources:

- Factory production and installation waste
- Demolition waste

The treatment of these two groups of materials is significantly different, because materials falling into the first category (factory and construction waste) will have known formulations and therefore waste processors will be aware of whether the components will impact the options for ongoing reuse, recycling or even incineration. In the second category (demolition waste), the composition of the foam will be less well understood. Although full chemical analysis might be an option for overcoming this uncertainty, it is not typically practised because the individual waste flows are too small to warrant the cost.

In countries where Municipal Solid Waste Incinerators (MSWI) are widespread, it is possible to make use of these facilities to deal with even the most contaminated sources, including those still containing CFCs, since incineration within MSWIs is an approved destruction technology under the Montreal Protocol. However, the current low availability of such incineration capacity in the UK makes this a less practical option and the bulk of demolition waste continues to be landfilled.

The choice of landfill for ODS containing foams will depend on the 'weight percentage' thresholds pertaining in the hazardous waste regulations, with those above the threshold going to hazardous waste landfills. The same principle will apply for other blowing agent types, although the threshold will vary depending on the hazard posed. Foams produced with either non-hazardous blowing agents or those below the threshold of concern continue to be managed in general landfills. With these factors in mind, the focus of current initiatives and projects is with factory production and installation waste. Since this is currently the larger of the two waste flows, this focus is legitimate.

A study by Consultic in 2008 indicated that there were four basic practices for PU construction waste in the UK: secondary use, combustion (waste-to-energy and cement kiln), mechanical/chemical recycling and landfill. The split between these is shown in Figure 2.

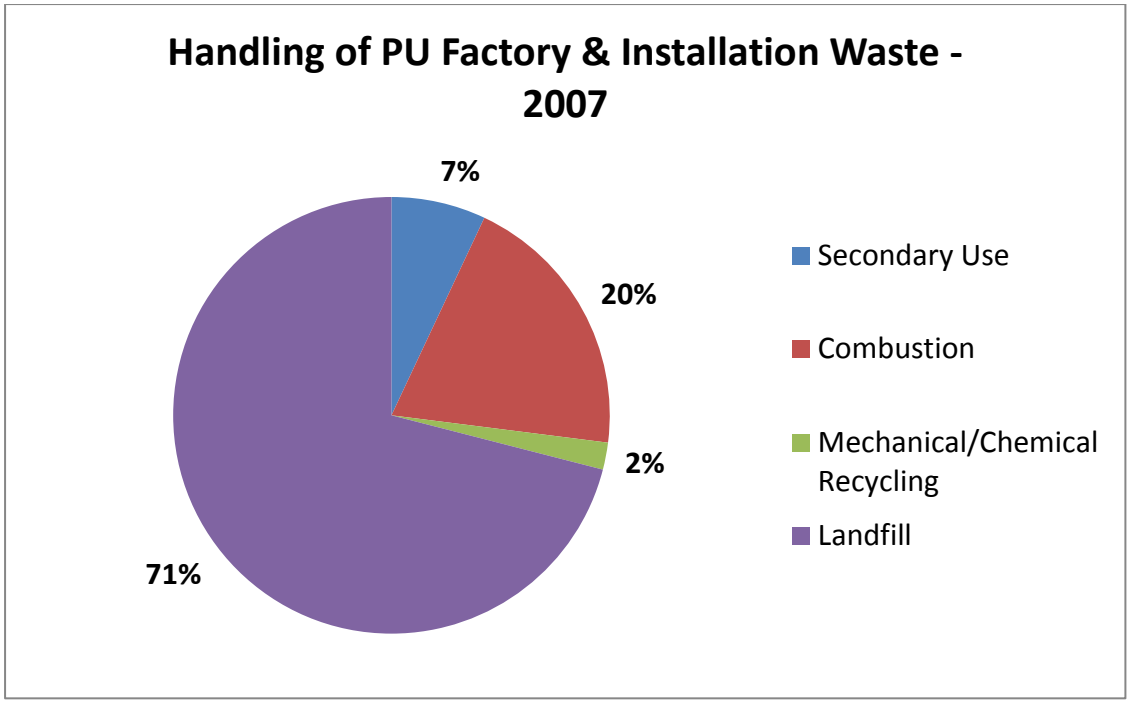

Figure 2: Split between the four methods of handling PU construction waste

Existing and potential recovery routes

9.5 Table 4 summarises existing and potential recovery routes for polyurethane-based waste.

Table 4: Summary of recovery routes for PU-based waste

Technology type	Description	Rationale
Waste prevention	Site waste prevention	It is possible to achieve financial and resource savings over and above common benchmarks by liaising closely with the design teams and other contractors and consistently observing good site resource management practices.
Combustion	WTE	Best *a priori*[12] treatment technology for construction site foam waste (as well as refurbishment/demolition site foam waste containing ODS).
Combustion	Cement kilns	The practice of processing waste foam through cement kilns is not widespread in the UK. Nevertheless, it is one of the known routes for managing foam waste.
Mechanical recycling – mixing with other substances to create new products	**a**) Granulate/ Powder reprocessing into variety of foam or alternative products **b**) Appliances Recycling Plant	Proven technology; potential to create light concrete & cement screeds; lightweight blocks; chipboards; acoustic absorption products; playground matting; MDF board alternatives; reed bed buoyancy medium; hydroponic mats; oil/liquid absorption uses; carpet backing uses Infrastructure in place in the UK; potential spare capacity for non-appliance foam destruction; technically proven with PU composite panels; possible markets: oil/liquid absorption uses; carpet backing uses
Thermal/Chemical Recycling	**a)** Glycolysis **b)** Hydrolysis **c)** Pyrolysis **d)** Hydrogenation	These routes are technically feasible but not widely employed Glycolysis creates Polyols; Hydrolysis creates Polyols & Amine intermediates; Pyrolysis converts to Oil & Gas; Hydrogenation converts to Oil & Gas

Specific waste reduction actions

9.6 With up to 10% of PU foam wasted during factory production/ installation, there is considerable scope for further reductions in the amount of waste being generated. If an average loss across the industry of 7% is assumed today, a reduction to an average of 5% would yield savings of 3,000–4,000 tonnes/yr in waste generated.

Achieving this goal is complicated by at least two factors:

- The ability to track baseline waste losses
- The ability to identify and quantify waste minimisation efforts.

It is perhaps simplest to start with the factory production sector where baseline percentage losses are best understood. However, since this is a factor influencing the efficiency and competitiveness of individual processes and manufacturers, it is unlikely that such data would be shared externally in isolation and would probably be seen as a competitive marketing advantage in any event. While aggregation of progress at industry (trade association) level

[12] Currently on balance, taking all factors of practicality and impact into account, this is the most logical treatment technology

seems unlikely, it might be useful to ensure that progress is, at least, understood and can be referenced by trade associations in more general coverage of the subject.

The most significant savings in economic terms are likely to emerge from process innovations which will result in lower wastage levels.

A further measure that could be considered is awareness-raising amongst building contractors about the losses (and costs) incurred by wasteful installation practices. Since this would be difficult to quantify across the industry with any accuracy, it might be most appropriate to develop one or more case studies and related guidance which could demonstrate the value of waste minimisation during installation.

Specific waste recovery actions

9.7 Factory production/installation sources will be the easiest to target in terms of waste recovery, since the sources are traceable and can be more easily characterised. This waste stream is also currently the larger of the two, although the cross-over point is likely to be reached around 2015. By that time, it is hoped that some waste recovery strategies developed for factory production/installation waste could be extended to demolition waste provided that uncertainties in sourcing can be overcome.

The homogeneous nature of factory production waste lends itself particularly well to mechanical and chemical recycling technologies as well as to secondary use strategies. It is likely that individual companies will not wish to publish their specific strategies in these areas, but an effort to collect and aggregate this data alongside the gross losses during factory production would allow the industry to communicate progress in waste recovery as well as in waste minimisation.

The industry is already actively investigating novel approaches to reuse and recycling activities, including recycling into other building products and use as acoustic insulation. The trade association, BRUFMA, has been involved in specific initial test work on the acoustic properties of recycled mixed crumb and initial results look promising.

For the installation sector, the quantification of waste recovery improvements across the industry will be particularly challenging. Again, it may be that case studies will be the most effective way of encouraging best practice. It would obviously make sense to combine the reduction and recovery case studies into one wherever possible in order to communicate that ‘reduction’ and ‘recovery’ steps are part of the same overall waste management strategy. The value of such case studies could be enhanced further if at least one of them is connected to a manufacturer’s take-back scheme.

Summary

9.8 Table 5 summarises the actions relating to waste reduction and recovery for polyurethane-based products and materials.

Table 5: Summary of actions for reduction and recovery of PU-based products and materials

Description/ desired outcome	Lead	Action
PU1 Increase range of options for PU recovery	BRUFMA	To continue to explore and encourage research into innovative solutions for the various PU foam waste streams. This should be a continuing activity and assessed at periodic meetings of BIFREP.
PU2 Reduce waste through design and site practices	BRUFMA	To assist in developing generic guidance on best practices for waste minimisation of insulation products. Such guidance to be issued by BRUFMA.
PU3 Better understanding of reduction and recovery opportunities	BRUFMA/WRAP together with installers (e.g. TICA – Thermal Insulation contractors Association)	To identify suitable case studies on reduction and recovery during installation. Suitable existing case studies to be identified, and further ones discussed at periodic meetings of BIFREP.
PU4 Increase reuse, recycling, recovery and appropriate disposal of demolition waste	NFDC supported by BRE/Caleb	To continue transfer of best practice to demolition arena by communication at periodic meetings of BIFREP.

10. Action Plan for polystyrene-based building foam

Photo: Flooring insulation boards (Courtesy of BPF)

About the products

10.1. **Expanded polystyrene (EPS)** is a thermoplastic polymer, so theoretically can be reprocessed and recycled more easily than thermoset polymers. Manufacture is by suspension polymerization of the styrene building blocks in the presence of pentane, to produce long polymer chains incorporating pentane in solution. The granules so produced will expand under the influence of steam (prefoaming) to produce beads which can be further processed to produce blocks and boards or shaped mouldings. The properties are largely determined by the density produced at the prefoaming stage. Densities up to 50kg/m^3 can be produced for specialist civil engineering applications but 15–20 or 25kg/m^3 is most common on construction sites. Pentane is the blowing agent used, CFCs and HCFCs have never been used in EPS.

10.2. EPS is supplied in the form of rigid lightweight slabs or boards and increasingly moulded shapes for insulation between floor beams and other applications. Boards are produced by fusing together expanded beads of polystyrene in a high-pressure steam environment to produce large blocks, followed by cutting into boards. All factory-produced trims and off-cuts are returned to the block moulding stage. Alternatively the beads can be shape-moulded for specific applications. It has a closed-cell structure, so beads are resistant to water penetration, but it is not a water vapour barrier owing to the pores/capillaries between the beads. EPS is a combustible product which is generally protected by a surface covering such as plasterboard when used internally, or below ground floors or in cavity walls. Flame retardants are introduced during manufacture of the expandable beads. EPS has a range of applications from floor insulation to walls (internal, cavity and external) insulation and also in roofs. Adhesively

bonded beads can be used for cavity-wall insulation. It is also used in flotation and civil engineering works including road embankments.

10.3. **Extruded polystyrene (XPS)** is also a thermoplastic polymer. XPS is made from solid polystyrene crystals that are fed into an extruder along with a blowing agent and other additives. CFC/HCFC blowing agents have been used in the past, but these were phased out due to the ODS regulation, and replaced completely from 2002. Within the extruder, the mixture is combined and melted at high temperature and pressure into a viscous plastic fluid. It is then forced through a die, expanded to form a foam and then shaped, cooled and trimmed to the required dimensions. The process results in a foam product with a uniform closed-cell structure and a smooth continuous skin.

10.4. As a foamed product, it has a high compressive strength with a closed cell structure and is used to produce rigid boards for use in roofing, flooring and wall applications. It offers high moisture resistance and its high compressive strength makes it suitable for load-bearing and specialist applications. It has similar fire performance to EPS, since the chemical matrix is essentially the same and is generally protected by a surface covering in a building. Flame retardants are introduced during manufacture of the extruded foam.

Current activities

Expanded polystyrene (EPS)

10.5 It is usually possible to recycle and recover post-consumer expanded polystyrene. This is largely driven by the widespread use of EPS as a packaging material, which has encouraged the development of recovery initiatives. There is an international agreement relating to the recycling of EPS packaging, which commits signatories:

- To enhance existing programmes and initiate new ones which enable EPS protective foam packaging to continue to meet individual, domestic environmental standards regardless of its country of origin.
- To continue to promote the use of recycled polystyrene in a wide variety of end-use applications.
- To continue to work towards uniform and consistent international environmental standards regarding EPS protective foam packaging, especially in the area of solid waste.
- To establish a network to exchange information about EPS environmental and solid waste management programmes between packaging professionals, product manufacturers, government officials, association members and consumers.

For uncontaminated EPS insulation foam, there should be a commonality of possible recovery routes with EPS packaging. In the UK, a key focal point for EPS recycling is the website set up by the British Plastics Federation.[13] This site hosts an interactive map of recyclers in the UK, of which five will accept clean post-consumer demolition EPS waste.

[13] http://www.eps.co.uk/sustainability/map_recyclers.html.

10.6 Case study: CREO house demolition – BRE Innovation Park

The practicalities of recycling EPS insulation waste arising from demolition were clearly demonstrated in this case study. An insulated concrete formwork structure (where the in-situ formwork was EPS) was the focus. The initial concern was to separate the concrete, reinforcement and EPS into separate streams. This was achieved, with the crushed concrete and metal reinforcement being easily recycled locally. Problems arose with finding a recycler to take the EPS due to the risk of contamination with concrete, and the unusual provenance of the material – it did not have the traditional recycling symbol and identifier stamped into it.

Consequently, a wide range of recovery options were explored further to find the most suitable. Suitability was judged on the criteria of impact to transport & recover, level of the application (using the Waste Hierarchy), and associated costs.

Using this approach, the most appropriate route to recovering the EPS insulation waste was to send it to a company specialising in the manufacture of soft fall landing systems. These are essentially filled with EPS and the company already uses recycled feedstock wherever possible. Transport impacts were mitigated through the use of return haulage.

Photo: Fall & arrest bags for testing (Courtesy of BRE)

Extruded polystyrene (XPS)

10.7 Extruded polystyrene presents a greater recycling challenge, partly because of its location (it is often used as floor insulation). The use of CFC-12 as a blowing agent in pre-1994 products means that traditional polystyrene recycling is a less viable option for buildings of that period. As with PU and PIR, the potential exists for incineration of the foams in waste-to-energy plants provided that appropriate incineration capacity is available within practical distances. Disposal of XPS at end-of-life in regular landfills is not a recommended option because of the likely ODS content of XPS foams from that period.

For factory production waste, it is typical to recycle directly back into the production plant. This can, however, release the blowing agent. Where this is CO_2 or other relatively inert blowing agent, there is no problem. However, where high GWP HFCs are used, the act of recycling can contribute significantly to the environmental burden of the product. Some producers have made efforts to recapture emissions during the recycling process while others have focused on minimising the waste levels in production in order to avoid such emissive recycling steps.

Existing and potential recovery routes

Expanded polystyrene

10.8 Table 6 summarises existing and potential recovery routes for expanded polystyrene-based waste.

Table 6: Summary of recovery routes for EPS-based waste

Technology type	Description	Rationale
Waste prevention	Design & site waste Prevention	It is possible to achieve financial and resource savings over and above common benchmarks by liaising closely with the design teams and other contractors and consistently observing good site resource management practices..
Reuse	Minimal processing to facilitate reuse	Most advised recycling of EPS is into new insulating material. Specifically, EPS can be recycled at a limited percentage with virgin EPS to make new insulation for use in building and construction, where it is sourced from these applications and could contain flame retardants.
Recycling	Feedstock replacement for polystyrene products	Without flame retardant, EPS can be reprocessed to make a new material such as hardwood replacement for making garden furniture, slate replacement for roofing tiles and new plastics items such as coat hangers, CD and DVD cases.
Combustion	Cement kilns	The practice of processing waste foam through cement kilns is not widespread in the UK. Nevertheless, it is one of the known routes for managing foam waste.
Combustion	Incineration with energy recovery	EPS has a higher calorific value than coal. It can be safely burnt within energy recovery units, or incinerators.
Chemical recycling	Treatment to recover as polymer	It is possible to dissolve EPS in limonene, an essential oil distilled from orange peel, and then extract it from the liquid. Other solvents could be used but are less environmentally benign.

Other technically possible routes that have not yet been trialled in the UK include:

- Road sub-base material
- Possible aggregates replacement in lightweight concrete

Extruded polystyrene

10.9 In terms of extruded polystyrene, Table 7 summarises possible recovery routes.

Table 7: Summary of recovery routes for XPS

Technology type	Description	Rationale
Waste prevention	Design & site waste Prevention	It is possible to achieve financial and resource savings over and above common benchmarks by liaising closely with the design teams and other contractors and consistently observing good site resource management practices.
Reuse	Minimal processing to facilitate reuse	A theoretical reuse route exists for XPS but this is only valid where it can be guaranteed that it does not contain ODS.
Recycling	Feedstock replacement for polystyrene products	XPS is recyclable. Recycling of XPS is possible when ODS and HBCD flame retardants are not present.
Combustion	Cement kilns	The practice of processing waste foam through cement kilns is not widespread in the UK. Nevertheless, it is one of the known routes for managing foam waste.
Combustion	Incineration with energy recovery	Treatment technology for construction site foam waste (as well as refurbishment/demolition site foam waste containing ODS). XPS has a higher calorific value than coal. It can be safely burnt within energy recovery units or incinerators.
Chemical recycling	Treatment to recover as polymer	It is understood to be possible to dissolve XPS in limonene, an essential oil distilled from orange peel, and then extract it from the liquid. Other solvents could be used but are less environmentally benign. Any potential releases of ODS and HBCD flame retardants need to be managed.

Specific waste reduction actions

Expanded polystyrene

10.10 Recent work by WRAP[14] concluded that typical wastage rates for rigid insulation board ranged from 3% to 10%. It also states that the extent of onsite cutting is a significant factor for rigid insulation in particular, with significant reductions in wastage possible where the design can be coordinated around panel sizes. Weatherproofing of these products is critical, as any contact with water means that the product cannot be used and will be wasted.

The actions to reduce waste mainly revolve around design decisions to reduce cutting into boards, and site practices to ensure products are kept dry and away from possible impact. These are covered in Table 3 (Section 8), as Actions X1, X2 & X3.

Extruded polystyrene

10.11 During installation, similar measures to those espoused for PU/PIR and EPS could be legitimately introduced at site level. As mentioned elsewhere, one or more case studies might be helpful in communicating with building contractors.

[14] WRAP – New wastage rates for building products (not yet published).

Specific waste recovery actions

Expanded polystyrene

10.12 The CREO house case study clearly demonstrated that the current information on recovery routes for EPS was closely aligned to the recycling of clean, uncontaminated waste – typically packaging-related waste. Once this was recognised, further options were identified, evaluated and decided upon.

Ideally, the EPS recycling group will look into this in more detail and update their website to include other options and provide guidance as to what is the best route depending on location and nature of the waste arising. The updated website could then be widely advertised to the demolition and installation sectors.

In addition, it is not clear what levels of contamination and compaction are acceptable for the options identified inTable 6. An action to undertake this research and communicate its results clearly via the EPS recycling website would help address this information gap.

Extruded polystyrene

10.13 For installation waste, it may be possible to operate take-back schemes that could permit the recycling of waste directly back into factory manufacture. Care should be taken to ensure that emissions are minimised.

Concerns over contaminants in end-of-life products make incineration the only practical alternative to landfill at present, although some reuse could be possible if a Position Statement can be obtained from the UK Environment Agency (see Section 8).

There may be some sectors of XPS end-use (e.g. inverted roofs) which are more accessible than others and have the potential to become sources for reuse and/or recycling. A further analysis of typical end-uses by the industry might therefore be helpful in this regard.

Summary

10.14 Table 8 summarises the actions relating to waste reduction and recovery for polystyrene-based products and materials.

Table 8: Summary of actions: polystyrene-based products and materials

Description/ desired outcome	Lead	Action
EPS1 Better understanding of options available	BPF / EPS recycling group	To develop more detailed understanding of currently available recovery routes, in particular their acceptance criteria.
EPS2 Raise awareness of all reuse, recycling and recovery options	BPF / EPS recycling group	To expand guidance and options recommended for EPS recycling on the EPS recycling website.
XPS3 Better understanding of options available	EXIBA and individual manufacturers	To develop more detailed understanding of currently available recovery routes, in particular their acceptance criteria.
XPS4 Waste reduction and increased recovery during installation	WRAP together with manufacturers, installers and their trade bodies	To include XPS in any publication developed to promote waste minimisation and/or recovery and recycling of waste during installation.

11. Action Plan for phenolic-based building foam

Photo: Phenolic boards (Courtesy of EPFA)

About the products

11.1. **Phenolic foam** (PF) is a thermoset cellular polymer created when phenolic resins (resoles) are reacted with a catalyst plus a blowing agent to foam the product. CFC/HCFC blowing agents have been used in the past, but these were phased out due to the ODS regulation, again being completely replaced from 2004. The catalyst is a cross-linking/hardening agent. Phenolic foams are used primarily because of their excellent intrinsic fire and smoke properties and can have an open or closed cell structure. The closed-cell structure offers improved properties of thermal resistance and lower moisture vapour transfer and offers optimal fire performance. Closed-cell PF is the sort generally used for insulation boards.

11.2. Because phenolic foams are manufactured using an emulsion technology, the cell structure can be controlled to produce fine cells which are very uniform in size. This optimises the thermal performance and allows for the use of thinner boards, thereby allowing thinner building elements or greater insulation levels for cavity wall and similar applications.

11.3. The phenolic structure is similar to polyurethane. Current products can be used interchangeably with PUR and PIR for most applications. In addition to its use in laminate and panel products, phenolic foam is widely used to insulate pipe work, where its high thermal efficiency and intrinsic fire properties are of particular value, especially where space is constrained.

Current activities

11.4 Although phenolic foams have been in minor production in the UK since the 1960s, their acceptance only began to grow when reliable closed-cell technologies emerged in the early 1980s. Initially, that growth was based on the pipe insulation sector but subsequently extended to laminates and panels as the manufacturing technologies were developed and optimised.

The later development of phenolic foams might be assumed to lead to proportionately lower levels of demolition waste as a proportion of the total for the product. However, the dominance of shorter-life products (e.g. pipe insulation) in the earlier history of phenolic foams means that more will have already reached the waste stream, or are in the process of doing so. For this reason, the ratio of construction to demolition waste for phenolic foams has been assumed to be the same as for PUR/PIR foams in Section 6 of this Action Plan.

Construction and building services waste practices centre mainly on landfilling for those phenolic foams reaching end-of-life. However, the opportunity exists to incinerate phenolic materials in a similar fashion to PUR and PIR foams. Possible mechanical recycling routes might also exist, since phenolic dusts tend to be relatively inert. However, the lack of sufficient waste flows would currently rule against this in anything but trial quantities.

Existing and potential recovery routes

11.5 Table 9 summarises existing and potential recovery routes for phenolic-based waste.

Table 9: Summary of recovery routes for phenolic-based waste

Technology type	Description	Rationale
Waste prevention	Site waste prevention	It is possible to achieve financial and resource savings over and above common benchmarks by liaising closely with the design teams and other contractors and consistently observing good site resource management practices.
Combustion	WTE	Best *a priori* treatment technology for construction site foam waste (as well as refurbishment/demolition site foam waste containing ODS).
Combustion	Cement kilns	The practice of processing waste foam through cement kilns is not widespread in the UK. Nevertheless, it is one of the known routes for managing foam waste.
Mechanical recycling – mixing with other substances to create new products	**a**) Granulate/ Powder reprocessing into variety of foam or alternative products	Potential to create light concrete & cement screeds; lightweight blocks; chipboards; acoustic absorption products; MDF board alternatives; oil/liquid absorption uses
	b) Appliances Recycling Plant	Infrastructure in place in the UK; potential spare capacity for non-appliance foam destruction; technically proven with PU composite panels; possible markets: oil/liquid absorption uses

At this stage, it is premature to speculate on the viability of chemical recycling.. However, Kingspan is actively investigating chemical recycling with suppliers. Small-scale experiments have shown this to be viable, producing resins which may be reusable as precursors to foam production.

Specific waste reduction actions

11.6 In recent years, the phenolic foam industry has made significant strides in reducing waste from production processes – particularly from those used to manufacture phenolic pipe insulation. This has been based on considerable process innovation which has, in turn, been made possible by increasing product demand.

In principle, opportunities exist for further improvement in factory production efficiencies. However, owing to the smaller number of phenolic foam producers in the UK, there may be confidentiality issues associated with collecting, aggregating and publishing trends in losses. This is therefore not carried forward as an action in this instance.

As with PU and PIR foams, there would be opportunities in promoting best practice for site waste minimisation through the identification of one or more case studies and the development of relevant guidance.

Specific waste recovery actions

11.7 Pipe insulation presents a particularly good opportunity for waste recovery, bearing in mind that much of it is routinely replaced during maintenance cycles rather than at the point of demolition. The cost-effectiveness of diverting these materials away from landfill depends on the alternative infrastructures in place. In continental Europe, there is more likelihood of an MSWI being in close proximity to the facilities being maintained and an environmental impact assessment might be necessary to establish whether special handling of pipe insulation would be justified. Since CFCs were phased out of use in phenolic foam pipe insulation in 1994, it is unlikely that there are any significant quantities of CFCs remaining in installed stock. The situation for HCFCs is less clear, since phase-out of HCFC use did not occur until 2004.

Opportunities for improved efficiencies in the handling of factory production/installation waste flows will continue to be explored, with opportunities for secondary use and mechanical recycling being the most obvious alternatives. The case for incineration is similar to that for PU and PIR, but ultimately depends on incineration capacity, whether for factory production/installation waste or for demolition waste. In the case of the latter, it is unlikely that phenolic laminate will be identified separately to PU and PIR product types.

Summary

11.8 Table 10 summarises the actions relating to waste reduction and recovery for phenolic-based products and materials.

Table 10: Summary of actions: phenolic-based products and materials

Description/ desired outcome	Lead	Action
PF1 Better understanding of reduction and recovery opportunities	EPFA (in conjunction with BRUFMA)	To identify case studies and develop related guidance on best installation practices for waste minimisation and management.
PF2 Better understanding of the impacts of recovery of pipe insulation	WRAP in conjunction with EPFA and other stakeholders	To undertake an Environmental Impact Assessment on recovery and destruction of pipe insulation from installation, routine maintenance and decommissioning cycles.
PF3 Better understanding of the impacts of recovery of all phenolic insulation waste	EPFA and phenolic foam manufacturers	To explore other waste recovery activities relating to factory production/ installation waste streams including further incineration trials.
PF4 Improved recovery of phenolic insulation demolition waste	EPFA in conjunction with BRUFMA and NFDC	To look for opportunities to expand PF3 technologies to laminate products in the demolition waste stream.

12. Action Plan for insulated sandwich panels and plasterboard

Photo: Insulated plasterboard installed (Courtesy of UKCG)

About the products

12.1. **Insulated plasterboard** is a composite board made from plasterboard with an insulation layer, typically used to improve the thermal performance of solid walls. The insulation materials used include expanded or extruded polystyrene, PU or phenolic insulation board bonded directly to the back of a sheet of plasterboard. They come in standard 2400 x 1200mm sheet sizes and may include a vapour control barrier.

12.2. **Metal insulated panels** are factory engineered panels used for exterior cladding, partitioning, load-bearing walls and roofing elements. Panels are metal faced, usually steel or aluminium, with an insulation core. The thickness of the insulation varies depending upon application and insulation characteristics. These products are also known as 'sandwich' panels and 'composite' panels. The main difference between panels is the insulating core which can be PIR and mineral wool, or to a lesser extent PUR, EPS, PF or XPS.

Photo: Metal insulated roof panel (Courtesy of EPIC)

12.3. **Structural insulated panels (SIPs)** are typically faced with a wood composite such as Oriented Strand Board (OSB), with a PU or EPS core. They can be used to construct the floor, walls and roof of a building, including off site manufactured housing systems.

Current activities

12.4 Metal insulated panels are generally recycled for the metal. When removed at demolition stage, the insulation can be stripped out and typically sent to landfill. If there is reason to believe the insulation could contain ozone-depleting substances, a recycling route developed for old fridges should be followed, as detailed in the recent EPIC guidance document.[15]

Existing and potential recovery routes

12.5 Table 11 summarises existing and potential recovery routes for composite products.

[15] Insulated Panels Identification and Disposal, Advice and guidance on the identification and disposal of metal faced insulation panels used in building, Engineered Panels in Construction.

Table 11: Recovery routes for composite products

Technology type	Description	Rationale
Waste prevention	Design & site waste prevention	Panel products tend not to produce waste on site. For insulated plasterboard, it is possible to reduce wastage through careful design & procurement, and good storage of product to protect from moisture and impact. Reuse of off-cuts can also be considered as waste prevention.
Reuse	Minimal processing to facilitate reuse	It is possible to reuse SIPs and metal insulated panels if removed carefully during the demolition process. Application depends upon fire rating and proximity to possible reuse market.
Recycling	Feedstock replacement	Metal and timber facing is readily recycled once separated. Insulation core recycling depends upon material type (refer to relevant section). Recycling route established for metal insulated panels aligned to end-of-life fridge recycling. Currently not possible to separate out insulated plasterboard to enable recycling.
Combustion	Incineration with energy recovery	Separated insulation core recovery depends upon material type (refer to relevant section). Timber from SIPs is readily recoverable, and possibly the whole panel if cut to a suitable size.

Specific waste reduction actions

12.6 Metal insulated and structural insulated panels should have low levels of waste at installation stage, apart from a small number of damaged products. Therefore the focus for waste reduction in this section is on insulated plasterboard. Increasing amounts of this product are being used to meet more demanding requirements for airtightness and thermal performance (Part L building regulations). As with other board products, onsite cutting is a significant contributor to waste production, with significant reductions in wastage possible where the design can be coordinated around panel sizes. However, when associated with refurbishment, existing wall sizes, opening, etc., may limit the reduction of waste by design, unless the board is cut off site (using CNC machinery).

Weatherproofing of insulated plasterboard is also critical as any contact with water means that the product cannot be used and will be wasted.

The actions to reduce waste mainly revolve around design decisions to reduce cutting into boards, and site practices to ensure products are kept dry and safe from possible damage. These are covered in Table 3 (Section 8), as Actions X1, X2 & X3.

Specific waste recovery actions

12.7 Metal insulated panels that are being taken out of buildings constructed after 2004 could be reused. The EPIC study showed that there is a market for metal insulated panels of more recent production that have LPS 1181 fire certification. SIPS panels can also be dismantled and reused; however, there is little guidance in terms of how best to access the fixing points and take the panels apart with minimal damage. A consideration of design for deconstruction and

the passing on of information to enable the demolition sector to determine the best way to dismantle structures made from panellised systems would facilitate reuse in the future.

12.8 If it is not possible to reuse panel products then recycling and recovery of the constituent materials should be considered. For metal insulated panels, there is an incentive to separate out materials into metallic and other. The metal will be recycled but the building insulation foam will probably be landfilled, although some EPS cores have been reprocessed into insulation boards. For SIPs (timber-clad) panels, the incentive to separate out into timber-based and building insulation foam is lower, but there is a good market for timber in terms of energy recovery. It could be possible to send the whole panel to an energy recovery facility, though larger panels would need to be cut into pieces small enough for the waste feed hopper. The ability to recover building insulation foam separated from each panel type will mirror the opportunities and actions detailed in each specific building insulation foam type section. A better understanding of whether these opportunities are viable, and case studies showing how recovery has been carried out would be a positive step in improving the recovery of all the materials in these panellised products.

12.9 The most challenging composite product (containing building insulation foam) to recycle or recover is insulated plasterboard, which is commonly used in construction. The plasterboard is essentially bonded to insulation board which makes separation by the demolition contractor impractical. Obviously, the improved thermal performance of these products needs to be set against this end-of-life challenge. However, it is important that recovery options are developed for insulated plasterboard in the near future. This is an area of interest to both the manufacturers of insulation boards and plasterboard. As such, they will work together with the demolition and waste industry to develop a viable separation and/or recovery route.

Summary

Table 12 summarises the actions relating to waste reduction and recovery for composite products.

Table 12: Summary of actions: composite products

Description/ desired outcome	Lead	Action
C1 Increase the reuse of panel products	Structural insulated panel manufacturers	To produce guidance and/or Code of Practice for panellised systems to facilitate future reuse.
C2 Increase the recycling and recovery of panel products	Metal insulated and structural insulated panel manufacturers/ NFDC/ EPIC	To produce guidance and case studies illustrating recovery and recycling of panellised systems.
C3 Reduce the proportion of insulated plasterboard waste being landfilled (from 100%)	Insulated plasterboard manufacturers and PSP (Plasterboard Sustainability Partnership) with NFDC and waste industry	To develop methods to separate and/or recover insulated plasterboard.

Appendix 1 – Summary of all actions and monitoring of actions

This is the template for BIFREP to monitor progress against the Action Plan. *An important aspect of Action Plan implementation will be to agree timescales by which each of the actions will be completed.

Table 13: Summary of all actions and monitoring of actions for BIFREP

Description/ desired outcome	Lead	Timescale*	Progress
X1 To consider amending NBS Section P10 to promote waste reduction measures	RIBA/ and relevant NBS technical writer		
X2 To consider inclusion of waste reduction of insulation measures in BSI Code of Practice – Designing out Waste	RIBA/ BSI		
X3 To provide guidance to installers by creating common text for inclusion in guidance and make members aware	Manufacturers/ Trade Associations/ UKCG		.
X4 To explore option to include BREEAM credits for 'difficult to recycle' waste types from demolition	BRE		
X5 To carry out demolition pilot studies and trials to develop industry approach to identifying in-situ insulation types	NFDC/UKCG (WRAP support)		
X6 To produce a cost benefit spreadsheet of recovery options compared to landfill	WRAP		
X7 To produce WRAP published guidance and case study report, widely disseminated	WRAP/Trade Associations		
X8 To approach the Environment Agency concerning the status of chemicals in reuse/recycling with a view to obtaining a Position Statement	WRAP/Caleb/BRE		

Description/ desired outcome	Lead	Timescale*	Progress
PU1 To continue to explore and encourage research into innovative solutions for the various PU foam waste streams. This should be a continuing activity and assessed at periodic meetings of BIFREP	BRUFMA		
PU2 To assist in developing generic guidance on best practices for waste minimisation of insulation products. Such guidance to be issued by BRUFMA	BRUFMA		
PU3 To identify suitable case studies on reduction and recovery during installation. Suitable existing case studies to be identified, and continuation at periodic meetings of BIFREP	BRUFMA/WRAP together with installers (e.g. TICA)		
PU4 To continue transfer of best practice to demolition arena by communication at periodic meetings of BIFREP	NFDC supported by BRE/Caleb		
EPS1 To develop more detailed understanding of currently available recovery routes, in particular their acceptance criteria	BPF / EPS recycling group		
EPS2 To expand guidance and options recommended for EPS recycling on the EPS recycling website	BPF / EPS recycling group		
XPS3 To develop more detailed understanding of currently available recovery routes, in particular their acceptance criteria	EXIBA and individual manufacturers		
XPS4 To include XPS in any publication developed to promote waste minimisation and/or recovery and recycling of waste during installation	WRAP together with manufacturers, installers and their trade bodies		
PF1 To identify case studies and develop related guidance on best installation practices for waste minimisation and management	EPFA (in conjunction with BRUFMA)		

Description/ desired outcome	Lead	Timescale*	Progress
PF2 To undertake an Environmental Impact Assessment on recovery and destruction of pipe insulation from installation, routine maintenance and decommissioning cycles	WRAP in conjunction with EPFA and other stakeholders		
PF3 To explore other waste recovery activities relating to factory production/ installation waste streams including further incineration trials	EPFA and phenolic foam manufacturers		
PF4 To look for opportunities to expand PF3 technologies to laminate products in the demolition waste stream	EPFA in conjunction with BRUFMA and NFDC		
C1 To produce guidance and/or Code of Practice for panellised systems to facilitate future reuse	Structural insulated panel manufacturers/ RIBA		
C2 To produce guidance and case studies illustrating recovery and recycling of panellised systems	Metal insulated and structural insulated panel manufacturers/ NFDC/ EPIC		
C3 To develop methods to separate and/or recover insulated plasterboard	Insulated plasterboard manufacturers and PSP (Plasterboard Sustainability Partnership) with NFDC and waste industry		

Appendix 2 – List of abbreviations and acronyms

BIFREP	Building Insulation Foam Resource Efficiency Partnership
BIM	Building Information Modelling
BMF	Builders Merchant Federation
BPF	British Plastics Federation
BRE	Building Research Establishment
BRUFMA	British Rigid Urethane Foam Manufacturers' Association
CPD	Construction Products Directive
CPR	Construction Products Regulation
EPFA	European Phenolic Foam Association
EPIC	Engineered Panels in Construction
EPS	expanded polystyrene
EXIBA	European Extruded Polystyrene Insulation Board Association
GWP	global warming potential
HBCD	hexabromocyclododecane (a brominated flame retardant)
MSWI	municipal solid waste incinerator
NBS	National Building Specification
NFDC	National Federation of Demolition Contractors
NFRC	National Federation of Roofing Contractors
ODS	ozone-depleting substances
OSB	oriented strand board
PF	phenolic foam
PIR	polyisocyanurate
PSP	Plasterboard Sustainability Partnership
PUR	polyurethane
RIBA	Royal Institute of British Architects
SIPs	structural insulated panels
SPRA	Single Ply Roofing Association
SWMP	site waste management plan
TICA	Thermal Insulation Contractors Association
UKCG	UK Contractors Group
WFD	Waste Framework Directive
WTE	waste-to-energy
XPS	extruded polystyrene