A RESOURCEFUL FUTURE – EXPANDING THE UK ECONOMY

Technical Appendix

A report commissioned by SUEZ recycling and recovery UK, written by Eunomia Research & Consulting

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Report for SUEZ recycling and recovery UK

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Acronyms

AD – Anaerobic Digestion

BaU – Business as Usual

C&I – Commercial and Industrial

C&D – Construction and Demolition

DEFRA – Department for Environment, Food and Rural Affairs

DRS – Deposit Refund Scheme

EEE – Electrical and Electronic Equipment

EfW – Energy from Waste

ELV – End of Life Vehicle

FTE – Full Time Equivalent

GDP – Gross Domestic Product

GHG – Greenhouse Gas

GPP – Green Public Procurement

GVA – Gross Value Added

IBA – Incinerator Bottom Ash

IVC – In-Vessel Composting

LWARB – London Waste and Recycling Board

MBT – Mechanical Biological Treatment

MRF – Materials Recovery Facility

OAW – Open Air Windrow Composting

OECD – Organisation for Economic Co-operation and Development

PAYT – Pay-As-You-Throw

PERN – Packaging Export Recovery Note

PRN – Packaging Recovery Note

R&D – Research and Development

RDF – Refuse Derived Fuel

SIC – Standard Industrial Classification

SRF - Solid Recovered Fuel

WEEE – Waste Electrical and Electronic Equipment

Contents

1.0 Introduction

Eunomia Research & Consulting (Eunomia) was commissioned by SUEZ to produce the report *A Resourceful Future – Expanding the UK Economy*. This Technical Appendix, produced in digital format only, is intended to accompany this report by providing additional supporting information, evidence and further details about the technical modelling that was undertaken for the study.

2.0 Measures for Realising the Vision

2.1 Completing the Job of Waste Management Policy

Waste management in the UK moved on leaps and bounds in the first decade of the millennium. There are, however, policies that are still missing, and ones that are simply no longer fit for purpose (if, indeed, they ever were). The job would be 'more or less complete' if the changes suggested in the sections below were adopted.

2.1.1 Extended Producer Responsibility Legislation

At a UK level, consideration should be given, in light of Defra's review of existing extended producer responsibility legislation, to the role that producers can play in improving the value proposition for recycling and creating a supply chain that is more resilient to price volatility and market risk. Producers should be incentivised to design products for longevity, that can readily be repaired or remanufactured, and failing that, recycled with ease. This latter point is consistent with recommendations made by the European Commission for producer responsibility schemes within proposals for a revised Waste Framework Directive.[1]

The existing mechanism for producer responsibility for packaging in the UK places few demands on producers, other than that they (or more usually, their 'compliance scheme') should purchase evidence – in the form of Packaging Recovery Notes (PRNs) and Packaging Export Recovery Notes (PERNs) – that recycling obligations have been met. The amount paid by producers in any given year varies according to the extent to which targets increase from one year and hence, which determines how tight the market is likely to be for PRNs and PERNs, although the majority of purchases of PRNs / PERNs are not determined by market transactions. The situation is very different in some other countries, where there is a more direct relationship between the costs of delivering a given obligation, and the amount that producers pay.

The characteristics of a well-designed extended producer responsibility system for packaging waste would have the following features:

1) One sole scheme for packaging waste collection undertaken by local authorities which is a single not-for profit private entity. Whether there is a need for a separate scheme for packaging collected from other sources is an open question: the mechanism for channelling funds would be different and the ultimate recipients would be waste collection companies;

[1] European Commission (2015) *Proposal for a Directive of the European Parliament and of the Council Amending Directive 2008/98/EC on Waste*, December 2015, http://eur-lex.europa.eu/resource.html?uri=cellar:c2b5929d-999e-11e5-b3b7-01aa75ed71a1.0018.02/DOC_1&format=PDF

2) A key purpose of the scheme is to channel funds from producers to local authorities and to waste collection companies, and hence, the lack of need for multiple schemes which, in the UK, leads to a 'syphoning off' of funds from the compliance system to compliance schemes;
3) The producers would be responsible for paying the full costs of collection, reprocessing and communication, as well as for the costs of treatment / disposal of the unrecycled fraction;
4) The fees paid by producers would be modulated in accordance with the ease with which materials could be reused / repaired / recycled;
5) The producers would have a say in the nature of the collection systems, having regard to the quality of the materials that would be collected; and
6) The scheme would have responsibility for arranging for preparation for reuse, and for any necessary treatment and reprocessing of collected materials; it would pay the necessary fees for treatment / preparation for reuse and / or generate revenues from the sale of collected and sorted material. This responsibility would allow for stable contracting arrangements with relevant parties.

The above scheme design thereby assigns greater financial responsibility to producers, as well as allowing the producers to offset some of their costs through the sale of secondary materials, giving the producers an interest in the nature of the logistics used. This revenue, in turn, leads to changes in the fees being charged to producers in order to fund the system: fees go up when secondary material prices, and hence revenues, are low, and vice versa. This implies that producers' fees increase at times when their raw material prices are lowest, so that there is a 'counter-cyclical' nature to the fees being charged to producers.

This approach can also help to support higher levels of recycling at a time when price volatility in the market for secondary materials has placed stress on the arrangements between local authorities and their contractors. It also has the potential to ensure that producers support secondary materials markets since declining values simply lead to a requirement for higher fees to make up the shortfall.

The UK should also consider developing producer responsibility schemes for a much wider range of products than are currently covered. As shown in Table 2-1, other European Member States have implemented such schemes across a wide range of materials beyond packaging, waste electrical and electronic equipment (WEEE), batteries, and end-of-life vehicles (ELVs). Well-designed schemes which place sufficient onus on producers and are applied to a wide range of products would go a long way to driving the circular economy forward. The situation as regards WEEE in the UK is unnecessarily complex, and would benefit from simplification.

Table 2-1: Materials Targeted by Extended Producer Responsibility Schemes Across the EU

Products	Example of Member States with EPR Legislating Covering the Designated Products
Agricultural plastics / film	Estonia; France; Ireland
Construction waste	Germany
Disposable cutlery	Belgium
Expanded polystyrene	Austria
Fluorinated refrigerants	France
Furniture	France
Gas cylinders	France
Graveside candles	Slovenia
Pesticides	France; Slovenia
Photographic chemicals	Belgium
Plastic bags	Belgium; Bulgaria; Ireland
Textiles	France
Tyres	Austria; Belgium; Bulgaria; Cyprus; Czech Republic; Denmark; Estonia; Finland; France; Greece; Hungary; Italy; Latvia; Lithuania; Netherlands; Portugal; Slovakia; Spain; Slovenia
Waste pharmaceuticals	Belgium; France; Slovenia
Waste mineral / motor oils / lubricating oils	Austria; Belgium; Cyprus; Czech Republic; France; Germany; Greece; Portugal; Spain; Slovenia

Source: D. Hogg, A. Mitsios, S. Mudgal, A. Neubauer, H. Reisinger, J. Troeltzsch, M. Van Acoleyen (2012) Use of Economic Instruments and Waste Management Performances, Report for DG Environment, April 2012, http://ec.europa.eu/environment/waste/pdf/final_report_10042012.pdf

2.1.2 Mandate Recycling Collections

The shaping of how local authorities and businesses collect waste is an area of obvious difference between the devolved administrations and England. In England, the legislative hooks are effectively to be found in a pre-treatment requirement and the Waste (England and Wales) Regulations. These have no meaningful impact on how waste is collected, even though, particularly in respect of the latter being the measure for transposing Article 4 of the Waste Framework Directive (concerning the waste hierarchy), they should be highly influential.

Scotland and Northern Ireland have already introduced mandates for business waste collections, notably, in respect of food wastes: Wales seems set to follow. Wales also has a 'Blueprint' for collections that it has encouraged local authorities to follow.

In England, there is an apparent aversion to regulation of this nature. Over many years, successive governments stated that decisions regarding the collection of household waste should be left to local authorities. This has had a number of detrimental consequences:

1) This freedom has not always led to the most sensible decisions: some of the revolts against fortnightly refuse collections that occurred mainly in the last decade were quite predictable given some of the choices of system being made: clear guidance from Government about what not to do would have been helpful;
2) The variation in recycling rates across the UK can be traced to a number of factors, but several of these simply relate to the nature of the collection service provided; and
3) The implied absence of ambition beyond what statutory targets happened to be in place at the time has led to an over-specification of residual waste treatment capacity in some local authority areas which is constraining further progress on recycling.

There is now an increasing interest in harmonising waste collection services for UK households. It is expected that this might reduce the extent of variation across, and improve the average level of performance of, local authority controlled waste management. Even so, there remains a reluctance by Government to move on business waste collections despite:

1) The likely potential for more of the 'dry materials and products' to be recycled (reflecting the growing desire of businesses to see this happen); and
2) Evidence that the costs of mandating food waste collections for businesses – as already happens in Scotland and Northern Ireland – would be unlikely to impose significant costs (and for many businesses, would lead to financial savings).[2]

Legislation should be adopted to go beyond current measures for both households and businesses to ensure that:

- Government should either indicate which systems – in terms of 'the perspective of the householder' – are deemed acceptable, or indicate what practices are no longer acceptable, as a means of giving guidance to local authorities as to what is considered consistent with a model that seeks to minimise residual waste. Either way, we would expect such guidance to effectively mandate food waste collections, ensure sufficient volume / frequency of collection for dry recyclables containers, and – once legislation is in place – implementation of pay as you throw systems, as described further in Section 2.2.1;
- Businesses should be required to arrange for the separate collection of a range of materials, including food waste, and to encourage staff to actively engage with these services with a view to maximising the capture of their materials for recycling; and
- Producers of construction and demolition waste should be required to sort wastes for recycling.

The latter measure is likely to induce waste collection companies to provide more comprehensive separate collection services for commercial clients.

[2] See, for example, Eunomia's recent report undertaken on behalf of the Renewable Energy Agency (REA): Eunomia Research & Consulting (2016) *The Real Economic Benefit of Separate Biowaste Collections: A Business Case*, May 2016, www.r-e-a.net/resources/pdf/244/REA_Report_On_Separate_Biowaste_Collections_19-05-2016.pdf

2.2 Influence Consumer Behaviour

There are a number of measures that should be adopted to help influence consumer behaviour in environmentally positive ways. Some suggestions for measures relating to resource efficiency are provided below.

2.2.1 Pay-as-You-Throw Schemes

Numerous studies the world over have shown that the introduction of pay-as-you-throw (PAYT) schemes help to divert waste towards recycling and, in many instances, also has a noticeable waste prevention impact. For example, South Korea achieved a 15% drop in waste arisings following the introduction of a volume-based waste fee. In the district of Schweinfurt in Germany a reduction of around 70 kg of residual waste per person was achieved following the introduction of PAYT. Eunomia has reviewed the international evidence of PAYT schemes and it clearly suggests that the introduction of PAYT is associated with a corresponding fall in household waste arisings.[3,4]

The UK government has come close to introducing PAYT schemes on many occasions in the past. The price signals provided by PAYT schemes have been shown to alter household behaviour in positive ways, with the added benefit of reducing the overall costs of managing municipal waste (i.e. by reducing overall waste volumes and diverting materials to recycling). It is suggested that the introduction of PAYT be seriously considered across the UK as a key measure for driving behaviour change and ensuring full cost recovery for all waste collection services.

2.2.2 Reducing Litter

The pervasive nature of litter, and the problems it can create in rivers and marine ecosystems in particular, have led to considerable emphasis on this as an issue that needs to be tackled. Methods based on educating and informing, useful as they may be, have less to recommend them than measures which incentivise change, and behaviours which reduce littering.

2.2.2.1 Taxes on Disposable Products

The success of levies on plastic bags in the different countries of the UK, following on from earlier deployment in the Republic of Ireland (and a number of other countries besides), has

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[3] Eunomia Research & Consulting (2006) *Impact of Unit-Based Waste Collection Charges*, Report for the Organisation for Economic Co-operation and Development, May 2006, www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=ENV/EPOC/WGWPR(2005)10/FINAL&docLanguage=En

[4] Eunomia Research & Consulting (2006) *Modelling the Impact of Household Charging for Waste in England*, Report for the Department for Environment, Food and Rural Affairs, December 2006, http://webarchive.nationalarchives.gov.uk/20130402151656/http://archive.defra.gov.uk/environment/waste/strategy/incentives/documents/wasteincentives-research-0507.pdf

made it abundantly clear that consumers will change their behaviour – actually, quite radically – in response to measures which target what are obviously wasteful items.[5]

Less surprising than this result is that producers are allowed to supply, unfettered, a host of disposable items which have no place in an economy that is seeking to take wise stewardship of resources. Recent discussions have turned to disposable cups: several coffee chains have sought to incentivise use of reusable cups by offering discounts to those who make use of them. However, these have not proved especially successful, most likely because the practice is not universally applied. The situation would be different in the case of a tax: we would expect more consumers to carry reusable cups, and the quantity of disposable cups used would decline as a result.

Similar measures could be applied to disposable cutlery, razors, and other items besides. These measures tend not to raise much revenue because they can be very effective in bringing about change. They may be particularly helpful in addressing the flow of plastic items (including bags) which contribute to the build-up of plastics in the marine environment.

2.2.2.2 Deposit Refund Schemes

Deposit refund schemes (DRSs) used to function in the UK, principally for reusable glass bottles. A number of schemes now operate in countries across the world, and many of these are focused mainly on 'single trip' beverage packaging, such as cans, plastic bottles and one-way glass packaging. Existing schemes exist in Sweden, Norway, Denmark, Finland, Estonia, Germany, Croatia, a number of states in the USA and in various provinces of Canada. Recent adopters of DRSs include Lithuania, and the Australian states of New South Wales, Queensland and Western Australia have announced their intention to implement such schemes. The Scottish Government has been reviewing the case for a system.

Deposit refund schemes offer the following benefits:

1) High rates of return for targeted beverage packaging (as long as the deposit is set high enough to encourage return);
2) High quality of material collected; and
3) A reduction in littering of beverage containers.

The impact on the price of beverages depends on the nature of the scheme, but in principle, the balance between unclaimed deposits and the costs of operating the scheme determines this figure. In Gross-Value Added (GVA) terms, any increase in price would be used largely to support the logistics of the return system. Although some technology may be imported, the suggestion is that the approach would contribute significantly to GVA through the increase in employment expected.[6] Furthermore, to the extent that there are impacts on litter, then there may be, at the margin, additional benefits to tourism. Research conducted by

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[5] According the Environmental Tax Reform Information System, taxes/charges on plastics bags have been applied in Belgium, Czech Republic, Denmark, Ireland, Spain, France, Latvia, Lithuania, Hungary, Malta, Portugal, and Romania.

[6] Eunomia Research & Consulting (2011) *From Waste to Work: the Potential for a Deposit Refund System to Create Jobs in the UK*, Report for Campaign to Protect Rural England, July 2011, www.cpre.org.uk/resources/energy-and-waste/litter-and-fly-tipping/item/2359-from-waste-to-work

Eunomia on behalf of Zero Waste Scotland indicates that the benefits from reduced disamenity are important parts of the justification of such an approach.[7]

The same principle can be deployed at public events to encourage the use, and return, of reusable glasses. Furthermore, there are good reasons to consider the use of DRSs for a range of other products, including WEEE and sports equipment. In a genuinely circular economy, if producers want to move towards a situation where they are effectively leasing materials to consumers of their products, then the logical approach is to maximise the prospects for take-back: that is what makes DRSs particularly interesting in the development of a circular economy.

2.3 Influencing Industry

An industrial strategy would seek to influence the behaviour of industry in terms of production and resource efficiency. A number of possible measures that could be used to drive changes in this area are outlined below.

2.3.1 Green Public Procurement

In the UK, the Government spends around £268 billion on goods and services each year, or around 15% of GDP.[8] Thus, moves to implement green procurement measures can, through shaping demand for goods and services, have extensive impacts on the design, composition, production and distribution of products and materials. For example, in 2015 the Federal Vehicle Repair Cost Savings Act was passed in the USA which requires all vehicles in the federal fleet – totalling 633,851 vehicles in 2014 – to be repaired and maintained using, as far as possible, remanufactured parts.[9]

The UK currently follows the voluntary EU Green Public Procurement (GPP) programme and has made efforts to integrate this into the mandatory Government Buying Standards, which cover all central Government departments and their related organisations.[10] The UK has agreed to the EU's proposal that 50% of all tendering procedures should be 'green' – that is, compliant with the 'core' GPP criteria. The percentage is measured on the basis of both the number and value of contracts concluded in the sectors for which common 'core' GPP criteria have been set.

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[7] Eunomia Research & Consulting (2013) *Exploring the Indirect Costs of Litter in Scotland*, Report for Zero Waste Scotland, www.zerowastescotland.org.uk/sites/files/zws/Indirect%20Costs%20of%20Litter%20-%20Final%20Report.pdf

[8] Gross current procurement by local government was £78 billion, whilst gross capital procurement was £16 billion. The same figures for central government were £135 billion and £32 billion, respectively. For all the public sector, the respective figures were £213 billion and £55 billion (see HM Treasury (2016) Public Expenditure: Statistical Analyses 2016, July 2016, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/539465/PESA_2016_Publication.pdf .

[9] Government Fleet (2015) *Federal Fleets to Use Remanufactured Parts*, Date Published: 4 November 2015, Date Accessed: 2 August 2016, Available at: www.government-fleet.com/news/story/2015/11/federal-fleets-to-use-remanufactured-parts.aspx

[10] Defra (2014) *EU Green Public Procurement Programme – Key Facts*, March 2014, www.gov.uk/government/uploads/system/uploads/attachment_data/file/324706/EU_Green_Public_Procurement_programme_-_Key_facts.pdf

The Government Buying Standards are split into two levels: the basic mandatory level and the voluntary best practice level.[11] Defra should seek to ensure that the standards are continually tightened and that the minimum 50% target for procuring 'green' goods is significantly increased. Measures must also be taken to ensure that central and local government abide by the Standards and place environmental concerns at the heart of their procurement decisions. The emphasis often tends to be on the procurement of goods rather than the provision of the service that the good provides. The aim should be to facilitate fair competition so that new business models, and products which are remanufactured or repaired, are not discriminated against in the market. The revision in approach requires a coherent strategy.

Training for procurement officers will also be necessary to ensure professionals understand the opportunities for greening public procurement within a circular economy context. It would make sense for this to follow the development of GPP criteria for an initial range of 'goods'. This would require them to consider issues such as procuring reused / remanufactured goods, or ensuring that their procurements were open to models of delivery of the product as a service. The last of these might prove challenging under existing EU procurement law, which requires notices to be identified in terms of their being for goods or for services (and CPV codings by and large reflect this). It might be difficult, and potentially, undesirable (from the perspective of value for money) to frame procurement as 'having to be' in the form of services rather than products. As a result, approaches are likely to have to consider bids to provide goods, but with different financing mechanisms. Criteria for award could include lifecycle costs rather than the cost of purchase, so as not to discriminate unfairly against those who seek 'to do the right thing' in terms of product and service design.

Consideration should also be given to requiring those involved in major construction projects to submit compliance bonds at the outset of their projects so as to meet criteria for recycling, and where appropriate, reuse, of waste materials. Bonds would be refunded where it could be demonstrated that target performance levels had been met (or partially refunded if they were not). This would drive recycling of waste in C&D projects to very high levels, as seen in Japan.

2.3.2 Invest in Innovative Research and Development

Research and development (R&D) plays a key role in any economy and will be central to facilitating a transition to a circular economy. The UK government should consider providing financial support to circular economy businesses and start-ups, and invest in R&D which aims to imbed circular economy principles into the broader economy. Business support in respect of the environment has generally focused on the efficient use of resources by a given company in its commercial and industrial activities. It has not always focused on how the company's way of doing things, and its consumption behaviour, might be better aligned with the circular economy. Funding support could be used to trial a new form of business

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[11] Defra (2012) *Sustainable Procurement: the Government Buying Standards (GBS)*, Date Published: 2 February 2012, Date Accessed: 2 August 2016, Available at: www.gov.uk/government/collections/sustainable-procurement-the-government-buying-standards-gbs

support of a cross-disciplinary nature, designed to help businesses re-think their strategy in line with circular economy principles. The potential for purchasing remanufactured / reused goods, and for using more secondary materials would also be highlighted alongside broader resource efficiency objectives.

Many business incubators and accelerators have focused on the digital sector. These concepts have been sufficiently successful that several corporately-backed accelerators now exist. The UK government should help to ensure that start-up companies with offerings of relevance to the circular economy are able to benefit from advice that incubators offer, and in due course, to seek support (potentially from private companies) for accelerators which focus on developing companies in the circular economy.

There are clearly some areas of R&D which can help to support the development of the circular economy. The nature of innovation being as it is, these might not always be readily identifiable in advance. In some cases, there may be clear areas for support (e.g. closed-loop recycling of textiles or for recycling composite materials). 'Circular economy thinking' is, much like sustainability, a cross cutting discipline. Innovations could occur in a range of areas including design of products, design of processes for, or which enable, ease of dismantling, product remanufacturing techniques, innovations supporting the development of smart logistics, innovations in logistics services, innovations supporting the development of markets where they did not previously exist at scale, developments in asset tracking, innovations in biorefining, biogas upgrading, nutrient stripping from digestate, phosphate recycling from sewage, and much else besides.

Funding sources for R&D are available through a number of sources. Innovate UK, for example, runs ongoing funding competitions for which businesses and research organisations can apply. Currently, Innovate UK funds emerging and enabling technologies, infrastructure systems, health and life sciences, and manufacturing and materials – all sectors for which there are substantial opportunities for making improvements through innovative circular economy thinking.[12] Scotland has already set up a circular economy investment fund, administered by Zero Waste Scotland, to help drive forward substantive changes across Scotland's business and social economy sectors.[13] London has already been taking steps to drive forward the circular economy and recently the London Waste and Recycling Board (LWARB) announced that it would set up a private equity fund to help speed up the Capital's transition to a more circular economy.[14]

2.3.3 Taxes on the Use of Natural Resources

The UK economy is one of the most open economies in the world: goods and services move relatively freely across borders, so much of what we consume is imported, and much of what we produce is exported. This fact alone highlights the centrality of the role that

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[12] Innovate UK (2016) *Innovation Grants for Business: Apply for Funding*, Date Published: 5 April 2016, Date Accessed: 1 August 2016, Available at: www.gov.uk/government/collections/innovation-grants-for-business-apply-for-funding

[13] Zero Waste Scotland (2016) *Circular Economy Investment Fund*, Date Accessed: 1 August 2016, Available at: www.zerowastescotland.org.uk/content/circular-economy-investment-fund

[14] London Waste and Recycling Board (2016) *LWARB to Set Up Early Stage Private Equity Fund to Accelerate London's Circular Economy*, Date Accessed: 1 August 2016, Available at: www.lwarb.gov.uk/private-equity-pin/

companies, often with supply chains in geographically diverse locations, will need to play in the transition to a global economy. It is, after all, not possible for UK policy-makers to set policy that directly affects producers in other countries, even if it might be able to influence them indirectly, or lobby for changes with a more international dimension.

One efficient policy would be a tax on the use of primary resources. The most often used taxes on primary materials are those on materials which are not widely traded, such as aggregates, and other minerals whose value is relatively low relative to their weight. In some countries, subsidies are used to support raw material extraction, but clearly, the UK is not in a position to see these removed unilaterally.

Such a tax would, classically, be set at the level of the externalities imposed by the use of primary resources. These would be expected to vary according to a range of factors, including the location from which the resource is extracted. That having been said, externalities associated with climate change and with air pollutants could are reasonably well understood.

The openness of the UK economy means that goods flow in and out of the country. For a country to implement such a tax unilaterally, and without causing harm to its domestic industry, there needs to be a system in place to enable imports to be subject to a tax, and there needs to be a way of allowing exports to escape the tax. In addition, if the basis for the tax on a product is the primary material content, then ideally, that needs to be known for all products being made, or being imported or exported. The demands, in terms of information, are not inconsiderable.

At the same time, our ability to handle large amounts of data has been increasing exponentially. Also, the drivers to understand the carbon footprint of various products will – because of the difference in embodied carbon content of primary and secondary materials – increasingly lead to demands to generate the underlying data. So, difficult as the approach may seem today, it seems too important a policy to set aside indefinitely.

HM Treasury should lead a detailed review of the potential mechanisms for introducing resource taxation in future. The question should be phrased not in terms of 'whether?', but 'how?' A routemap for delivery on the most promising option should be developed with a view to implementation in the medium-term. Other incentives should also be explored as interim measures. Related to this, the UK should play a leading role in international fora (including at the EU and at, for example, at UN / OECD levels). It would be useful to explore the linkages to the valorisation of greenhouse gas emissions: these are covered to varying degrees by the EU Emissions Trading Scheme, and the range of emissions trading schemes emerging around the world. This means that some valorisation of externalities associated with resource use is taking place, but the extent is limited both by the scope of the existing trading schemes, and the traded price of carbon under those schemes.

3.0 Model Overview and Scope

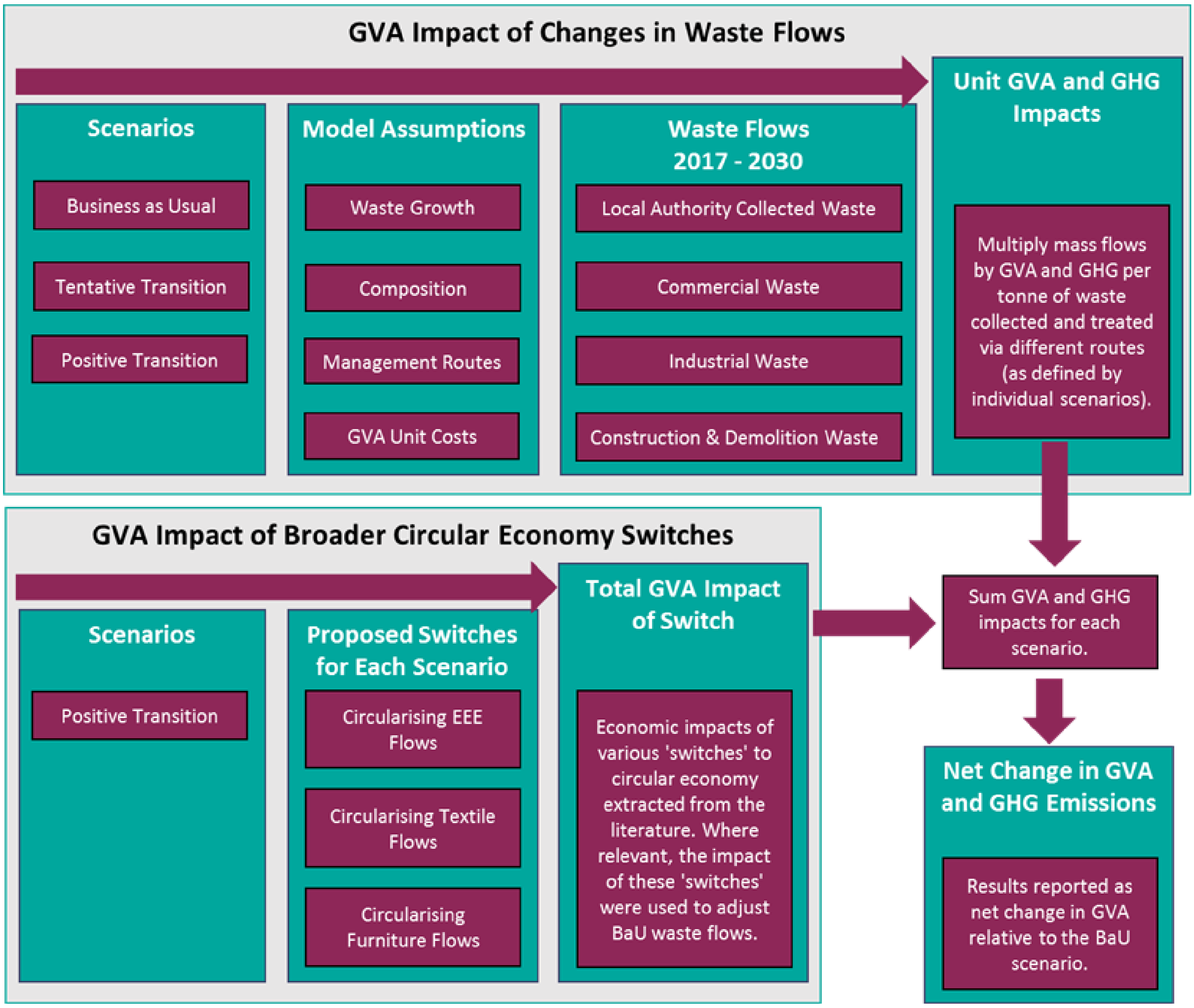
The structure of the model developed for this study is shown in Figure 3-1. It can be seen from this that the model comprises of two key elements:

1) a waste flow module covering household waste, commercial & industrial (C&I) waste, and construction & demolition (C&D) waste; and
2) a broader circular economy module which assesses the likely impact of broader changes to the economy arising from switching to more circular business models and the embedding of circular economy principles.

The remaining sections of this Technical Appendix relate to the different elements of the model shown in Figure 3-1:

- **Section 4.0** – Provides a brief overview of the scenarios that were introduced in the main report and explains the rationale for the various 'switches' that were included under each scenario;
- **Section 5.0** – Describes how the baseline mass flows were developed for the waste streams covered by the model;
- **Section 6.0** – Presents the unit GVA figures that were used to calculate the economic impact associated with moving from one scenario to the next;
- **Section 7.0** – Describes the approach taken to modelling the broader circular economy switches; and
- **Section 8.0** – Presents the climate change impact factors that were used to calculate the greenhouse gas savings associated with changes in waste flows under the different scenarios.

Figure 3-1:Overview of Model Structure



4.0 Description of Scenarios

Depending on the level of ambition and the rate of transition, the UK economy may look quite different in 2030. Three scenarios were modelled to illustrate different possible trajectories for the UK economy. Each scenario includes a number of 'switches' or changes that relate to the different ways in which materials can be managed within our economy and these are presented in Table 4-1. The switches are divided between those that apply to household waste, C&I and C&D waste, and broader non-waste switches to, for example, new business models.

As described in the main report, the three scenarios are as follows:

- **Business as Usual (BaU)** – this scenario provides a baseline against which the performance of the two circular economy scenarios can be compared. It assumes no policy change and limited progress on waste related issues outside of Scotland and Wales. The results presented below are all given relative to this baseline scenario. Positive results show a net gain in GVA or net savings in GHG emissions, whereas negative values indicate that, relative to the baseline situation, a loss in GVA or increased emissions is anticipated.
- **Tentative Transition** – this scenario assumes that some early but clear steps are taken to improve the circularity of the UK economy by 2030.
- **Positive Transition** – this scenario assumes that, by 2030, significant strides have been taken towards improving the circularity of the UK economy.

The model compares the performance of the Tentative Transition and Positive Transition scenarios against the BaU scenario.

Table 4-1: Summary of Modelled Scenarios

Switch / Measure	Materials Impacted	Scenario 1 Business as Usual	Scenario 2 Tentative Transition	Scenario 3 Positive Transition	Rationale
Household Waste					
Waste growth	All household waste	Growth of 0.5% per annum to 2030	0% waste growth to 2020, then 0.2% per annum reduction thereafter (except for food waste – see below)	0% waste growth to 2020, then 0.5% per annum reduction thereafter (except for food waste – see below)	It was assumed that under BaU conditions household waste would grow at 0.5% per annum which is consistent with historical trends and assumptions used in Eunomia's bi-annual Residual Waste Infrastructure Review.[15] Under the two circular economy scenarios it was assumed that waste prevention measures targeted at households would begin to have a measurable and sustained impact.
Food waste prevention	Food waste	Assume 0.5% per year reduction to 2030	Assume 1% per year reduction to 2030	Assume 1.5% per year reduction to 2030	Courtauld Commitment 3 set a target to reduce household food waste arisings by 5% by 2015. Courtauld Commitment 2025 sets a new target to reduce total food and drink waste arisings between 2015 and 2025 by 20% per inhabitant.[16] The three scenarios demonstrate varying levels of ambition with regards to reducing food waste and contributing to the broader 20% target.

[15] Eunomia Research & Consulting (2016) *Infrastructure Review*, Date Accessed: 10 August 2016, Available at: www.eunomia.co.uk/services/waste-recycling/treatment/rwir/

[16] WRAP (2016) *The Courtauld Commitment 2025: Cutting the Cost of Food and Drink*, Date Accessed: 10 August 2016, Available at: www.wrap.org.uk/content/courtauld-commitment-2025

Switch / Measure	Materials Impacted	Scenario 1 Business as Usual	Scenario 2 Tentative Transition	Scenario 3 Positive Transition	Rationale
Increase preparation for reuse	WEEE	BaU rate based on WasteDataFlow data for 2014/15 and assumed to remain static over time	40% by 2030	50% by 2030	The amount of material that can be prepared for reuse under the Tentative Transition and the Positive Transition scenarios is based on research conducted by WRAP.[17] It is anticipated that improved design and extended producer responsibility obligations will help improve the ease with which products can be repaired / refurbished. These rates are separate to the improved circular flow of products within the economy (see 'broader circular economy switches below).
	Furniture		40% by 2030	60% by 2030	
	Mattresses		10% by 2030	20% by 2030	
	Textiles		40% by 2030	50% by 2030	
Increase recycling	England household waste	45% by 2020	55% by 2030	70% by 2030	Given the current policy vacuum and the lack of penalties for local authorities missing the current 50% target, it is assumed that under the BaU scenario England's recycling rate remains static. Under the Positive Transition scenario it is assumed that England and Northern Ireland align themselves with Wales and Scotland to achieve 70% recycling by 2030.

[17] See, for example: WRAP (2012) *Composition and Re-use Potential of Household Bulky Waste in the UK (WEEE)*, August 2012, www.wrap.org.uk/sites/files/wrap/WEEE%20-%20bulky%20waste%20summary.pdf; WRAP (2012) *Composition and Re-use Potential of Household Bulky Furniture in the UK*, August 2012, www.wrap.org.uk/sites/files/wrap/Furniture%20-%20bulky%20waste%20summary.pdf; WRAP (2012) *Composition and Re-use Potential of Household Bulky Textiles in the UK*, August 2012, www.wrap.org.uk/sites/files/wrap/Textiles%20-%20bulky%20waste%20summary.pdf

Switch / Measure	Materials Impacted	Scenario 1 Business as Usual	Scenario 2 Tentative Transition	Scenario 3 Positive Transition	Rationale
	Northern Ireland household waste	45% by 2020	60% by 2030	70% by 2025	A 60% recycling target by 2020 has been talked about in the updated waste management strategy for Northern Ireland.[18] However, it is unlikely that this will be achieved. The BaU scenarios assumes a slight increase on 2014/15 recycling rates. It is assumed that higher recycling rates are achieved under the two circular economy scenarios.
	Scotland household waste	60% by 2025, rising to 70% in 2030	70% by 2025	70% by 2025	Under the BaU scenario it is assumed that Scotland will struggle to reach its 70% target by 2025, but will do so by 2030. Under the other scenarios it is assumed that the target is met by 2025.
	Wales household waste	64% by 2025	64% by 2025	70% by 2025	The Welsh recycling target allows for the inclusion of incinerator bottom ash. The actual recycling rate is assumed to be 64% when the country reaches the 70% target in 2024/25.
Increase amount of food waste sent to AD	Food and garden waste	Maintain existing ratio between OAW, IVC and AD	All additional food waste captured through higher levels of recycling assumed to go to AD	All additional food waste captured through higher levels of recycling assumed to go to AD	The Tentative Transition and Positive Transition scenarios assume significant uptake of AD treatment as the preferred option for treating additional food waste.

[18]Northern Ireland Department of the Environment (2013) *Delivering Resource Efficiency: Northern Ireland Waste Management Strategy*, www.daera-ni.gov.uk/sites/default/files/publications/doe/waste-policy-delivering-resource-efficiency-northern-ireland-waste-management-strategy-2013.pdf

Switch / Measure	Materials Impacted	Scenario 1 Business as Usual	Scenario 2 Tentative Transition	Scenario 3 Positive Transition	Rationale
Shift from landfill to other residual waste treatment options	Residual waste	Based on current and firmly planned residual waste infrastructure, with additional development of infrastructure in the long-term to manage higher levels of residual waste arisings	Assume that by 2030 all remaining residual waste is treated as follows: 10% to landfill and 90% to other forms of recovery	Assume that by 2030 all remaining residual waste is treated as follows: 5% to landfill and 95% to other forms of recovery	The BaU scenario reflects Eunomia's detailed understanding of the market as described in the bi-annual Residual Waste Infrastructure Reviews.[19] The two other scenarios assume that step-changes are made in moving away from landfill to other forms of residual waste treatment which add greater value to the economy
Commercial Waste					
Waste growth	All	0.5% per annum to 2030	0% waste growth to 2020, then 0.2% per annum reduction thereafter (except for food waste – see below)	0% waste growth to 2020, then 0.5% per annum reduction thereafter (except for food waste – see below)	It was assumed that under BaU conditions commercial waste would grow at 0.5% per annum which is consistent with historical trends and assumptions used in Eunomia's bi-annual Residual Waste Infrastructure Review.[20] Under the two circular economy scenarios it was assumed that waste prevention / resource efficiency measures would begin to have a measurable and sustained impact.

[19] Eunomia Research & Consulting (2016) *Infrastructure Review*, Date Accessed: 10 August 2016, Available at: www.eunomia.co.uk/services/waste-recycling/treatment/rwir/

[20] Eunomia Research & Consulting (2016) *Infrastructure Review*, Date Accessed: 10 August 2016, Available at: www.eunomia.co.uk/services/waste-recycling/treatment/rwir/

Switch / Measure	Materials Impacted	Scenario 1 Business as Usual	Scenario 2 Tentative Transition	Scenario 3 Positive Transition	Rationale
Food waste prevention	Food waste	Assume 1% per year reduction	Assume 2% per year reduction	Assume 3% per year reduction	Courtauld Commitment 2025 has set a target to reduce total food and drink waste arisings between 2015 and 2025 by 20% per inhabitant.[21] The three scenarios demonstrate varying levels of ambition with regards to reducing food waste and contributing to this broader 20% target.
Increase preparation for reuse	WEEE	Assumed to remain static at 5.3%	30% by 2030	40% by 2030	Baseline preparation for reuse rates were obtained from a study conducted in Northern Ireland. It was assumed that these rates could be increased under the Tentative Transition and Positive Transition scenarios. It is anticipated that improved design and extended producer responsibility obligations will help improve the ease with which products can be repaired / refurbished. These rates are separate to the improved circular flow of products within the economy (see 'broader circular economy switches below).
	Textiles	Assumed to remain static at 3.3%	20% by 2030	30% by 2030	
Increase recycling	All commercial waste	Remain static at baseline rate of 54%	60% by 2030	70% by 2030	Assumed baseline recycling rate of 54% based on interpolations from 2009 data published by Defra. This rate was assumed to apply across the UK. The two circular economy scenarios assume greater levels of ambition on recycling over time.

[21] WRAP (2016) *The Courtauld Commitment 2025: Cutting the Cost of Food and Drink*, Date Accessed: 10 August 2016, Available at: www.wrap.org.uk/content/courtauld-commitment-2025

Switch / Measure	Materials Impacted	Scenario 1 Business as Usual	Scenario 2 Tentative Transition	Scenario 3 Positive Transition	Rationale
Increase amount of food waste sent to AD	Food and garden waste	Maintain existing ratio between OAW, IVC and AD	All additional food waste captured through higher levels of recycling assumed to go to AD	All additional food waste captured through higher levels of recycling assumed to go to AD	
Shift from landfill to other residual waste treatment options	Residual waste	Based on current and firmly planned residual waste infrastructure, with additional development of infrastructure in the long-term to manage higher levels of residual waste arisings.	Assume that by 2030 all remaining residual waste is treated as follows: 10% to landfill and 90% to other forms of recovery.	Assume that by 2030 all remaining residual waste is treated as follows: 5% to landfill and 95% to other forms of recovery.	The BaU scenario reflects Eunomia's detailed understanding of the market as described in the bi-annual Residual Waste Infrastructure Reviews.[22] The two other scenarios assume that step-changes are made in moving away from landfill to other forms of residual waste treatment which add greater value to the economy.

[22] Eunomia Research & Consulting (2016) *Infrastructure Review*, Date Accessed: 10 August 2016, Available at: www.eunomia.co.uk/services/waste-recycling/treatment/rwir/

Switch / Measure	Materials Impacted	Scenario 1 Business as Usual	Scenario 2 Tentative Transition	Scenario 3 Positive Transition	Rationale
Industrial Waste					
Waste growth	All	Decrease of 1.0% per annum to 2030	Decrease of 1.0% per annum to 2030	Decrease of 1.0% per annum to 2030	It was assumed that under all scenarios industrial waste would decrease by 1.0% per year. This is due to a declining industrial sector and waste prevention / resource efficiency measures. The assumption is consistent assumptions used in Eunomia's bi-annual Residual Waste Infrastructure Review.[23]
Increase recycling	All commercial waste	Remain static at baseline rate of 51%	60% by 2030	70% by 2030	Assumed baseline recycling rate of 51% based on interpolations from 2009 data published by Defra. This rate was assumed to apply across the UK. The two circular economy scenarios assume greater levels of ambition on recycling over time.
C&D Waste					
Waste growth	All C&D waste	Remain static (i.e. 0% growth)	0.4% reduction per year	0.7% reduction per year	
Increase recycling	All C&D waste	33% recycling + 47% reuse - remains static over time	90% combined recycling and reuse	95% combined recycling and reuse	

[23] Eunomia Research & Consulting (2016) *Infrastructure Review*, Date Accessed: 10 August 2016, Available at: www.eunomia.co.uk/services/waste-recycling/treatment/rwir/

Switch / Measure	Materials Impacted	Scenario 1 Business as Usual	Scenario 2 Tentative Transition	Scenario 3 Positive Transition	Rationale
All Waste Streams					
Reduce the tonnage of secondary materials that are exported	Metals	10% increase on 2014 tonnage by 2030	10% reduction in 2014 tonnage by 2030	30% reduction in 2014 tonnage by 2030	Baseline data on the amount of secondary materials exported from the UK in 2014 was obtained from Defra.[24] The Tentative Transition and Positive Transition scenarios assume that varying proportions of this material is kept within the UK so that local manufacturers can add value to the materials rather than the GVA being accrued by foreign economy.
	Plastics	10% increase on 2014 tonnage by 2030	10% reduction in 2014 tonnage by 2030	30% reduction in 2014 tonnage by 2030	
	Paper	Remain static at 2014 levels	30% reduction in 2014 tonnage by 2030	50% reduction in 2014 tonnage by 2030	
	Textiles	Remain static at 2014 levels	5% reduction in 2014 tonnage by 2030	10% reduction in 2014 tonnage by 2030	
Re-shore SRF / RDF	RDF	Remain static at 3.3 million tonnes	Export no more than 7.5% of remaining residual waste	Export no more than 5% of remaining residual waste	Export is assumed not to be eliminated completely as it allows for some flexibility in the system.
Broader Circular Economy 'Switches'					
Circularise EEE flows	EEE	-	-	Assume 30% reduction in retail sales and a transfer of the reduced spending to repair and	Improved product design will increase product lifespans and allow for easier repair and maintenance. There will likely be an increase in product costs, but overall sales will fall as less units will be purchased new.
Circularise textile flows	Furniture	-	-		

[24] Raw data provided to Eunomia by Defra and based on the figures published in: Defra (2016) *Digest of Waste and Resource Statistics – 2016 Edition (Revised)*, March 2016, www.gov.uk/government/uploads/system/uploads/attachment_data/file/508787/Digest_of_Waste_and_Resource_Statistics_rev.pdf

Switch / Measure	Materials Impacted	Scenario 1 Business as Usual	Scenario 2 Tentative Transition	Scenario 3 Positive Transition	Rationale
Circularise furniture flows	Textiles	-	-	maintenance activities and second hand sale of products.	Instead, there will be greater amounts of repair and maintenance facilitated, in part, through new business models. Waste arisings associated with these products under the Positive Transition scenario were assumed to halve by 2030 (due to an assumed average doubling of product lifespans).

5.0 Baseline Mass Flows

One of the first tasks in the study was to develop a mass flow baseline to represent the BaU scenario, against which the effects of the other two scenarios could be compared in the waste flow element of the report. Household waste flows were modelled separately for England, Scotland, Wales and Northern Ireland, mainly due to the need to set different recycling targets for each country, while the C&I and C&D waste streams were modelled for the UK as a whole.

This section describes the approach taken to gathering the necessary data to understand the historic waste management practices and likely future trends under the BaU scenario. In seeking to understand historic and future mass flows the following elements were required for each waste stream:

- Total waste arisings;
- Projected growth in waste arisings and changes in recycling rates;
- Waste compositions; and
- Management destinations for different waste streams.

These elements are described for each waste stream in the sections below.

5.1 Household Waste

5.1.1 Waste Arisings

Historic household waste arisings and recycling rates used in the model were sourced from Defra statistics. At the time the modelling was undertaken, the most recent available data was from 2014/15 – this is presented in Table 5-1. It is recognised that the data reported by Defra does not perfectly match up with that reported separately by Northern Ireland, Wales and Scotland. However, for the purposes of this macroeconomic modelling at the UK level, it was believed to be sufficiently accurate. Any slight differences in actual rates reported by the devolved administrations will have a negligible impact on the final results, which are reported at the level of the UK.

Table 5-1: Household Waste Arisings in the UK (2014/15)

Measure	England	Northern Ireland	Scotland	Wales
Arisings ('000 tonnes)	22,355	808	2,349	1,285
Recycled ('000 tonnes)	10,025	352	962	705
Recycling rate	44.80%	43.60%	41.00%	54.80%

Source: Defra (2015) UK Statistics on Waste, Date Published: 15 December 2015, Date Accessed: 28 June 2016, Available at: www.gov.uk/government/statistical-data-sets/env23-uk-waste-data-and-management

Household waste flows were split into three categories for modelling across all scenarios:

- Kerbside collected wastes;
- HWRC collections; and
- Other sources of waste (this category included the following WasteDataFlow categories: waste collected at bring sites, voluntary / community collections, other recycling from household sources, and voluntary bring sites).

Using data from WasteDataFlow for all English authorities in 2014/15, we calculated the proportion of total recycling and residual waste associated with each of these categories, and then apportioned the total household waste arisings accordingly.

5.1.2 Waste Growth and Recycling Rate Assumptions for 2016 Baseline

It was assumed that household recycling rates increased slightly between 2014 and 2016. The assumed 2016 recycling rates are shown in Table 5-2. It was necessary to assume a baseline 2016 recycling rate so that all scenarios would commence from the same starting point in 2016.

Table 5-2: 2016 Recycling Rate Assumptions

Country	Recycling Rates	
	2014 (Actual)	2016 (Assumed)
England	44.8%	45%
Scotland	41.0%	43%
Wales	54.8%	58%[1]
Northern Ireland	43.6%	45%

Note:

1. It has been reported that Welsh authorises achieved 60% recycling in 2015/16. This figure, however, included the recycling of incinerator bottom ash (IBA) which is not included in the recycling tonnage of the model developed for this study. It was assumed that IBA may be contributing 2% to this figure. See: Let's Recycle (2016) Welsh Councils Set to Hit 60% Recycling, www.letsrecycle.com/news/latest-news/welsh-councils-set-to-hit-60-recycling/

In terms of waste growth, it was assumed that waste arisings would increase by 0.5% per annum over the entire period from 2014 to 2030. The only exception was for food waste, which it was assumed would decrease by 0.5% per annum under the BaU scenario. The assumed growth rates for the two other scenarios are described in Table 4-1.

5.1.3 Composition

Work undertaken by Resource Futures on behalf of Defra was used to define the baseline composition of household waste in each of the four countries.[25]

5.1.4 Preparation for Reuse

As preparation for reuse will begin to play a much more important role under the circular economy it was necessary to break this out as a separate stream in the modelling. The final 'recycling' figures reported by local authorities include both recycling and preparation for reuse and it was therefore necessary to define two separate rates. The baseline preparation for reuse rates for different materials – that is, the % of total waste arisings that are prepared for reuse – were calculated by using the 2014/15 WasteDataFlow data for all English authorities.[26] The proportion of each material-specific recycling rate that was made up of material that had been prepared for reuse was calculated. This rate was then applied to the total tonnage of waste recycled in each of the devolved administrations. The overall preparation for reuse rates and individual rates for key materials are presented in Table 5-3.

Table 5-3: Assumed Baseline Preparation for Reuse Rates (2014)

Material	England	Northern Ireland	Scotland	Wales
Textiles	2.5%	2.3%	2.1%	3.4%
WEEE	3.6%	3.5%	3.3%	4.1%
Furniture	25%	24%	22%	32%
Mattresses	0%	0%	0%	0%
Overall rate[1]	0.4%	0.4%	0.4%	0.5%

Note:

1. *As a proportion of total household waste.*

5.1.5 Organic Waste Management Destinations

Household organic waste comprises of two main waste types: food waste and garden waste. The organic waste streams can be treated through one of three main processes: anaerobic digestion (AD), in-vessel composting (IVC), or open-air windrow composting (OAW). WasteDataFlow was analysed to determine the baseline situation for how local authorities are managing the organic waste they collect. The results of this analysis are

[25] Resource Futures (2013) *National Compositional Estimates for Local Authority Collected Waste and Recycling in England, 2010/11*, Report for DEFRA, February 2013, http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=18237#RelatedDocuments

[26] WasteDataFlow (2016) 2014/15 *WasteDataFlow data*, Accessed 26th June 2016, www.wastedataflow.org/

presented in Table 5-4 – these rates form the baseline organic waste treatment destinations for the BaU scenario.

Of the food waste separately collected for treatment (either as separate food waste, or mixed food and garden waste), approximately 40% is sent to AD and 60% to IVC. Similarly, of all separately collected garden waste (collected either as separate garden waste, or mixed food and garden waste) approximately 30% goes to IVC and 70% to OAW.

Table 5-4: Assumed Baseline

Waste Stream	AD	IVC	OAW
Food waste	40%	60%	0%
Garden waste	0%	30%	70%

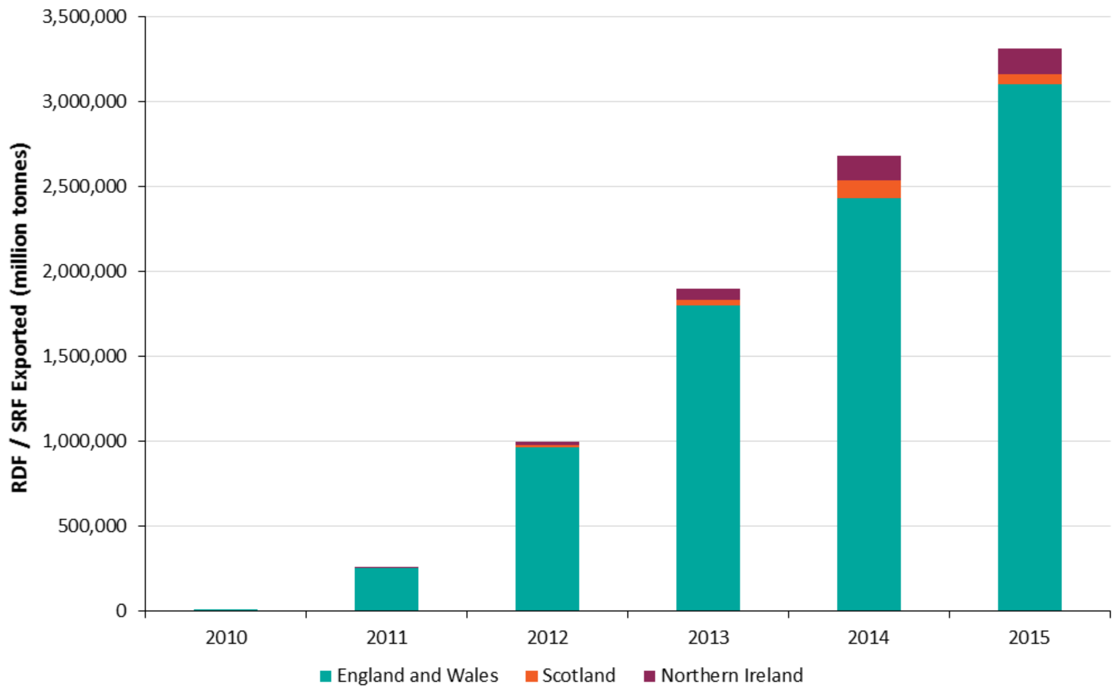
5.1.6 Residual Waste Management Destinations

Household waste management destinations for residual waste were calculated using local authority waste data published by Defra, NRW, SEPA and DOENI.[27,28,29,30] These data sources provide information on the total tonnage of residual waste arisings, as well as the quantity of waste sent to landfill, incineration, and mechanical biological treatment (MBT).

The quantity of waste sent to incineration which is exported to incinerators in mainland Europe was also estimated based on data gathered via freedom of information requests.[31] The change in the quantity of refuse derived fuel (RDF) / solid recovered fule (SRF) exported to maintain Europe between 2010 and 2015 is shown in Figure 5.1. The exact proportion of RDF / SRF exports of which originated from household sources is uncertain; however, we have assumed that 20% of this waste was from household sources. Based on this, we calculated the proportion of residual waste going to domestic and European incinerators.

[27] Defra (2015) Local Authority Collected Waste Statistics - Local Authority data 2014/15, December 2015.
[28] SEPA (2015) Household Waste – Summary data 2014
[29] NRW (2015) Local Authority Municipal Waste Management Report for Wales 2014-15, October 2015,
[30] DOENI (2015) Northern Ireland Local Authority Collected Municipal Waste Management Statistics Annual Report 2014/15, November 2015
[31] Freedom of information requests to the Environment Agency (England), Natural Resources Wales, Scottish Environmental Protection Agency, & Department of the Environment (Northern Ireland)

Figure 5.1: Growth of RDF (and SRF) Export from the UK



Note: Tonnage for 2015 is for England only as data from Natural Resources Wales has not yet been made available

5.2 Commercial and Industrial Waste

5.2.1 Waste Arisings

Creating a baseline for C&I waste is more challenging and open to greater interpretation than that for local authority collected waste. This is mainly due to the lack of accurate and consistent historic data on arisings and management routes. Historic C&I waste data used in the model was sourced from surveys of C&I waste arisings and treatment in England and each of the devolved administrations.[32] The surveys provide a breakdown of

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[32] Jacobs (2011) *Commercial and Industrial Waste Survey 2009*, May 2011, Report for Defra, www.gov.uk/government/uploads/system/uploads/attachment_data/file/400597/ci-project-report.pdf; Jacobs (2014) *New Methodology to Estimate Waste Generation by the Commercial and Industrial Sector in England*, Report for Defra, August 2014, http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=19118&FromSearch=Y&Publisher=1&SearchText=ev0804&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description; WRAP (2011) *Northern Ireland Commercial & Industrial (C&I) Waste Estimates*, November 2011, www.wrapni.org.uk/sites/files/wrap/Northern_Ireland_CI_waste_estimates_2009_v4_1.4bb45bd7.11553[1].pdf; SEPA (2013) *Business Waste Data 2011*, September 2013, www.sepa.org.uk/environment/waste/waste-data/waste-data-reporting/business-waste-data/; RSK Environment Ltd and Urban Mines (2012) *Survey and Industrial & Commercial Waste Generated in Wales 2012*, Report for Natural Resources Wales, 2012, https://naturalresources.wales/media/1995/survey-of-industrial-and-commercial-waste-generated-in-wales-2012pdf.pdf

treatment and disposal destinations for C&I waste. These destinations were grouped into three categories for the model:

- Recycling (which includes composting and preparation for reuse);
- Residual disposal; and
- 'Other'.

This latter category is used for waste sent to land recovery and where the final destination of the waste is reported as unknown in national surveys. No data on recycling rates was available for Scotland, and we therefore made the assumption that the proportion of waste sent to residual disposal, recycling and other destinations was equal to the average of the proportions for England, Wales and Northern Ireland. For England, the treatment paths of the original (2009) survey were apportioned to the calculated arisings from the 2014 report, which applied a new approach to estimate C&I waste arisings.[33] The model split out commercial and industrial waste as two separate streams as they are both managed in slightly different ways and arisings are expected to grow at different rates.

An adjustment was made to the total tonnage of C&I residual waste arisings. We observed that the combined tonnage of household waste (available from WasteDataFlow) and C&I waste going to landfill was significantly higher than the total tonnage of non-inert waste landfilled implied by UK landfill tax revenues. As the C&I surveys are only estimates (and furthermore, each survey states that there is significant uncertainty in the reported waste flows), we assumed that this disparity was due to incorrect residual waste arisings reported in the surveys. To correct this difference, which would lead to a potential overestimate of residual waste arisings in the UK, we took the following steps:

- We calculated the total tonnage of residual waste arisings in the UK using the following sources (we assumed that residual arisings of non-inert C&D waste are negligible):
    - The tonnage of waste landfilled at the standard rate of tax implied by UK landfill tax revenue for 2009 (there are some potential issues here with the misclassification of waste at a lower rate of tax; however, we do not have data on this so have not taken this into account);[34]
    - The total tonnage of waste sent to incinerators and cement kilns;[35]
    - Exports of RDF / SRF (none in 2009); and

[33] Jacobs (2014) *New Methodology to Estimate Waste Generation by the Commercial and Industrial Sector in England*, Report for Defra, August 2014, http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=19118&FromSearch=Y&Publisher=1&SearchText=ev0804&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description

[34] HMRC (2009) Landfill Tax Bulletin, www.gov.uk/government/statistics/landfill-tax-bulletin

[35] Sourced from the Environment Agency data on incineration facilities that accepted waste in England and Wales during 2009. We also assumed 150,000 tonnes going to Scottish EfW.

- The effective treatment capacity of MBT, assumed to be 40% of the total operational MBT treatment capacity. [36]

- We then estimated the tonnage of C&I residual waste arisings by calculating the difference between the total residual waste and the amount that is produced by households; and
- Assuming that the overall waste arisings reported in the C&I surveys are correct, this new estimate implies that the surveys overestimate residual arisings. To correct this, we reapportioned some of what these surveys reported as residual waste into the 'Other' category.[37]

With the exception of the Northern Ireland survey, the surveys do not provide material specific management rates – that is, the proportion of each material sent to disposal (residual waste), recycling, or other destinations. Material specific management rates were therefore estimated so that the overall rate for each main management route was achieved. The estimated rates were set to reflect the most up-to-date sources of data, such as the 2009 Northern Ireland survey, and a study on landfill bans conducted by Eunomia in 2012 for WRAP, which included an analysis of C&I waste management.[38]

5.2.2 Waste Growth and Recycling Rate Assumptions for 2016 Baseline

We assumed that C&I recycling rates remained constant between 2009 and 2016. Waste growth rates during this period were estimated for the UK using available data from national surveys. Table 5-5 presents the growth rates used for modelling and the assumptions required to calculate these rates. Under the BaU scenario it was assumed that commercial waste arisings would grow at a rate of 0.5% per annum over the period 2015 to 2030. In the case of industrial waste arisings, it was assumed that arisings would decrease by 1% per annum due to a declining industrial sector and improved gains in resource efficiency.

[36] Data sourced from the Eunomia facilities database

[37] It should be noted that, while the total quantity of C&I waste to be reapportioned can be calculated using the methodology described here, the surveys do not provide sufficient information to estimate how much of this waste is commercial in origin, and how much is industrial. We therefore assumed that each of these sectors (commercial and industrial) produced 50% of the total tonnage of reapportioned waste.

[38] Eunomia (2010) Landfill Bans: Feasibility Research, Report for WRAP, February 2010

Table 5-5: Assumed Growth in Commercial and Industrial Waste (2010 – 2016)

Waste Stream	2010[1]	2011[1]	2012[2]	2013[3]	2014[3]	2015[4]	2016[4]
Commercial	-5.1%	6.5%	3.5%	2.0%	2.1%	0.5%	0.5%
Industrial	13.3%	5.7%	3.8%	6.7%	4.6%	-1.0%	-1.0%

Notes:

1. *Based on reported growth rates for England.*
2. *Average of reported growth rates for England and Scotland.*
3. *Average of reported growth rates for Scotland and estimated England growth rates (assumed same growth rate per annum as the average of the previous three years).*
4. *Uses baseline modelling assumption – see Table 4-1.*

Sources: Jacobs (2014) New Methodology to Estimate Waste Generation by the Commercial and Industrial Sector in England, Report for Defra, August 2014, http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=19118&FromSearch=Y&Publisher=1&SearchText=ev0804&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description; SEPA (2016) Business Waste Data 2011-2014, http://www.sepa.org.uk/environment/waste/waste-data/waste-data-reporting/business-waste-data/

5.2.3 Composition

As there are no published C&I waste compositions for the UK as a whole. Thus, C&I waste compositions were based on the 2009 composition for England as it applies to the largest tonnage of material and is therefore expected to be most representative of the country as whole.[39] Four of the compositional categories – that is, animal & vegetable wastes, discarded equipment, metallic wastes and non-metallic wastes – were further subdivided based on a more detailed C&I waste composition published by SEPA.[40] This was a simplifying assumption that was made in the absence of robust compositional data on C&I waste. It was done to enable greater insight into individual material flows which are of importance in a circular economy.

5.2.4 Preparation for Reuse

Preparation for reuse rates were estimated on a material-specific basis using data from the 2009 Northern Ireland survey, which provides a breakdown of management routes by material. The baseline preparation for reuse rates for 2009 used in the model are presented in Table 5-6.

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[39] Jacobs (2011) *Commercial and Industrial Waste Survey 2009*, May 2011, Report for Defra, www.gov.uk/government/uploads/system/uploads/attachment_data/file/400597/ci-project-report.pdf

[40] SEPA (2014) *Business Waste Data 2014*, April 2016, www.sepa.org.uk/environment/waste/waste-data/waste-data-reporting/business-waste-data/

Table 5-6: Preparation for Reuse Rates

Waste Stream	Overall Preparation for Reuse Rate
Commercial	2.4%
Industrial	3.2%

5.2.5 Organic Waste Management Destinations

Data on organic waste treatment from C&I sources is limited. Using data from WRAP[41] and food manufacturing trade associations[42] we assumed that all C&I organic waste that is collected for recycling is managed across four main routes: AD, IVC, OAW, and land spreading. The breakdown of these routes is detailed in Table 5-7. These rates were applied in the BaU scenario. The Tentative Transition and Positive Transition scenarios assumed that all additional food waste collected for recycling, over and above baseline rates, would be sent to AD (see Table 4-1).

Table 5-7: Assumed Baseline

	AD	IVC	OAW	Land Spreading
Organic waste	20%	14%	1%	65%

5.2.6 Residual Waste Management Destinations

C&I waste management destinations for residual waste were estimated for 2009 – 2014 (from 2014 onwards the scenario assumptions set out in Section 4.0, Table 4-1 were used). Table 5-8 sets out the approach used to calculate the tonnage of waste sent to each destination.

[41] WRAP (2016) *Estimates of Food Surplus and Waste Arisings in the UK*, May 2016, http://www.wrap.org.uk/sites/files/wrap/UK%20Estimates%20May%2016%20%28FINAL%20V2%29.pdf

[42] Food and Drink Federation (2014) *Members' Waste Survey*, February 2014 https://www.fdf.org.uk/responses/FDF-Report-Waste-Survey-Feb2014.pdf

Table 5-8: Methodology for Estimating C&I Management Destinations

Treatment / Disposal Option	Methodology
Landfill	The total C&I waste sent to landfill was assumed to be equal to the quantity of non-household waste landfilled at the standard rate of tax implied by UK landfill tax revenue for 2009 – 2014.
Domestic incineration	The total C&I waste sent to domestic incineration was assumed to be equal to the quantity of non-household waste sent to domestic incinerators.
European incineration	We assumed that 20% of RDF / SRF exports were from household sources and the rest from C&I feedstock (see Section 5.1.5 for more details).
MBT	The proportion of residual waste sent to MBT was assumed to be equal to the proportion sent to non-thermal treatment in England, based on the 2009 Defra survey.

The residual waste management destinations for C&I waste for 2014 are shown in Table 5-9.

Table 5-9: Assumed Residual Treatment Destinations for Commercial and Industrial Waste (2014)

Treatment / Disposal Option	Proportion of Residual Waste	
	Commercial	Industrial
Landfill	40%	40%
Domestic Incineration	45%	39%
European Incineration	3.9%	4.9%
MBT[1]	11%	16%

5.3 Construction and Demolition Waste

5.3.1 Waste Arisings

Historic C&D waste arisings and recovery rates used in the model were sourced from the 2015 UK Statistics on Waste. The most recent available data states that 44,786 thousand tonnes of C&D waste were generated in 2012, of which 38,759 thousand tonnes were recovered, equivalent to a recovery rate of 86.5%.[43] Recycling rates are not reported by

[43] DEFRA (2015) *UK Statistics on Waste*, Date Accessed: 28 June 2016, Available at: www.gov.uk/government/statistical-data-sets/env23-uk-waste-data-and-management

this publication; the methodology used to estimate recycling rates is detailed in Section 5.3.4.

5.3.2 Waste Growth and Recycling Rate Assumptions for 2016 Baseline

We assumed that C&D recovery rates stayed constant between 2012 (the most recent year for which data was available) and 2016. There was no evidence to suggest that the (already high) 86.5% recovery rate for C&D waste would vary over this period. We also assumed that waste arisings stayed constant during this period.

5.3.3 Composition

The C&D composition was taken from a 2012 survey published by Natural Resources Wales.[44] This is the only recent C&D compositional study for any of the four UK countries.

5.3.4 Reuse, Recycling, and Backfilling Rates

As noted above, UK waste statistics only publish recovery rates (i.e. recycling, backfilling and energy recovery) and do not provide recycling rates. However, information on management destinations of each C&D waste material is published by Natural Resources Wales and these data were used in our analysis. The assumed material-specific recycling, preparation for reuse, and backfilling rates set out in Table 5-10 were used. This table shows that 48.2% of waste arisings are prepared for reuse, 33.8% are recycled, 3.6% are sent to backfilling, and a minor amount of waste (0.9%) is sent to energy recovery (not shown). The sum of these rates is equal to the published UK recovery rate of 86.5%.

[44] Natural Resources Wales (2012) *Survey of Construction & Demolition Waste Generated in Wales 2012*, https://naturalresources.wales/our-evidence-and-reports/waste-reports/construction-demolition-waste-survey/?lang=en

Table 5-10: Material Specific Destinations for C&D Waste

Material	Preparation for Reuse	Recycling	Backfilling	Total
Soil and stones	64%	17%	1.9%	82%
Aggregate	48%	42%	7.3%	98%
Mixed	0.8%	49%	0%	50%
Wood	22%	74%	0%	96%
Metals	17%	83%	0%	100%
Plastic	22%	74%	0%	96%
Insulation and gypsum	22%	74%	0%	96%
Other	2.4%	70%	0.5%	73%
Paper and card	22%	74%	0%	96%
Overall capture rate	48%	34%	4%	86%

Notes:
We assumed a constant proportion of waste sent to preparation for reuse and recycling, equal to the proportion published in Welsh statistics. The same assumption was made for waste sent to backfill and residual waste sent to disposal.

Source: Based on waste destinations (adjusted for UK recovery rate) reported in: Natural Resources Wales (2012) Survey of Construction & Demolition Waste Generated in Wales 2012, 2012, https://naturalresources.wales/our-evidence-and-reports/waste-reports/construction-demolition-waste-survey/?lang=en

5.3.5 Residual Waste Destinations

The destinations for C&D residual waste were set to reflect the management destinations reported in the Natural Resources Wales survey using a similar approach as described in Section 5.3.4.[45] The assumptions used for modelling are that 97% of residual waste arisings were sent to land disposal, and 3% to other treatment – this latter category includes waste treated at C&D material recovery facilities (MRFs) and other similar facilities. The Natural Resources Wales survey does also include incinerated waste. However, these tonnages are aggregated with other treatment destinations and it is therefore not possible to understand what quantity of waste is sent to incineration, although it is possible to infer that this was equivalent to less than 1% of residual arisings being sent to incineration. With such low tonnages, and taking into account the considerable uncertainty described, it was decided not to include incineration as a disposal destination for C&D waste.

[45] Natural Resources Wales (2012) *Survey of Construction & Demolition Waste Generated in Wales 2012*, 2012, https://naturalresources.wales/our-evidence-and-reports/waste-reports/construction-demolition-waste-survey/?lang=en

6.0 Calculating Gross Value Added

Given that the transition foreseen in this document under moves towards a more circular economy are generally of an economic character, it is surprising that our understanding of the impact of a move to a circular economy remains somewhat opaque. A number of documents have produced various 'large numbers' designed to engage policymakers with such a transition, but the numbers come in various forms, are based on different forms of extrapolation, and might have different macroeconomic implications for different countries. For example, the overall effect may be dependent upon the extent to which their economies are, or are not, dependent, at present, on industries who might be negatively affected by such a transition (such as, for example, countries that are more heavily reliant upon primary raw materials for export earnings). Indeed, the macroeconomic consequences of a radical shift to more circular economics might be, relative to plausible counterfactuals, not entirely positive for some of the world's poorest countries.

In recent years, government have paid increasing attention to the contribution that different measures can make to Gross Value Added (GVA). The measure – alongside employment impacts (to which it is related) - has been used to assess the merit of different projects and initiatives at the regional level, including in the context of devolution.

GVA is closely linked to Gross Domestic Product.[46] Consequently, as a metric of economic activity, GVA suffers many of the same (and well-discussed) drawbacks as GDP. These include:

1) That environmental costs and benefits (externalities) are not factored into GVA other than to the extent that they are reflected in taxes on production;
2) That the measure is indifferent to the nature and purpose of expenditures: for example, the economic activity resulting from the impact of floods would be included in the same way as any other activity (and the links to the previous point regarding externalities becomes relevant here);
3) The measure does not account for 'unpaid activity', such as housework; and
4) Although the Office for National Statistics (ONS) is making progress in respect of natural capital accounting, there has been no mechanism for accounting for the erosion of the value of stocks of natural capital.

The choice of metric is, therefore, a pragmatic one: it has been used here as a basis for illustrating the economic potential of the waste and resources sector. Relative to many other sectors of the economy, the contribution of the waste and resources sector is

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[46] Office for National Statistics (2016) *UK Non-Financial Business Economy Statistical Bulletins*, Date Accessed: 10 August 2016, Available at: www.ons.gov.uk/businessindustryandtrade/business/businessservices/bulletins/uknonfinancialbusinesseconomy/previousReleases

likely to appear somewhat better than it appears when assessed only through the lens of GVA. On the one hand, the role of the sector as a means to 'deal with waste' would tend one towards the view that this was not the most desirable form of expenditure: on the other hand, the evolution of the sector indicates that there are benefits to be gained in terms of the contribution to reducing raw materials extraction, and the attendant benefits which flow with that (for example, reductions in energy use and GHG emissions, reduces impact on habitats, etc.).

6.1 Measuring GVA

As noted in the main report, the model used the income approach to measuring GVA. The income approach to calculating GVA sums up all of the income earned by individuals or businesses involved in the production of goods and services. The main components of income based GVA are:

- Compensation of employees;
- Gross operating surplus (includes gross trading profit and surplus, mixed income, non-market capital consumption, rental income, less holding gains); and
- Taxes (less subsidies) *on production* are included, whereas taxes *on products* are not. This means that landfill tax – effectively a unit tax on a 'product' – has not been included in the analysis.

In 2012, the average income components for UK businesses, as a percentage of GVA, were as follows:[47]

- Compensation of employees – 61%;
- Gross operating surplus – 37%; and
- Taxes (less subsidies) on production – 2%.

This shows that labour and gross operating surplus tend to make up the vast proportion of GVA (98%). In the sections below, where data exists for specific waste treatments, the unit GVA figures have been calculated based on these two elements of GVA.

6.2 Use of Multiplier Effects

The model developed for this study takes into account the direct, indirect and induced effects on the economy. An increase in demand for a product will result in an increase in the production of that product, as producers react to meet the increased demand. This is known as the 'direct effect'. As producers increase output there will be a corresponding increase in demand on their suppliers along the entire supply chain. This is known as the 'indirect effect'. As a result of the direct and indirect effects, the level of household income throughout the economy will increase as a result of increased employment. A

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[47] Office for National Statistics (2014) *UK Regional Accounts Methodology Guide*, www.ons.gov.uk/ons/guide-method/method-quality/specific/economy/regional-accounts/regional-accounts-methodology-guide.pdf

proportion of this increased income will be spent on final goods and services and thereby generate additional economic activity. This is known as the 'induced effect'. By accounting for the various effects across the economy it is possible to gain a more accurate picture of the likely impact that changes to specific sectors, such as waste and resource management, will have on the broader economy.

In this study, the direct effects have been based upon the data from ONS. ONS does not, however, publish Tier 1(covering indirect effects) and Tier 2 (indirect and induced effects) multipliers. The Scottish government publish useful data on GVA multipliers which can be used to estimate the indirect and induced GVA created through a direct change in the final demand for a product or service.[48] We have assumed, in the absence of alternative information, that the Scottish multipliers were reflective of the broader UK economy. While there will be differences in practice, it was believed that this provided a close enough approximation for the purposes of the macroeconomic modelling being undertaken as part of this study.

The waste flow element of the model calculates the direct GVA generated through changes in the UK's waste management practices. However, in order to demonstrate what the likely wider economic impacts of this are likely to be, it is necessary to factor up these results to estimate the additional GVA generated (or lost) through indirect and induced effects. Economists differentiate between the following types of multipliers when dealing with GVA:

- **Type 1 multipliers** – these account for direct and indirect GVA.
- **Type 2 multipliers** – these account for direct, indirect, and induced GVA.

Examples of Scottish GVA multipliers used in the modelling are shown in Table 6-1. The final results presented in the main report use the Type 2 multipliers to provide the best estimate of what the broader economic impacts would be of the proposed switches in the economy.

Table 6-1: Scottish GVA Multipliers Used to Account for the Indirect and Induced Impacts on GVA for the UK as a Whole

Sector	Type 1 Multiplier	Type 2 Multiplier
Repair and maintenance	1.22	1.48
Waste, remediation and management	1.53	1.88
Construction	1.65	2.01

Source: Scottish Government (2016) Input-Output Tables 1998-2013 - All Tables, July 2016, www.gov.scot/Topics/Statistics/Browse/Economy/Input-Output/Mulitipliers

[48] Scottish Government (2016) *Multipliers*, Date Accessed: 1 August 2016, Available at: www.gov.scot/Topics/Statistics/Browse/Economy/Input-Output/Mulitipliers

6.3 Household Waste

6.3.1 Waste Prevention

The Tentative Transition and Positive Transition scenarios assume that over time increasing amounts of food waste and non-food waste items are prevented from arising in the municipal waste stream (the BaU scenario also assumes a small amount of food waste prevention over time). Accounting for the economic impact of waste prevention is not straight forward as there are a number of upstream and downstream impacts that need to be taken into account. In order to estimate what the likely impacts of waste prevention would be on GVA we used an approach that was based, for the main part, on the 2014 Office for National Statistics' summary supply and use tables.[49] These tables provide an overview of:

1) the value of products supplied by different sectors of the UK economy;
2) the value of intermediate consumption by each sector; and
3) the total consumption expenditure spent by households across each sector of the economy.

These tables were supplemented with additional information to derive GVA values for every tonne of food waste and non-food waste items prevented.

6.3.1.1 Food Waste Prevention

From the summary supply and use tables it is possible to calculate the impact on GVA, on average, of each £1 of final household expenditure. Using the relevant Type 2 GVA multipliers for each sector, it is possible to calculate the direct, indirect and induced GVA from such expenditure.

Research undertaken by WRAP suggests that total preventable household food waste ranges between 4.2 and 5.4 million tonnes per annum and is worth a total of £12.5 billion.[50] This is equal to £2,604 per tonne of preventable food waste if one takes the average of the range suggested by WRAP (i.e. 4.8 million tonnes). In principle, households will spend, invest or save the money that was not spent on food and, depending on their choices, this will have an effect on the economy.

Previous research by WRAP has indicated that expenditure of food tends to hold up even where there is evidence of waste prevention, suggesting that households might 'trade-up' to higher value products. It might not be unreasonable to assume that this could translate into higher GVA per unit of spend in the sector, but such a change would be extremely difficult to estimate. As a proxy for the fact that household savings related to food waste are likely to translate into an impact on GVA, we have assumed that

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[49] Office for National Statistics (2016) *Supply and Use Tables*, Date Accessed: 22 July 2016, Available at: www.ons.gov.uk/economy/nationalaccounts/supplyandusetables

[50] WRAP (2016) *Estimates of Food Surplus and Waste Arisings in the UK*, May 2016, www.wrap.org.uk/sites/files/wrap/UK%20Estimates%20May%2016%20%28FINAL%20V2%29.pdf

household savings are effectively spent in a manner reflecting the average spend by households across the economy. In principle, it would be better to have insight into the way household income is spent at the margin (rather than on average), but again, this is is an assumption that is made in the absence of better information. This allows us to estimate the additional GVA for the UK economy as a whole as a result of each tonne of food waste that is prevented (i.e. £2,604 × 0.83 per tonne of waste).

Countering this increase, there are also likely to be impacts on retailers and their supply chains as a result of reduced demand for food based products and this also needs to be taken into account. On average, every £1 of turnover generated by the UK's retail sector (Standard Industrial Classification (SIC) 47 – Retail, excluding vehicles) generates £0.29 of direct GVA.[51] Accounting for the indirect and induced effects this rises to £0.44 per £1 of turnover (i.e. using the Type 2 multiplier for the sector). This means that if households reduce consumption of food there could be a 44% reduction in GVA for every £1 that is not spent. In light of this, it can be assumed that for every £2,604 not spent by households there will be a £1,137 downstream reduction in GVA. This gives a net waste prevention impact of £1,034 per tonne. The model therefore assumes that for every tonne of food waste that does not arise there will be a £1,304 uplift in GVA as households shift spending to higher value added products and services that generate greater GVA benefits than those that are lost through reduced retail sales (and those of their supply chain).

6.3.1.2 Non-food Waste Prevention

The avoided purchase of many commonly consumed household products – such as newspapers – could potentially save households money relative to the weight of waste that they produce:

- One tonne of textiles generated from basic 135g T-shirts, worth £15 each, would represent expenditure of £111,111 per tonne of waste generated;
- A 200g newspaper at a value of £1 would imply expenditure of £5,000 per tonne of waste generated.

To the extent that waste prevention might bring with it attendant savings related to the products which generate the waste, then as a high level conservative assumption, it was assumed that households could save £2,000 per tonne of avoided non-food waste. It should be noted that waste prevention can occur not only as a result of reduced consumption, but also due to product lightweighting, increased product lifespans, and diversion of products away from the waste stream (e.g. through sharing, reuse via charity shops or online exchange platforms).

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[51] Office for National Statistics (2016) *UK Non-financial Business Economy: 2014 Regional Results (Annual Business Survey)*, Date Published: 16 July 2016, Available at: www.ons.gov.uk/businessindustryandtrade/business/businessservices/bulletins/uknonfinancialbusinesseconomy/2014regionalresultsannualbusinesssurvey

Using the same approach to that outlined above for food waste, it is possible to estimate that, based on an assumed household savings of £2,000 per tonne, the net impact would be an additional £794 of GVA generated per tonne of waste avoided (accounting for direct, indirect and induced impacts). This figure is multiplied by the amount of waste projected to be avoided when moving from the BaU scenario to either the Tentative Transition or Positive Transition scenarios. For the Positive Transition scenario this figure was not applied to the tonnage of WEEE, textiles and furniture projected to have been avoided in the household waste stream. This was because the potential GVA benefits of circularising the flow of these products were assessed separately for this scenario which assumed wider shifts in the economy – see Section 7.0 for further details.

6.3.2 Collection

Eunomia has undertaken extensive modelling of local authority collection schemes across the UK.[52] We drew on this information to calculate the direct GVA of local authority collections for both comingled and kerbside sort type schemes. Figures were calculated for services which are believed to be able to deliver moderate (i.e. around 40%-50%) and high (i.e. >65%) recycling rates. It is believed that the cost per household for comingled collections will not vary substantially from lower to higher recycling rates. For comingled schemes the additional added value is generated through the processing of materials at MRFs (see Section 6.4.4). The assumed GVA figures for the collection of local authority waste presented in Table 6-2. No data could be obtained for the GVA of collecting 'other waste'.[53] Therefore, as a simplifying assumption, it was assumed that this amounted to 25% of the HWRC figure. These figures are for the collection of waste materials only and do not take into account back office employment which is likely to remain largely unchanged as local authorities move to higher recycling rates. Note that whilst the collection (and sorting) costs increase, this typically results in reduced expenditure on waste treatment and disposal (see below). Based on our experience, we have assumed that as regards local government spending, there is no net increase in costs to the household.

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[52] Eunomia has completed options appraisals for 36% of UK authorities (144 in total), who manage 28% of municipal waste based on 2009/10 tonnage data. Eunomia has recently completed waste collections modelling work for Devon County Council, South Hams, Calderdale, and the London Boroughs of Hackney, Hounslow, and Enfield.

[53] 'Other waste' includes: waste collected at bring sites, voluntary/community collections, other recycling from household sources, and voluntary bring sites

Table 6-2: Direct GVA for Collecting Local Authority Waste

Collection Route	Unit	Moderate Recycling Performance	High Recycling Performance
Kerbside sort	£ per household	£50	£64
Comingled	£ per household	£46	£46
HWRC	£ per tonne	£34	£37
Other waste	£ per tonne	£8.5	£9.3

The collection systems – and hence the associated costs – were assumed to change from 'moderate' to 'high' performance schemes on an incremental basis as the model assumes more materials are collected for recycling. In other words, the costs from moving from 'moderate' to 'high' performing schemes were assumed to be linear and associated with the modelled increase in the overall UK recycling rate as defined by the different scenarios (Table 4-1). At the UK level, an incremental increase in GVA over time is likely, as local authorities will start to roll out new services at different points in time as they aim to achieve higher recycling targets. Data extracted from WasteDataFlow for all English and Welsh authorities suggests that 71% of kerbside collected materials are collected via comingled collections and 29% via twin stream or kerbside sort type schemes. This split was applied to the UK as a whole and was assumed to remain constant over the entire period of the model, though there are a number of reasons to believe this split may change over time.

In order to calculate the total added value of kerbside collection services the unit GVA figures in Table 6-2 were multiplied by the projected number of households in the UK between the baseline year and 2030. The projections were based on country specific estimates of future household numbers provided by each of the four countries.[54] The GVA associated with HWRC and 'other waste' collections were calculated by multiplying the unit figures by the projected tonnage of material collected via each of these channels.

[54] Office for National Statistics (2016) *2014 Based Household Projections: England, 2014-2039*, July 2016, www.gov.uk/government/uploads/system/uploads/attachment_data/file/536702/Household_Projections_-_2014_-_2039.pdf; Welsh Government (2016) *Household Projections*, Date Accessed: 13 July 2016, Available at: http://gov.wales/statistics-and-research/household-projections/?lang=en; Northern Ireland Statistics and Research Agency (2015) *Household Projections*, Date Accessed: 13 July 2016, Available at: www.nisra.gov.uk/demography/default.asp21.htm; and National Records of Scotland (2012) *Household Projections for Scotland, 2010-Based*, Date Accessed: 13 July 2016, Available at: www.nrscotland.gov.uk/files/statistics/household-projections/2010-based/j22968400.htm

6.3.3 Preparation for Reuse

Eunomia has undertaken a number of studies that have covered the reuse sector.[55,56] Based on interviews with operators in the sector we were able to obtain average times for pre-inspection and repairing furniture, WEEE, mattresses and textiles. The proportion of each material stream that was assumed to require some form of repair was based on research conducted by WRAP that showed what proportion of these materials could be reused without the need for any repair activity.[57]This was supplemented with data from Defra, who have estimated the GVA per hour worked in the following sectors:[58]

- Repair of computers and communication equipment (£31 per hour);
- Repair of personal and household goods (£16 per hour); and
- Repair of fabricated metal products, machinery and equipment (£33 per hour).

To account for the indirect and induced GVA associated with preparation for reuse the figures were factored up by the Type 2 multiplier for repair and maintenance services shown in Table 6-1.

6.3.4 Dry Recycling

The direct GVA associated with recycling different materials was calculated based on the employment intensities of different recycling processes. We undertook a brief literature review for this purpose, the results of which are summarised in Table 6-3.[59] This table shows the assumed employment figures that were used as part of this study to calculate the direct GVA generated through recycling each type of material. These figures were multiplied by the UK average salary for 'recovery of sorted materials' in 2014 – that is,

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[55] Eunomia Research & Consulting (2015) *Repair Service Models for the Preparation for Re-use Sector: Cost Benefit Analysis*, Report for Zero Waste Scotland, June 2015

[56] Eunomia Research & Consulting (2009) *Third Sector: Investment for Growth*, Report for WRAP, November 2009, www.wrap.org.uk/sites/files/wrap/BTS008%20TSO%20Investment%20for%20Growth%20Final%20Report%20(2).pdf

[57] WRAP (2012) *Composition and Re-use Potential of Household Bulky Waste in the UK (WEEE)*, August 2012, www.wrap.org.uk/sites/files/wrap/WEEE%20-%20bulky%20waste%20summary.pdf; WRAP (2012) *Composition and Re-use Potential of Household Bulky Furniture in the UK*, August 2012, www.wrap.org.uk/sites/files/wrap/Furniture%20-%20bulky%20waste%20summary.pdf; WRAP (2012) *Composition and Re-use Potential of Household Bulky Textiles in the UK*, August 2012, www.wrap.org.uk/sites/files/wrap/Textiles%20-%20bulky%20waste%20summary.pdf

[58] Defra (2016) *Digest of Waste and Resource Statistics – 2016 Edition (Revised)*, March 2016, www.gov.uk/government/uploads/system/uploads/attachment_data/file/508787/Digest_of_Waste_and_Resource_Statistics_rev.pdf

[59] See for example: Friends of the Earth (2010) *More Jobs, Less Waste: Potential for Job Creation Through Higher Rates of Recycling in the UK and EU*, September 2010, www.foe.co.uk/sites/default/files/downloads/jobs_recycling.pdf; Cascadia (2009) *Recycling and Economic Development: a Review of Existing Literature on Job Creation, Capital Investment, and Tax Revenues*, King Country Linkup, https://your.kingcounty.gov/solidwaste/linkup/documents/recycling-economic-development-review.pdf; LEPU (2004) Jobs from Recycling: Report on Stage II of the Research, London South Bank University

£21,822 per annum.[60] Given the limited inflation over the last couple of years and the continued pressure on salaries, it was assumed that salaries were the same in 2016 (i.e. the value was not inflated).

Table 6-3: Employment Intensity for Recycling by Material (FTEs per 10,000 tonnes per annum)

Material	Value Used for Estimating GVA
Glass	29
Paper	20
Plastic	103
Ferrous metal (iron and steel)	54
Non-ferrous metal (aluminium)	110
Wood	7.5
Textiles	50
Furniture	136
Average all recycling	28

Given the fluctuation in commodity prices that occur over time it is difficult to derive an accurate estimate of what the operating surplus is for reprocessors. For this reason, it was assumed that there is no operating surplus associated with recycling. Thus, the GVA generated by recycling was assumed to be made up purely of labour costs. This assumption is therefore, at least in the medium- to longer-term, assumed to be a conservative one and direct GVA from recycling would have to be higher if the sector is to flourish.

The employment intensities do not differentiate between open- and closed-loop recycling and are intended to provide an average. Although one would aim to achieve greater levels of closed-loop recycling under a more circular economy, it has not been possible to quantify the benefits of this as part of this study. The GVA unit values used in the model were multiplied by the tonnage of additional material, relative to the BaU scenario, collected for recycling under the Tentative Transition and Positive Transition scenarios. This enabled the total direct GVA benefit of recycling municipal waste to be determined. The indirect and induced GVA benefits were calculated by multiplying the final figures by the Type 2 multiplier for the waste, remediation and management sector shown in Table 6-1.

[60] Officer for National Statistics (2016) *Industry (4 digit SIC) - ASHE: Table 16*, Date Accessed: 22 July 2016, Available at: www.ons.gov.uk/employmentandlabourmarket/peopleinwork/earningsandworkinghours/datasets/industry4digitsic2007ashetable16

Defra figures suggest that, in recent years, the UK has been exporting between 12 to 14 million tonnes of secondary materials each year.[61] Based on the assumptions presented for each scenario in Table 4-1, the future quantities of secondary materials were estimated. These tonnages were then multiplied by the unit GVA figures to estimate the amount by which the UK's GVA is reduced as a result of sending these materials abroad. The Tentative Transition and Positive Transition scenarios assumed that some of this exported material would be reshored so that the added value associated with reprocessing these materials could be retained within the UK.

6.3.5 Sorting, Treatment and Disposal

The unit GVA figures for sorting comingled materials at MRFs, composting / digesting organic waste, and treating / disposing of residual wastes were calculated based on data provided, in confidence, by SUEZ, and through using Eunomia's experience of modelling waste treatment infrastructure in the UK. The GVA figures used in the modelling include both the cost of labour and a typical operating surplus for the activities concerned. The indirect and induced GVA benefits were calculated by multiplying the final figures by the Type 2 multiplier for the waste, remediation and management sector shown in Table 6-1.

Taxes on products, which includes landfill tax, are not taken into account when measuring GVA (they are, however, taken into account in the measurement of Gross Domestic Product (GDP)). The model, therefore, does not consider landfill tax savings that can be generated by shifting away from landfill. However, because of the low labour intensity of landfill – typically around 1 full time equivalent (FTE) per 10,000 tonnes processed[62,63] – the GVA benefits quickly accrue as waste moves up the hierarchy to more labour intensive activities that can add greater value to materials.

6.4 Commercial and Industrial Waste

6.4.1 Waste Prevention

6.4.1.1 Food Waste Prevention

Figures published by WRAP estimate that the total preventable food waste in the C&I waste stream amounts to the following:

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[61] Raw data provided by Defra and based on the figures published in: Defra (2016) *Digest of Waste and Resource Statistics – 2016 Edition (Revised)*, March 2016, www.gov.uk/government/uploads/system/uploads/attachment_data/file/508787/Digest_of_Waste_and_Resource_Statistics_rev.pdf

[62] Seldman, N. (2006) *Recycling Means Business.* PhD Institute for Local Reliance, Waste to Wealth Program, www.ilsr.org/recycling/recyclingmeansbusiness.html;

[63] Murray, R. (1999) *Creating Wealth From Waste*, DEMOS, www.demos.co.uk/files/Creatingwealthfromwaste.pdf

- **Hospitality and food service** – 0.7 million tonnes with associated savings of £2.5 billion;
- **Retail** – 0.2 million tonnes with associated savings of £0.65 billion; and
- **Manufacturing** – 0.9 million tonnes with associated savings of £1.2 billion.

The weighted average savings that could be made per tonne of food waste prevented across these sectors amounts to £2,417 per tonne. The financial savings made by businesses will help to boost profit margins and thereby a company's operational surplus, resulting in a direct positive impact on GVA. However, businesses often have to make investments, for example, in new equipment, training and so on, in order to achieve the resource efficiency gains. It was assumed that 30% of the £2,417 of savings would have to be invested in order to reduce food waste in the first place, this results in £1,692 of savings to the bottom line.

The reduced downstream consumption of C&I food waste was estimated using the same approach as for household food waste. Every £1 of turnover in the food manufacturing sector (SIC 10 – manufacture of food products) directly generates £0.26 of GVA. Factoring up this figure by the average Type 2 multipliers across the sectors shows that direct, indirect and induced GVA can amount to £0.63 per pound of turnover. Applying a factor of 0.63 to £2,417 suggests that downstream GVA could be reduced by £1,522 per tonne of avoided waste. The net impact is therefore a £170 overall gain in GVA per tonne of food waste prevented.

6.4.1.2 Non-Food Waste Prevention

Approximately 27.9 million tonnes of C&I waste were produced in 2014. In this year the sector consumed £182,165 million worth of products from the following sectors: agriculture, production, construction, and information and communications. These sectors were thought to be those most likely associated with the generation of waste once their products had been consumed. This gives a figure of £6,529 of expenditure per tonne of waste generated by the sector.

It was assumed, conservatively, that prevention of waste would, conservatively, result in savings of £3,000 per tonne of non-food waste prevented, and that 30% of this value would have to be invested in order to achieve the required efficiency savings. This generates £2,100 in additional GVA through increased company profits, while downstream GVA is reduced by an estimated £873. The net GVA impact of waste prevention occurring in the commercial waste stream was therefore estimated to be £210 per tonne (no waste prevention impact was assumed for industrial waste).

For the Positive Transition scenario this figure was not applied to the tonnage of WEEE and textiles projected to have been avoided in the C&I waste stream. This was because the potential GVA benefits of circularising the flow of these products were assessed separately for this scenario which assumed wider shifts in the economy – see Section 7.0 for further details.

6.4.2 Collection

There is very limited publicly available information on the labour costs and operating surpluses associated with collecting C&I waste. It is also an incredibly diverse waste stream, ranging from materials in the commercial waste stream that can be very similar to household waste, to industrial sludges and chemical wastes. This makes it difficult to identify representative GVA figures for collecting either commercial or industrial waste as a whole, let alone, for understanding how these might change as recycling performance improves. Eunomia has undertaken a range of modelling scenarios with commercial waste service providers. It seems reasonable to take the view that the changes will, at the margin, be more representative of what happens with smaller waste producers than those generating waste in large quantities (who are more likely to be already avoiding disposal, either through recycling, or other forms of treatment).

Based on our own modelling, we have developed figures for the GVA changes associated with 'marginal' tonnes being recycled, and for 'marginal' tonnes being lost from residual waste (strictly speaking, the modelling assumes changes that have the potential to alter round logistics through the changes being made).

6.4.3 Preparation for Reuse

The unit GVA figures associated with preparation for reuse of household products were applied to the commercial waste stream. However, the nature of the compositional breakdown of commercial waste means that it is only possible to account for preparation for reuse in relation to WEEE and textiles. For the other waste streams that the BaU mass flows suggest are prepared for reuse it was assumed that these were equal to the GVA unit costs for recycling.

6.4.4 Dry Recycling

Material specific GVA figures were calculated using the same approach as described in Section 6.3.4 (i.e. based on the employment intensities set out in Table 6-3). These values were multiplied by the tonnage of additional material, relative to the BaU scenario, collected for recycling under the Tentative Transition and Positive Transition scenarios. This enabled the total direct GVA benefit of recycling C&I waste to be determined. The indirect and induced GVA benefits were calculated by multiplying the final figures by the Type 2 multiplier for the waste, remediation and management sector shown in Table 6-1.

6.4.5 Sorting, Treatment and Disposal

The same unit figures were used as for household waste. For C&I waste which is sent for 'land spreading' it was assumed that the GVA of this activity was equivalent to landfilling. The 'other waste' category in the C&I data refers to waste sent to land recovery and where the final destination of the waste is reported as unknown in national surveys. As a conservative assumption it was assumed that the GVA generated from this material was equal to that of landfilling. This is likely to be an underestimate, but in the absence of better data it is safe to assume that, as a minimum, it will be able to generate as much

GVA as landfill. The final figures were factored up by the Type 2 multiplier for the waste, remediation and management sector shown in Table 6-1.

6.5 Construction and Demolition Waste

6.5.1 Waste Prevention

An estimated 44.8 million tonnes of C&D waste were produced in 2014. In this year the sector consumed £108,131 million worth of products from the following sectors: agriculture, production, construction, and information and communications. These sectors were thought to be those most likely associated with the generation of waste once their products had been consumed. This gives a figure of £2,414 per tonne of waste generated by the sector. Assuming that 20% of the savings from waste prevention would have to be invested in achieving the efficiency savings in the first place, this leaves £1,931 per tonne of additional savings.

The construction sector produces £0.82 of direct, indirect and induced GVA for every £1 of turnover. Thus, reducing expenditure by £2,414 would results in a downstream reduction in GVA to the tune of £1,978 per tonne of waste. The net impact of waste prevention across the C&D sector was therefore estimated to be -£47 per tonne. This means that waste prevention in the C&D sector, at least using the approach and assumptions adopted here, is associated with reductions in GVA.

6.5.2 Collection

There is very limited publicly available information on the labour costs and operating surpluses associated with collecting C&D waste. This makes it difficult to identify representative GVA figures for collecting different fractions of the waste stream. Eunomia developed a cost benefit model for modelling different C&D waste scenarios on behalf of the European Commission.[64] Data on collection costs from this model were used to estimate the GVA associated with collecting C&D waste.

6.5.3 Preparation for Reuse

Although the baseline data on C&D waste suggests that a large proportion is prepared for reuse, it is not clear what the GVA benefits of this would be (Table 5-10). As a minimum, the added value is likely to be at least equal to the GVA created through recycling. In the absence of better data, it was assumed that the direct GVA derived from preparing C&D products and materials for reuse was equivalent to the recycling unit figures. To account for the indirect and induced GVA associated with preparation for

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[64] Eunomia Research & Consulting (2015) *Further Development of the European Reference Model on Waste Generation and Management*, May 2015, Report for DG Environment of the European Commission, http://bookshop.europa.eu/en/further-development-of-the-european-reference-model-on-waste-generation-and-management-pbKH0415906/

reuse the figures were factored up by the Type 2 multiplier for repair and maintenance services shown in Table 6-1.

6.5.4 Dry Recycling

The assumed GVA generated directly through recycling for different C&D waste streams was calculated based on the same approach set out in Section 6.3.4. For a number of waste streams, in the absence of better data, it had to be assumed that the GVA was equivalent to either landfill or energy recovery – for example, for the recycling of soil and stones, aggregates, mixed waste, and insulation and gypsum. Given that preparation for reuse and recycling rates are relatively high in the BaU scenario (Table 5-10) there is a limited change in C&D mass flows when shifting to the Tentative Transition and Positive Transition scenarios.

6.5.5 Backfilling, Land Disposal and Treatment

According to the baseline data available for C&D waste, materials which are not recycled are either backfilled or sent for land disposal or treatment. It was assumed that the GVA associated with backfilling and land disposal was equivalent to landfilling. In the context of C&D waste, treatment refers to processing of materials at C&D type MRFs. It was assumed that the direct GVA of this activity was equal to 80% of MRF figure used for processing household and commercial waste.

7.0 Broader Circular Economy Switches

Improved product design would help extend product lives and facilitate reuse and repair. The incorporation of these products within circular business models would further help to circularise the flow of materials within the UK economy. Assessing the macroeconomic impacts of such changes to the economy is challenging given the limited data currently available on product and resource flows. The only real source of data available relates to waste arisings and even this, as noted in Section 5.0, is not very reliable for C&I and C&D waste flows.

A high level approach was adopted for measuring the impact of the broader circular economy switches identified in Table 4-1 (i.e. improving the circular flow of electrical and electronic equipment (EEE), textiles and furniture). It was assumed that improved design and the doubling of product lives would reduce waste arisings – at least in the longer term – by half. Improving the longevity and reparability of products may increase the final retail price. This and the slower turnover of products would result in a net decrease in the consumption of new products, resulting in an assumed net decrease of 30% in the total turnover of the retail sectors responsible for selling these products by 2030. It was assumed that net spending in the economy would remain constant and that the money saved from reduced sales would instead be invested in repairing / maintaining the better designed products. Repairs and maintenance and the sale of second hand goods add more value to the economy per £1 of turnover generated than retail. The net effect is that a reduction in GVA through reduced retail sales is more than compensated for by greater value being added through the more labour intensive activities of repair and reuse. The details of the approach adopted for each product stream are outlined below.

7.1 Electrical and Electronic Equipment

The total turnover for retail stores involved in the sale of EEE was £10.2 billion in 2014, with a corresponding GVA of £1.7 billion. For the analysis presented in the main report, retail sales were assumed to fall by 30% due to reduced demand for new products. As noted above, it was also assumed that overall spending in the economy would not decrease and that the money saved on buying new products would instead be invested in repairing and maintaining a smaller number of better designed EEE. With this in mind, the net GVA impact was estimated as follows:

- A 30% reduction in turnover for the electronics retail sector would equate to a fall of £3.1 billion in revenue, which would equate to a direct, indirect and induced GVA impact of £0.79 billion across the supply chain (see Section 6.2 for a discussion on GVA multipliers).
- If the £3.1 billion were then spent on more labour intensive repair and maintenance services it could generate an additional £2.2 billion of GVA after accounting for indirect and induced effects further upstream.

The repair of electronic equipment directly generates £0.49 for every £1 of turnover. Once the indirect and induced effects have been factored in this rises to £0.73 per pound of turnover. Given that this sector adds greater value to the economy, relative to retail, it generates higher levels of GVA for the same amount of spending. As a result, the switch to greater levels of repair and maintenance of EEE results in an estimated net uplift in GVA to the tune of £1.4 billion. For the purposes of the modelling it was assumed that this was the added benefit that could be achieved by 2030.

7.2 Textiles

The improved quality and design of textile products would act to increase product lifespans. This, coupled with greater consumer acceptance for buying second hand goods, could, by our calculations, result in a net uplift in GVA. This was calculated as follows:

- The total turnover for retail stores involved in the sale of textiles was £43 billion in 2014, with a corresponding GVA of £13.2 billion being directly added to the economy. It was assumed that retail sales would fall by 30% due to reduced demand for new products, but that overall spending would not decrease. The money saved on buying new products would instead be spent on buying second hand goods.
- A 30% reduction in turnover equates to a fall of £12.9 billion in revenue and a £6.0 billion reduction in direct, indirect and induced GVA.
- If the £12.9 billion were then spent on purchasing second hand goods it could generate an additional £7.8 billion of GVA after accounting for indirect and induced effects further upstream.

The sale of second hand goods directly generates £0.40 of GVA for every £1 of turnover. Once the indirect and induced effects have been factored in this rises to £0.61 per pound of turnover. Given that this sector adds greater value to the economy, relative to the sale of new textile products, it generates higher levels of GVA for the same amount of spend. As a results the switch here results in an estimated net uplift in GVA of £1.8 billion. For the purposes of the modelling it was assumed that this uplift in GVA would only occur by 2030.

7.3 Furniture

The net GVA impact of this switch was calculated as follows:

- The total turnover for retail stores involved in the sale of ‘furniture, lighting equipment, and other household articles’ was £10.3 billion in 2014. These sales directly generated £2.9 billion of GVA. Again, retail sales were assumed to fall by 30% due to reduced demand for new products. It was also assumed that overall spending in the economy would not decrease and that the money saved on buying new products would instead be spent repairing and maintaining a smaller stock of better designed and more durable furniture. With this in mind, the net GVA impact was estimated as follows:

- A 30% reduction in turnover equates to a fall of £3.1 billion in revenue which would equate to a negative direct, indirect and induced GVA impact of £1.3 billion across the supply chain.
- If the £3.1 billion were spent on buying second hand goods and repairing furniture it could generate an additional £1.8 billion of GVA after accounting for indirect and induced effects further upstream.

The weighted average GVA to turnover of the repair of household furniture and the sale of second hand goods suggests that £0.40 of direct GVA can be generated for every £1 of turnover. Once the indirect and induced effects have been factored in this rises to £0.59 per pound of turnover. Given that this shift generates greater value for the economy, relative to the sale of new products, it creates higher levels of GVA for the same amount of spending. As a results the switch here results in an estimated net uplift in GVA of £0.5 billion, which was assumed to materialise by 2030.

8.0 Climate Change Impacts

Eunomia has undertaken extensive modelling of the greenhouse gas (GHG) costs / benefits associated with different waste collection systems and scenarios. Based on many years of research we have developed a proprietary environmental model called 'Atropos'. This model has been used to model the environmental costs and benefits of waste treatment options for a range of clients, including Zero Waste Scotland, WRAP, Greater London Authority, Defra, and Scottish Government. The Atropos model contains environmental assumptions for most household waste streams, but not for many of waste categories found in C&I and C&D waste. Therefore, where necessary, this data was supplemented with data on the benefits of residual waste treatment from the Scottish Carbon Metric and other relevant sources.[65]

The GHG impact factors from the above sources – provided as CO_2 equivalents (eq) per tonne of waste processed – were multiplied by the waste flows modelled under the BaU, Tentative Transition and Positive Transition scenarios. This allowed for the GHG savings to be calculated relative to the BaU scenario, the results of which are presented in the main report.

[65] Zero Waste Scotland (2011) *The Scottish Carbon Metric Carbon Factors*, March 2011; and Zero Waste Scotland (2013) *The Scottish Carbon Metric - A National Carbon Indicator for Waste: 2013*