Final report

Quantification of food surplus, waste and related materials in the grocery supply chain

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CSC103-001
WRAP, 2016, Quantification of food surplus, waste and related materials in the grocery supply chain

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Executive summary

In early 2015 WRAP established a 'Manufacturing and Retail Working Group' to help develop resources aimed at maximising the effectiveness of actions to reduce food waste. These included a range of guidance documents, tools and case studies to facilitate the prevention of food waste arising in the first place, redistribution of food surplus that could not be prevented and diverting suitable surplus to animal feed if redistribution to people was not possible. In addition the Working Group oversaw the inception of this research project, on the amounts and types of food surplus and waste arising, as such evidence is key to prioritising activities in the future. This information will be important for those developing strategies to achieve international, national or organisational targets to prevent food waste and will inform delivery of Courtauld 2025[1].

The main objectives were to:

- Produce estimates of the amount of food surplus, waste and related materials at retail and manufacture (including third party logistics); and
- Quantify the amount of surplus and waste that might be prevented from arising, be suitable for redistribution and/or diversion to animal feed.

The methodologies used within this research are consistent with the principles outlined in the FUSIONS guidance for food waste quantification, as are the definitions of food waste[2]. Criteria for assessing suitability for prevention of food surplus and waste arising, redistribution and diversion to produce animal feed were agreed with relevant experts.

There are some inherent challenges with such a complex analysis which combines data from a range of sources with other intelligence. There are some inevitable data uncertainties and limitations which are acknowledged and explained in the report. Food by-product and waste data for retail and manufacture are linked to the latest available national data, which is for 2014, whilst food surplus data draws on more recent sources and therefore these estimates are for 2015.

Headline results

Food surplus and waste at retail amounted to 240,000 tonnes, or the equivalent of 0.7% of sales. Of this, 5,000 tonnes was redistributed to people, 27,000 tonnes used in the production of animal feed and 210,000 tonnes was food waste. Of food not sold as intended, 13% was either redistributed or sent for the production of animal feed.

In manufacture (including third-party logistics) there was 2.4 million tonnes of food surplus and waste, the equivalent of 4.2% of UK production. 42,000 tonnes was redistributed to people, 635,000 tonnes used to produce animal feed and 1.7 million tonnes was food waste. Of food not sold as intended, 28% was either redistributed or sent for the production of animal feed.

[1] *Courtauld Commitment 2025*
[2] *FUSIONS Guidance on Food Waste Quantification*

The new approach developed within this research has allowed a much better understanding of the nature of the surpluses and wastes arising at retail and manufacture, and these methodological refinements have contributed to a significantly lower estimate of food waste for manufacture:

- Wasted food products make up around 50% of the waste streams with organic material from manufacture, with the remainder consisting of water from site cleaning processes and other materials such as soil and stones. This finding together with a reduction in food waste due to waste prevention (of around 10% from 2011 to 2014) leads to a significantly lower overall estimate of food waste from manufacture compared to the one previously published by WRAP (1.7 million tonnes vs 3.9 million tonnes for 2011); and
- For the first time this research has produced an estimate of how much of the food waste could be defined as avoidable (that is could have been eaten, with or without further processing). Of the total food waste at retail and manufacture (1.9 million tonnes), around 1.1 million tonnes or 56% was avoidable (with a potential sales value of £1.9 billion).

Detailed estimates are provided for the amount of food surplus and waste arising for retail and manufacture (overall and for 11 sub-sectors), and the current fate of these materials. Five sub-sectors are responsible for around 80% of avoidable food waste in manufacture; dairy products, meat, poultry and fish, ambient products, fresh fruit and vegetable processing and bakery, cake and cereals.

The extent to which food waste could be defined as avoidable varies by sub-sector, with a higher proportion being avoidable for ambient products, bakery and pre-prepared meals.

Analysis has been carried out to assess the extent to which food surplus and waste might be prevented within the ten-year timeframe of Courtauld 2025, based on the characteristics of the material itself, knowledge of potential interventions and alignment with the food waste or utilisation hierarchy[3]. Prevention of waste arising in the first place has been prioritised, followed by redistribution (either via charitable or commercial routes), then diversion to animal feed. Both of the latter are higher up the hierarchy than sending food waste to anaerobic digestion or to composting facilities, and will contribute to the delivery of food waste prevention targets.

Various factors will influence the implementation of interventions to prevent food waste and the timescales for these, and a range of scenarios were developed to reflect this. These included one maximising the amount of food that may be suitable for redistribution (including some that may be challenging to manage), one that maximises surplus to animal feed (assuming more of the material that is suitable for animal feed is diverted to this use) and the primary scenario which prioritises the implementation of actions to prevent food waste arising, followed by redistribution and then diversion to animal feed. These scenarios give rise to a range of potential tonnages that may be prevented, and may be suitable for redistribution or diversion to animal feed.

This analysis suggests that:

- Of the current food surplus and food ending up as waste, 270,000 tonnes may be suitable for redistribution, including 37,000 tonnes currently being used to produce animal feed, 190,000 tonnes going to waste (where on average around 40% goes to anaerobic digestion and other recycling options, 40% for energy recovery and 20%

[3] *Find out more about the food waste or utilisation hierarchy here*

to landspreading) and the 47,000 tonnes already being redistributed. This suggests therefore that 18% of what may have been suitable for redistribution was actually redistributed in 2015; and
- 860,000 tonnes of food surplus and material now going to waste could be suitable for use in animal feed, compared to the 660,000 tonnes currently being used for this purpose[4].

The results from the primary scenario (which incorporates prevention of food surplus and waste arising in the first place, then prioritises redistribution followed by diversion to animal feed) indicate the potential outcomes by 2025:

- Prevention of food waste at source could save almost £300 million a year of food from being wasted (185,000 tonnes);
- Redistribution of surplus food could provide the equivalent of 360 million meals a year (from around 185,000 tonnes of food surplus, a four-fold increase compared to 2015);
- The amount of food surplus being used to produce animal feed could be increased by around 20% (to around 800,000 tonnes a year);
- A combination of preventing food waste being generated, redistributing more of the food surplus that can't be prevented to people and diverting surplus that isn't suitable for human consumption to animal feed will all be needed to achieve the Courtauld 2025 target;
- Together these actions could reduce the 1.1 million tonnes of avoidable food waste at retail and manufacture by 42% or 450,000 tonnes (resulting in a 23% reduction in total food waste); and
- Around 1.5 million tonnes of food waste may not be suitable for prevention, at least not within the shorter term, and will need to be assessed for optimal treatment and recovery.

Some of the changes required could be implemented in the shorter term (for example using the resources already available from WRAP and others) whilst some will require medium-term innovations and collaboration to bring about. Courtauld 2025 will aim to facilitate this.

The potential reduction in retail and manufacturing food waste identified in this report is broadly consistent with that modelled during the development of the Courtauld 2025 food waste prevention target. That target requires a 20% per capita reduction by 2025 across the food system, and takes in to account potential population and production growth. Achieving the target will be challenging for all sectors, but this research shows that the contribution from retail and manufacturing is stretching but realistic, and provides insights that will help deliver against it.

The potential scale of food waste reduction identified in this report, and the contributions from prevention, redistribution and diversion to animal feed are based on an overall assessment of what is realistic at a UK level. There will be significant differences between different businesses in what they may be able to achieve, and what interventions may work best for them, as a result of their product mix, size, location, policies towards mark-downs, progress made to date and so on. The estimates in this report are not therefore targets for individual businesses, but a guide to what the sectors as a whole could achieve – which WRAP will monitor through Courtauld 2025.

[4] These estimates for maximum redistribution and maximum diversion to animal feed are not additive as they arise from different scenarios.

Main recommendations

This research has applied a new approach to estimating both how much food surplus and waste comes from manufacture and retail, and how much of this might be suitable for a range of waste prevention interventions. It has pulled together data and insights from a wide range of sources, covering a diverse set of sectors and sub-sectors. It clearly identifies the potential for stopping food waste arising, redistributing more to people and diverting more surplus to produce animal feed. It should however be stressed that this forms the foundation upon which to build a more comprehensive understanding of this area, as methodologies evolve, interventions are evaluated and more targeted research undertaken.

The following represent opportunities to further improve data quality and relevance over time:

- Refine the estimates for how much food waste might be prevented from arising based on a) the evaluation of innovations in processing, equipment, packaging management etc., as these are implemented, b) from monitoring the levels of food surplus and waste arising over time and c) from feedback on the barriers to implementing relevant innovations;
- Refine the estimates for how much of the food surplus and waste might be suitable for redistribution based on learnings from both the providers and recipients of food surplus. Innovations in the types of material that could be turned in to products suitable for use by recipients could lead to an even higher percentage of future food surplus and food that might have been wasted being used to feed people; and
- It should also be noted that whilst this research provides more granular estimates of food surplus and waste for the sectors, it does not reveal priorities for action within a sub-sector. Further and more focused 'mapping' will be required for the sub-sectors with the greatest potential to prevent food waste. As a first step WRAP is working with a major dairy business to map material flows from multiple sites and a wide range of products (including milk, soft and hard cheeses, butter, yoghurt etc.), with the objective of identifying the greatest opportunities for both prevention and maximising value from the non-preventable materials.

The following are also critical for the delivery of the waste prevention opportunities identified in this report:

Collaborative action targeting priority areas:

- This research has identified areas where the greatest potential impacts can be made, and also that collaboration between businesses across the supply chain will be needed to realise the greatest benefits (for example between brands and retailers in tackling some of the in-store food waste, and retailers and manufacturers in addressing some of the opportunities around forecasting). The outputs from this research will inform decision making on where resources should be allocated, for example through working groups under Courtauld 2025, and future 'whole chain resource efficiency' projects[5].
- WRAP will establish a Redistribution Working Group under Courtauld 2025 to understand more about the implications associated with realising some of the redistribution potential identified in this study. It will be particularly helpful to share insights from retailer back of store and manufacturing trials that have been undertaken in different parts of the UK during 2015 and early 2016.

[5] *See Whole chain resource efficiency*

Awareness raising/behavioural change:

- The study found that there was often a poor understanding across the sector about the sorts of surplus that were within scope for redistribution and how businesses with food surpluses can partner with redistribution organisations. This issue should be addressed through the improved guidance and partnership tools developed by the redistribution sector and WRAP, the use of awareness raising resources such as 'Your Workplace Without Waste' and through greater engagement on this issue with individual businesses and trade associations under Courtauld 2025[6].
- In order to enable greater amounts of food surplus to be diverted to animal feed production WRAP will be working with the FSA and representatives of national and local enforcement bodies to improve the consistency and clarity of both the guidance available to food businesses and the training of staff on the ground.

Maximising value from food waste that cannot be prevented:

- Around 1.5 million tonnes of food waste may not be suitable for prevention (120,000 tonnes from retail, equivalent to 0.3% of product sold in 2014; 1.4 million tonnes from manufacture, equivalent to 2.4% of product sold), at least not within the shorter term. This will need to be assessed for optimal treatment and use. This will need to look at the balance between on-site versus off-site treatment options, both in terms of commercial and environmental benefits.

[6] For example see Surplus food redistribution, Your Workplace Without Waste, The FareShare Food Efficiency Framework

Summary report

Background

The United Nations Food and Agriculture Organisation (FAO) estimated that in 2011 roughly one-third of all food produced in the world ended up as waste[7], although some estimates put the figure as high as 50%, or up to 2 billion tonnes a year[8]. FAO also estimated that the global carbon footprint of food waste, excluding land use change, was 3.3 billion tonnes of CO_2e, equivalent to approximately 8% of global GHG emissions. There are also significant implications for water and land use of producing food that ends up not being consumed, and serious financial consequences for food producers, consumers and those responsible for managing food that is wasted[9]. Preventing food waste has been a priority for Governments in the UK and WRAP for over a decade, and a range of mechanisms have been put in place to deliver this, notably voluntary agreements with key sectors[10] and the Love Food Hate Waste consumer-facing campaign[11]. Reductions in food waste have been reported for households, retail and manufacturing and hospitality and food service, but there is the opportunity to do more[12].

In March 2016 WRAP launched the Courtauld Commitment 2025 (Courtauld 2025), an ambitious 10-year voluntary agreement that brings together a broad range of organisations involved in the food system to make food and drink production and consumption more sustainable. One of the Courtauld 2025 targets is to reduce the amount of food waste across the food system. Retailers and manufacturers have a central role to play in achieving this food waste reduction target, both in terms of tackling food waste within their own operations and how they help their suppliers and customers. Retailers and manufacturers have been working under WRAPs Courtauld 2 and 3 agreements to reduce waste in the supply chain since 2009, and achieved a 7.4% reduction in food and packaging waste between 2009 and 2012[13]. Interim results from Courtauld 3 indicated a further 3.2% reduction by 2014 compared to 2012, and a 74% increase in redistribution of surplus food by signatories[14]. WRAP and Courtauld signatories also influence non-signatories through a variety of mechanisms[15] and WRAP estimated that overall food waste in the supply chain could have reduced by around 6% between 2009 and 2012[16].

In early 2015 WRAP established a 'Manufacturing and Retail Working Group' to help develop resources aimed at maximising the effectiveness of actions to reduce food waste. These included a range of guidance documents, tools and case studies[17] to facilitate the prevention of food waste arising in the first place, redistributing surplus food that could not be prevented and diverting suitable surplus food to animal feed if redistribution to people was not possible – all three of these actions contributing to food waste prevention targets. In addition the Working Group oversaw the inception of the research project that resulted in

[7] *Global food losses and food waste study*
[8] *Food Wastage Footprint report*
[9] *Strategies to achieve economic and environmental gains by reducing food waste*
[10] *For example the Courtauld Commitment and the Hospitality and Food Service Agreement*
[11] *More on Love Food Hate Waste can be found on the campaign website*
[12] *UK Food Waste - Histoical changes and future influences; HaFSA progress 2 years on; CC3 Supply chain targets on track for success*
[13] *Courtauld Commitment 2; this is the combined reduction in the weight of food and packaging waste*
[14] *Courtauld Commitment 3 interim results and case studies; this is the combined reduction in the weight of food and packaging waste*
[15] *See UK Food Waste - historical changes and future influences*
[16] *UK Food Waste - historical changes and future influences*
[17] *These can be found at Whole Chain Resource Efficiency; Surplus food redistribution; Extending product life to reduce food waste; Food waste prevention information at your fingertips - digests and webinars; Guidance for Food and Drink Manufacturers and Retailers on the Use of Food Surplus as Animal Feed*

this report, as having updated evidence-based insights on the amounts and types of food surplus and waste arising is key to prioritising activities in the future. In addition to supporting delivery of the Courtauld 2025 targets, this information will be important for those developing strategies to achieve international, national or organisational targets to prevent food waste.

This summary provides an overview of the research objectives, methodology, limitations, headline results and key recommendations/next steps. Full details of the methodology and UK-level results are contained within the main body of the report. A series of appendices provide more detail on the findings within each food and drink manufacturing sub-sector, for example dairy and bakery.

Food by-product and waste data for retail and manufacture is linked to the latest available national data, which is for 2014, whilst food surplus data draws on more recent sources and therefore these estimates are for 2015.

Objectives

The aims of this research are to improve the understanding of food surplus and food waste in the UK grocery supply chain and to provide policy and business relevant insights, particularly in relation to the delivery of Courtauld 2025[18]. One of the Courtauld 2025 targets is to reduce the amount of food waste across the food system, and these research outputs will help focus resources on those areas where most impact might be achieved.

The key research objectives were to:

- Produce estimates of the amount of food surplus, waste and related materials at retail and manufacture (including third party logistics);
- Quantify the amount of food surplus and waste that might be prevented from arising, suitable for redistribution and/or diversion to animal feed; and
- Identify the most significant causes of food surplus and waste.

Scope

The study included UK-based food manufacturers and grocery retailers[19]. It did not extend to hospitality and foodservice or wholesalers. The agriculture sector and households were also outside of the project scope. In order to provide a structure for the research design, food and drink manufacturing activity was clustered into a number of industry sub-sectors: milling; confectionery; fruit and vegetables; ambient products; meat, poultry and fish; pre-prepared meals; dairy products; alcoholic drinks; bakery, cakes, biscuits and breakfast cereals; sugar and soft drinks and fruit juices.

The food waste definitions were aligned with those developed by the European Commission funded FUSIONS project[20]. The definition of food surplus and criteria for determining preventability and suitability for redistribution or diversion to animal feed were based on discussions with industry experts and consideration of relevant regulations and guidance.

Total food waste is any food, including inedible parts of food, removed from the food supply chain to be recovered or disposed of – that is, it contains both material that may be, or has the potential to be edible plus the inedible fractions associated with food. In this report

[18] *Courtauld Commitment 2025*
[19] *Food surplus and waste from staff and customers restaurants was also excluded*
[20] *A Food Waste Definitional Framework was published by the FUSIONS project in 2014*

WRAP uses the term 'theoretically avoidable food waste[21]' to define food waste that could in theory be edible (with or without further processing). In reality, not all theoretically avoidable food waste can be prevented and therefore the term 'practically avoidable' is used to describe what could realistically be prevented (in the timeframe of Courtauld 2025). For example during the manufacture of flavoured milk drinks some product waste will occur during line cleaning between batches, and would be defined as theoretically avoidable (as it would be edible product) but whilst improved sensors and low volume purging may reduce this (and contribute to what would be defined as practically avoidable) it would not be possible to eliminate this source of food waste altogether.

Figure S1: *Illustration of how total, theoretically and practically avoidable food waste relate to one another*

The range of data sources and methodologies used within this research are briefly discussed at the end of this summary, and more detail can be found in the main body of the report.

Results and analysis

UK estimates of food surplus and waste for 2014/15

It is estimated that total food waste (which includes materials such as inedible peelings) in the manufacturing and grocery retail sectors amounts to 1.9 million tonnes, with 56% of this theoretically avoidable (which excludes materials such as inedible peelings), which is worth £1.9 billion a year. In addition there were 710,000 tonnes of food surplus being redistributed or sent for animal feed (see Table S1) and 2.8 million tonnes of animal and other by-products.

The amounts of food surplus and waste in manufacture represent the equivalent of 4.2% of UK production (around 58 million tonnes in 2014[22]), whilst retail food surplus and waste represent the equivalent of 0.7% of product sold (around 37 million tonnes in 2014[23]).

[21] See FUSIONS Definitional Framework for Food Waste for more discussion on the definition of food waste. It should also be noted that others, such as the UN FAO, use the term 'edible' rather than 'avoidable' food waste
[22] Derived from PRODCOM data as described in Appendix K

This study did not re-estimate total food waste from the retail sector, as new estimates had been reported by the BRC in 2015 and extrapolated to the wider sector by WRAP[24]. The main focus was therefore on understanding the detail beneath the 210,000 tonnes estimated to arise from the sector in 2014.

The new approach developed within this research has allowed a much better understanding of the nature of the surpluses and wastes arising at retail and manufacture. Wasted food products make up around 50% of the organic waste streams from manufacture, with the remainder consisting of material associated with food production but not made up of food (for example cleaning water, soil and stones etc.). This improved granularity, together with a reduction in food waste being generated (of around 10% from 2011 to 2014, and amounting to around 200,000 tonnes), leads to a significantly lower overall estimate of food waste from manufacture compared to the one previously published by WRAP (1.7 million tonnes vs 3.9 million tonnes for 2011).

Table S1: *Manufacture and retail food surplus and waste (2014 for food waste; 2015 for food surplus[25])*

	Total food waste (t)	Total food surplus (t)	Total food surplus and waste (t)	% surplus and waste of production/sales
Manufacture	1,700,000	680,000	2,400,000	4.2%
Retail	210,000	32,000	240,000	0.7%
Total	1,900,000	710,000	2,600,000	

The amount of food surplus redistributed via charitable and commercial routes is estimated at 47,000 tonnes for 2015, with 660,000 tonnes of food surplus being diverted to produce animal feed (Table S2).

Table S2: *Manufacture and retail food surplus by use (2015 data)[26]*

	Food surplus to redistribution (t)	Food surplus to animal feed (t)	Overall food surplus (t)
Manufacture	42,000	635,000	680,000
Retail	5,000	27,000	32,000
Total	47,000	660,000	710,000

For the first time this research has produced an estimate of how much of the food waste could be defined as avoidable (that is it could have been edible, with or without further processing). Of the total food waste at retail and manufacture (1.9 million tonnes) around 1.1 million tonnes or 56% was avoidable (with a potential sales value of £1.9 billion). All of the food waste at retail is defined as avoidable, as all of this was originally intended to be sold, whilst 51% of food waste at manufacture is avoidable.

[23] Derived from Family Food 2014 by WRAP, as described in Household Food & Drink Waste – A Product Focus
[24] See Handy facts and figures on waste in the UK
[25] The estimate for redistribution from retail for 2015 may be an underestimate as data on store level redistribution via local charities is not held centrally by all retailers. These volumes are likely to be small compared to the current redistribution from retail distribution centres
[26] Data is rounded to 2SF and therefore the totals may not equal the sums of the contributory rows

Detailed estimates are provided below for the amount of food surplus and waste arising for retail and manufacture (overall and for 11 sub-sectors), and the current fate of these materials.

Potential for food waste prevention

Analysis has been carried out to assess the extent to which food surplus and waste might be prevented within the timeframe of Courtauld 2025, based on the characteristics of the material itself, knowledge of potential interventions and alignment with the food waste or utilisation hierarchy. Prevention of waste arising in the first place has been prioritised, followed by redistribution (either via charitable or commercial routes), then diversion to animal feed. Both of the latter are higher up the hierarchy than sending food waste to anaerobic digestion or to composting facilities, and will contribute to the delivery of food waste prevention targets

Various factors will influence the implementation of interventions to prevent food waste and the timescales for these, and a number of scenarios were developed to reflect this. These included one maximising the amount of food that may be suitable for redistribution (including some surpluses that may be challenging due to very short shelf-life), one that maximises surplus to animal feed (assuming more of the material that is suitable for animal feed is diverted to this use) and the primary scenario which prioritises the implementation of actions to prevent food waste arising, followed by redistribution and then diversion to animal feed. The different scenarios give rise to a range of potential tonnages that may be prevented, and may be suitable for redistribution or diversion to animal feed. The results from the primary scenario (which balances prevention, redistribution and diversion to animal feed) and the ranges from all scenarios are shown in Table S3.

Table S3: *Potential levels of food surplus and waste by 2025 (tonnes)*

	Total food waste (potential; t)	Food surplus (potential; t)	Redistribution (potential; t) [range; t]	Animal feed (potential; t) [range; t]
Manufacture	1,400,000	895,000	130,000 [52,000-160,000]	765,000 [615,000-805,000]
Retail	120,000	95,000	55,000 [47,000-110,000]	40,000 [10,000-50,000]
Total	1,500,000	990,000	185,000 [99,000-270,000]	805,000 [625,000-860,000]

The analysis suggests that of the current total of food surplus (710,000 tonnes) and food ending up as waste (1.9 million tonnes), 270,000 tonnes may be suitable for redistribution (25% of theoretically avoidable food waste), including 37,000 tonnes currently being used to produce animal feed, 190,000 tonnes going to waste (where on average around 40% goes to anaerobic digestion and other recycling options, 40% for energy recovery and 20% to landspreading)[27] and the 47,000 tonnes already being redistributed. This suggests therefore that 18% of what may have been suitable for redistribution was actually redistributed in 2015.

Figures S2 and S3 illustrate where the additional food suitable for redistribution could be diverted from, for manufacturing and third-party logistics and for retail. These estimates are

[27] Based on the waste treatment or disposal routes for manufacture (derived from Environment Agency data as reported in Section 6) and retail (derived from WRAP Courtauld 3 signatory reporting data). Data on food waste routes for third-party logistics is not available and it was therefire assumed that these would be similar to those for retail (as both consist primarily of finished product).

derived from the 'maximum redistribution' scenarios, and as described below, efforts to prevent food surplus and waste arising in the first place would have an impact on the amount of food available for redistribution (as shown in Figures S10 and S11).

Figure S2: *Illustration of where food suitable for redistribution might be diverted from, for manufacturing and third-party logistics (tonnes)*

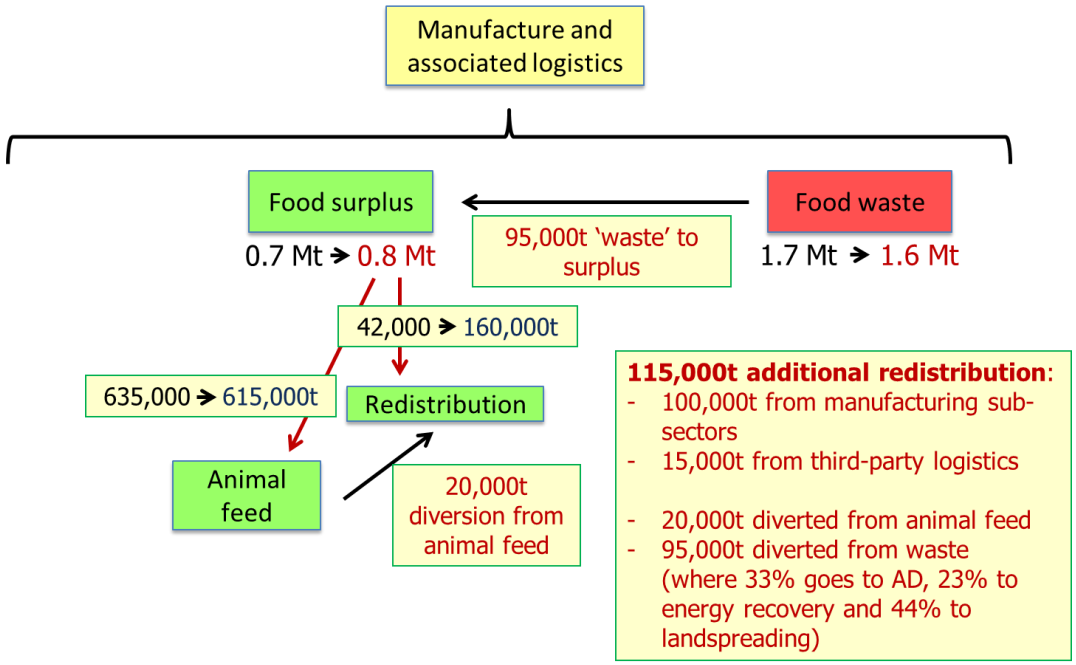
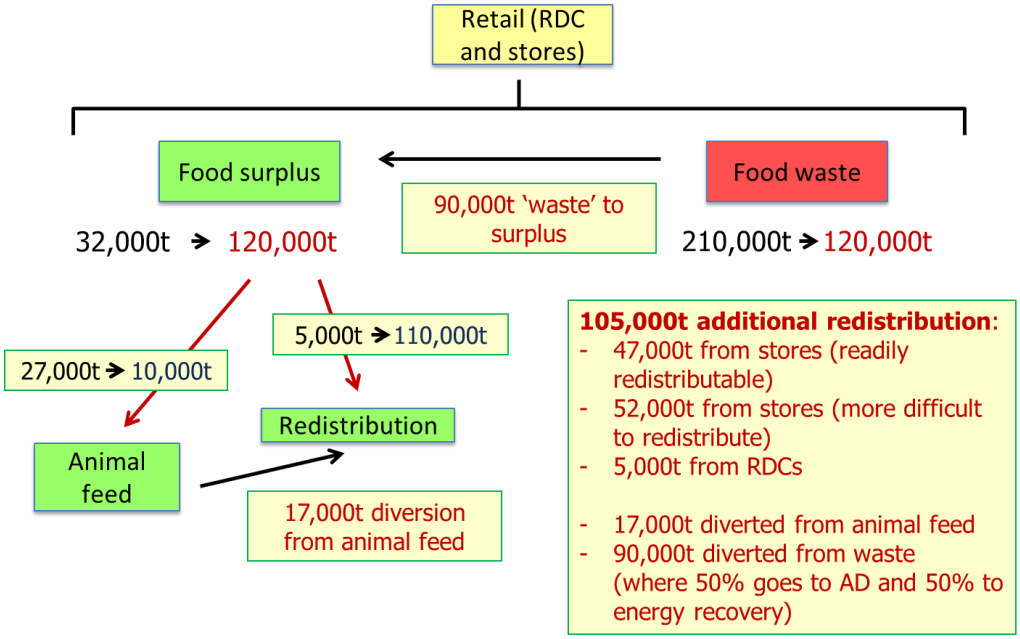


Figure S3: *Illustration of where food suitable for redistribution might be diverted from, for retail (tonnes)*



The analysis also suggests that of the current food surplus and material going to waste within manufacture and retail, 860,000 tonnes could be suitable for use in animal feed, compared to the 660,000 tonnes currently being used for this purpose. These estimates are derived from the 'maximum diversion to animal feed' scenarios, and as described below,

efforts to prevent food surplus and waste arising in the first place, and increase redistribution of surplus food would have an impact on the amount of food available for diversion to animal feed (as shown in Figures S10 and S11). It is important to stress that the estimates for maximum redistribution and maximum diversion to animal feed are not additive as they arise from different scenarios, as illustrated in Figure S14.

The results from the primary scenario (which incorporates prevention of food surplus and waste arising) reflect the potential outcomes by 2025 and suggest that of the total 1.1 million tonnes of theoretically avoidable food waste almost 450,000 tonnes or 42% is likely to be practically avoidable (in the timeframe of Courtauld 2025) (Table S4), through a combination of prevention of arisings, increased redistribution and diversion to animal feed (both of the latter are classed as waste prevention activities).

***Table S4**: Assessment of how much manufacture and retail food waste is theoretically and practically avoidable*[28]

	Total food waste (t)	Theoretically avoidable food waste (t)	Practically avoidable food waste (t)	% of total food waste practically avoidable	% of avoidable food waste practically avoidable
Manufacture	1,700,000	870,000	355,000	21%	41%
Retail	210,000	210,000[29]	93,000	44%	44%
Total	1,900,000	1,100,000	450,000	23%	42%

Around 1.5 million tonnes of food waste may not be suitable for prevention, at least not within the shorter term, and will need to be assessed for optimal treatment and recovery.

Manufacturing material flows for 2014/15

In the simplified model presented in Figure S4, it can be seen that by-products, surplus and food waste combined represent around 5.2 million tonnes, equivalent to 9% of UK manufacturing output of 58 million tonnes. Food surplus and food waste represent the equivalent of 4.2% of UK production, and theoretically avoidable food waste arisings are equivalent to 1.5% of this output. Of food not sold as intended, 28% is redistributed or sent for the production of animal feed. The majority of by-product and surplus are sent for the production of animal feed. Around half of the food waste is subject to some form of on-site treatment (such as dissolved air filtration [DAF] or anaerobic digestion [AD]) prior to being moved off site.

Figures S5 and S6 show the breakdown of total and theoretically avoidable food waste at manufacture by sub-sector. For total food waste five sub-sectors are responsible for around 80% of the sector's food waste, and a similar picture is seen for avoidable food waste (although bakery comes in to the top five and alcoholic drinks moves out).

[28] *See the glossary for definitions of these terms*
[29] *All of the food wasted at retail is defined as avoidable, as all food at retail is intended for sale*

Figure S4: *Manufacturing material flows for 2014/15 (total food waste streams shown sum to 1.65 million tonnes, an additional 90,000 tonnes is in minor streams and not shown[30])*

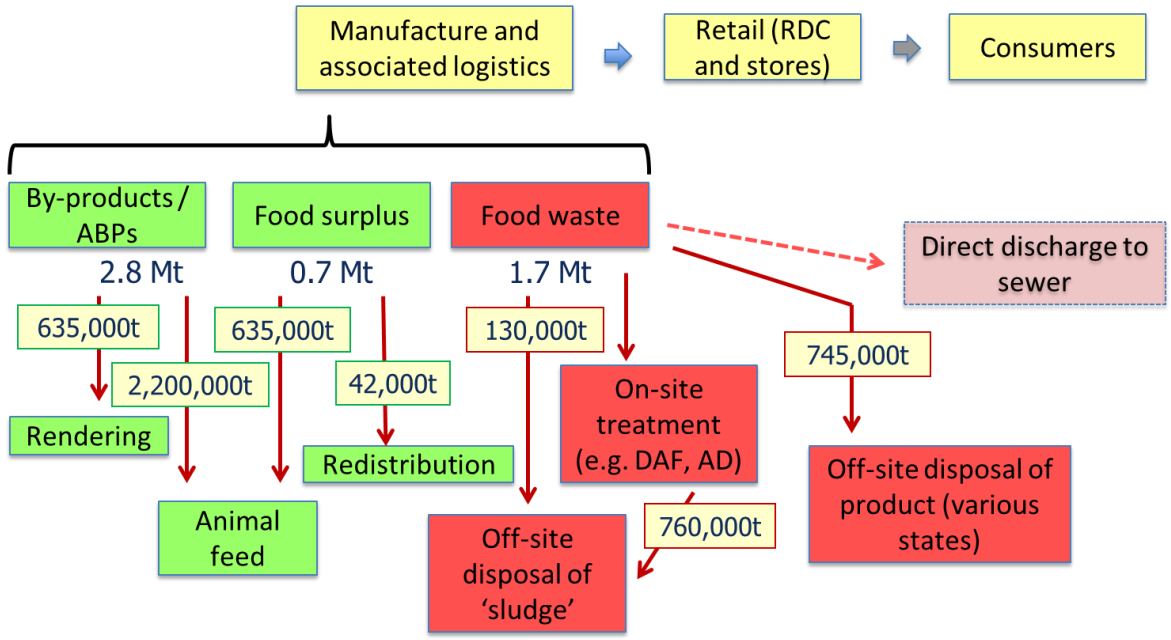
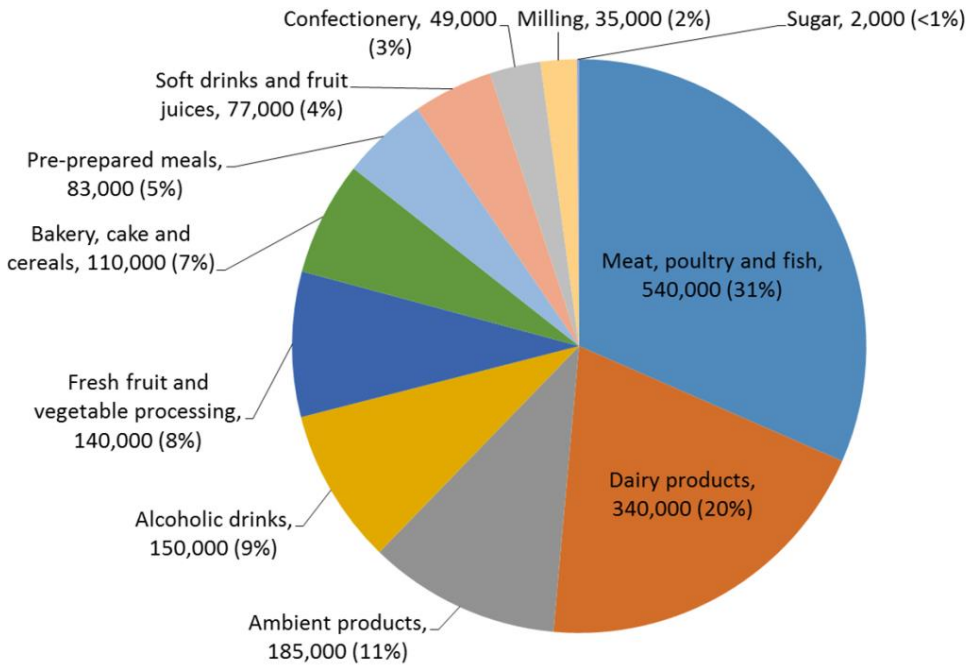
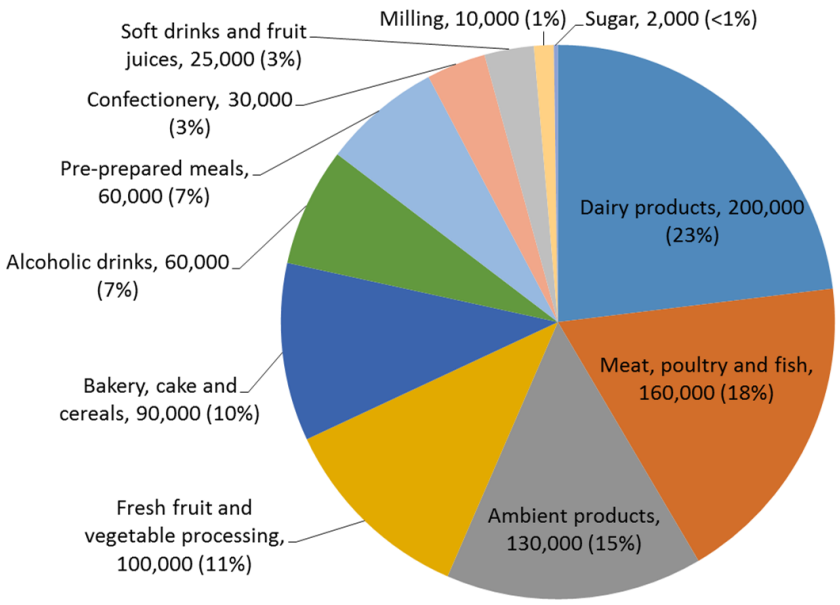


Figure S5: *Total food waste from manufacturing, split by sub-sector (tonnes; total equals 1.7 million tonnes; for 2014)[31]*



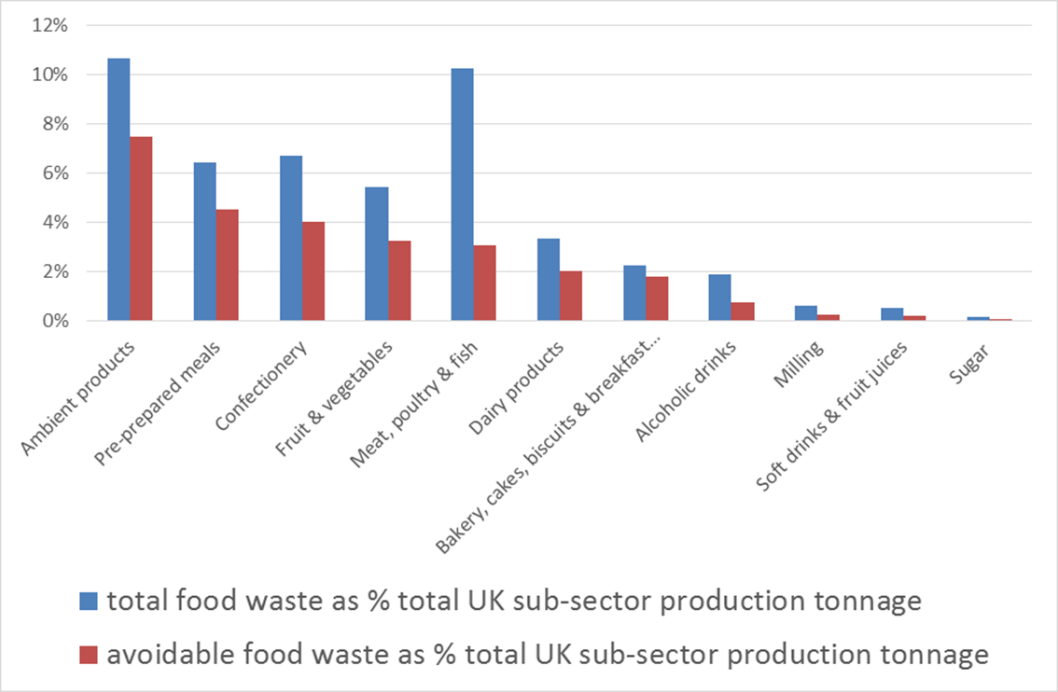
[30] *See Figure 6.3 in the main report for the full detail*
[31] *For the purposes of this analysis, the ambient sub-sector includes canned foods, preserves, jams and jellies; dried and dehydrated fruits, vegetables and soup mixes; pickled fruits and vegetables, vegetable sauces and seasonings, and salad dressings etc.*

Figure S6: *Theoretically avoidable food waste from manufacturing, split by sub-sector (tonnes; total equals 870,000 tonnes; for 2014)*



The proportion of food waste in relation to production volumes varies widely by industry sub-sector (Figure S7), with the highest proportion of theoretically avoidable food waste in ambient and pre-prepared meals sub-sectors. Generally, the wastage rate is higher in those sub-sectors which produce more complex end products involving multiple ingredients and production lines. The avoidable food waste for these two sub-sectors is equivalent to around 8% and 4% of their UK production tonnage respectively.

Figure S7: *Food and drink waste (total and theoretically avoidable as a proportion of UK food and drink manufacturing production; tonnes; for 2014)*

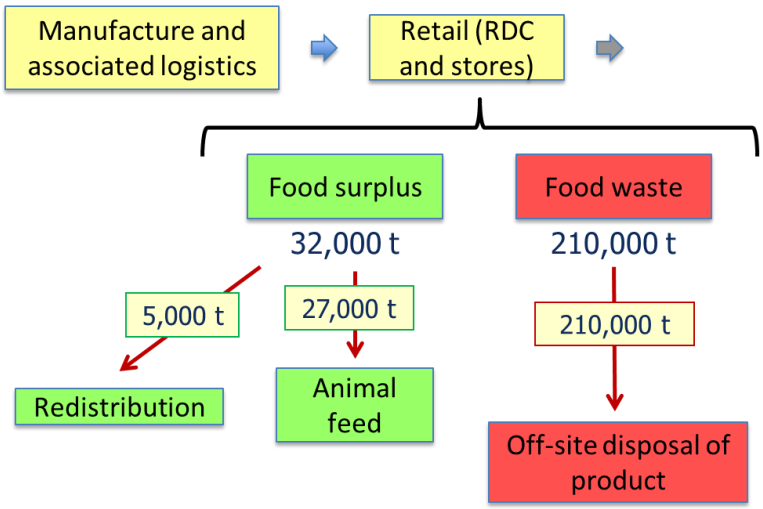


(adapted from PRODCOM data, provisional, food waste estimated from EP2014 data)

Retail material flows for 2014/15

In the simplified model presented in Figure S8, it can be seen that food surplus and food waste combined represent around 240,000 tonnes, equivalent to 0.7% of UK grocery food sales. Of food not sold as intended, 13% is redistributed or sent for the production of animal feed.

Figure S8: *Retail material flows for 2014/15*



Potential for food waste prevention, additional redistribution and diversion to animal feed

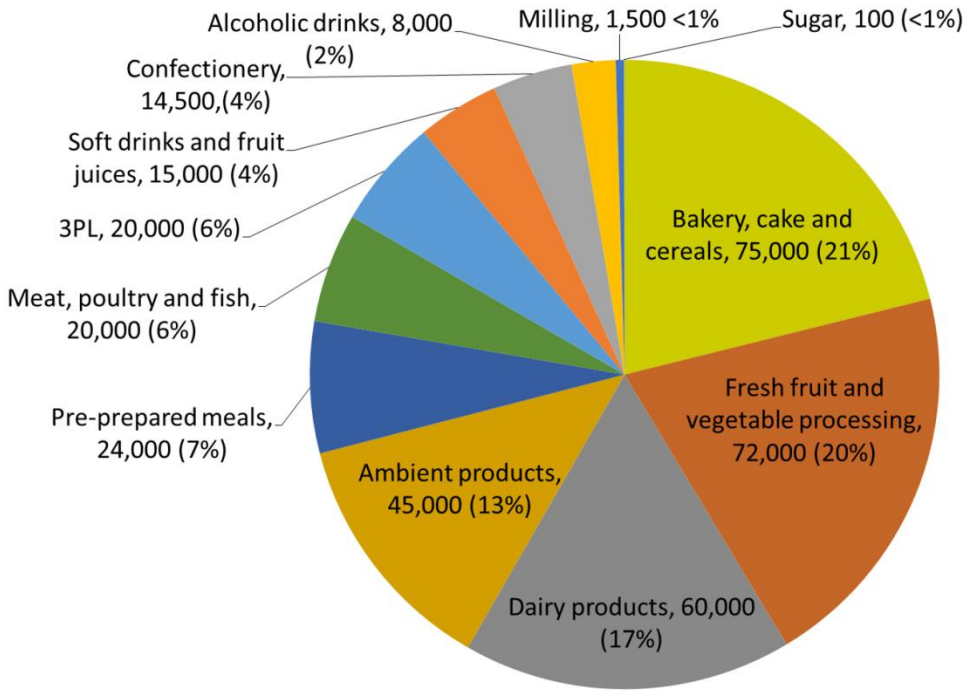
Manufacturing and third-party logistics (3PL)

Potential root causes of food surplus and waste varied considerably across the sub-sectors, depending on the product and the nature of the manufacturing operation. Sub-sector specific insights are provided in the main report, but in general the following would be relevant to the prevention of food waste:

- Better operational practices, for example application of Lean practices to food manufacturing or the application of continuous improvement methodologies to production processes, improved product handling procedures, changes to shut-down/ production line break-down procedures, batch change-overs with respect to improved line balancing and waste associated with machine breakdown;
- Improvements to process control of existing operations: such as making less 'off-spec' product through better control of raw material additions, avoidance of spoilage through improved temperature control, better stock control systems ('first-in-first-out'), better waste measurement and feedback into workplace practices and unit processes;
- Innovations in food processing technologies to improve yields and reduce waste, such as technologies to reduce product loss in cleaning system and extend product life;
- Improvements to forecasting and processes around changes to orders;
- Increased redistribution of food surplus;
- Increased diversion of food surplus for animal feed; and
- Linked to many of the above, improvements in staff training and awareness of the opportunities to address surplus and waste.

It is estimated that around 355,000 tonnes of food waste at manufacture could be practically avoidable by 2025, through a combination of preventing waste arising, additional redistribution and diversion to animal feed, equivalent to a 21% reduction in total food waste or 41% in theoretically avoidable food waste. A combination of prevention of waste arising and increases in redistribution and diversion to animal feed will be required to deliver this reduction, and a number of factors are likely to influence this balance, and how this changes over time. Four sub-sectors contribute around 75% of this potential (bakery, fresh fruit and vegetables, dairy and ambient; Figure S9).

Figure S9: *Overall prevention potential* for manufacture, by sub-sector and for 3PL (tonnes; total = 355,000 tonnes)*



The analysis suggests that around 155,000 tonnes of food waste could be prevented from arising at manufacturing and 3PL, through a wide range of awareness raising, behavioural, operational, process and product innovations. Some of the changes required could be implemented in the shorter term (for example using the resources already available from WRAP and others) whilst others will require medium-term innovations and collaboration to bring them about. Courtauld 2025 will aim to facilitate this. Five sub-sectors have more than 80% of the potential to prevent food waste arising (dairy, ambient, meat, poultry and fish, fruit and vegetables and pre-prepared meals).

The primary estimate for the amount of food that is currently wasted but could be suitable for redistribution is 70,000 tonnes (55,000 tonnes from the manufacturing sub-sectors and 15,000 tonnes from 3PL), and in addition there could be 15,000 tonnes of food surplus that is currently being diverted to animal feed that could be redistributed to people. Added to the 42,000 tonnes being redistributed in 2015 (37,000 tonnes from the sub-sectors and 5,000 tonnes from 3PL) this could mean around 130,000 tonnes of suitable food being available for redistribution. Around half of the additional food is from the fruit and vegetable sub-sector, and another 40% from 3PL, dairy, ambient, bakery and pre-prepared meals.

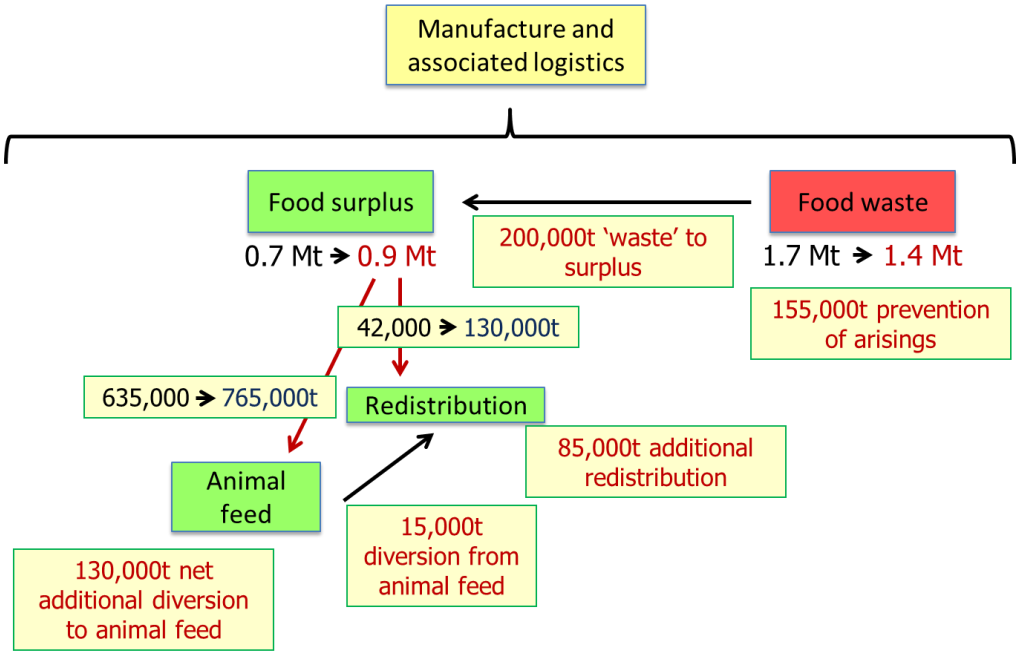
The range of future redistribution tonnages from the scenarios modelled could vary between 52,000 and 160,000 tonnes (vs 42,000 tonnes in 2015), representing between a 25% to 290% increase. The higher estimate would depend on the infrastructure and capabilities

being in place to redistribute more challenging surplus, and would reduce as the prevention of food surplus and waste arising took effect. The lower estimate assumes the full implementation of measures to prevent surplus arising and the diversion of more of the surplus to animal feed (for example from short shelf-life bakery products).

The primary estimate for the amount of food that is currently wasted but could be diverted to animal feed is 130,000 tonnes (all assumed to come from the manufacturing sub-sectors rather than 3PL). Added to the 635,000 tonnes being diverted in 2015 this could mean around 765,000 tonnes of food surplus being used for the production of animal feed. Around half of the additional food surplus is from the bakery sub-sector, and another third from fruit and vegetable and dairy sub-sectors.

Under different scenarios future tonnages diverted to animal feed could range between 615,000 and 805,000 tonnes, representing between a modest (3%) reduction to a 30% increase. These reflect differences in the amounts of food surplus being redistributed, and the extent to which measures to prevent surplus and waste arising are implemented. Figure S10 shows the potential shifts in material, by 2025, under the primary scenario.

Figure S10: *Potential prevention of food waste in the manufacturing sector by 2025*



Retail

The main causes of retail food waste relate to either product damage or product that is 'out of code' (i.e. beyond 'use by' or 'best before' dates), whilst surpluses in distribution centres can relate to a number of different causes, such as over-orders, surplus seasonal products, non-conformity with agreed 'minimum shelf-life on receipt' criteria and over-delivery by suppliers.

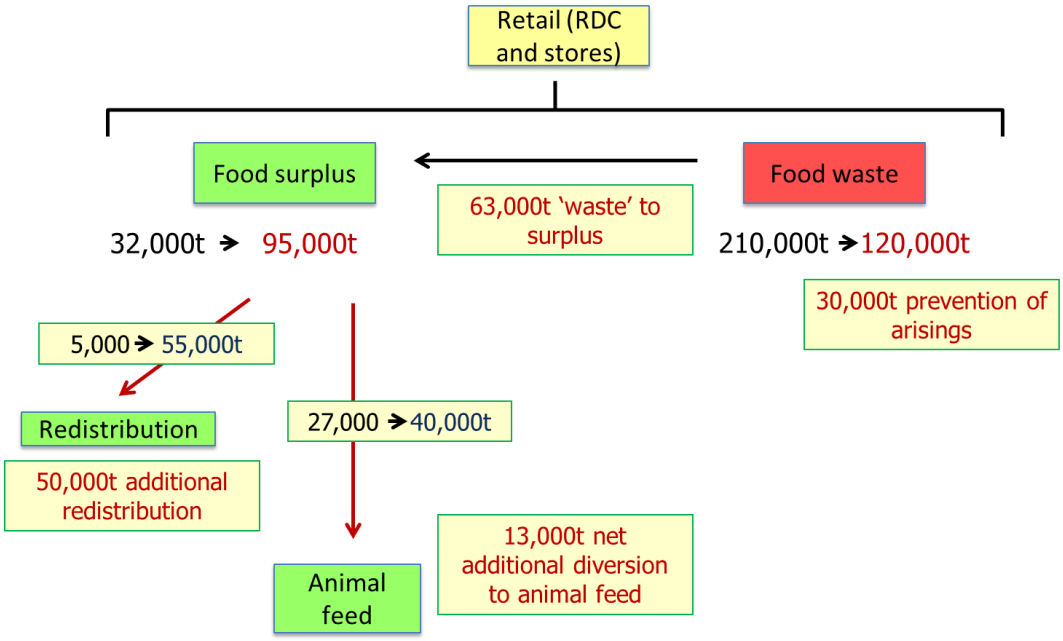
It is estimated that 93,000 tonnes could practically be avoided, through a combination of preventing waste arising, additional redistribution and diversion to animal feed, equivalent to a 44% reduction in the estimated 210,000 tonnes of total food waste. All of retail food waste can be defined as theoretically avoidable as all food at retail is intended for sale. As for manufacture, a combination of prevention of waste arising and increases in redistribution

and diversion to animal feed will be required to deliver this reduction, and a number of factors are likely to influence this balance, and how this changes over time.

It has been estimated that around 30,000 tonnes of food waste could be prevented from arising at retail via improved stock ordering and control to reduce surpluses and 'out of code', plus reducing damage by improved packaging and handling techniques.

Greater potential was identified to make use of food surplus, with 50,000 additional tonnes suitable for redistribution and a further 13,000 tonnes suitable for animal feed. Figure S11 shows the potential shifts in material, by 2025, under the most likely scenario.

Figure S11: *Potential prevention of food waste in the retail sector by 2025*



The range of future redistribution tonnages could vary between 47,000 and 110,000 tonnes (vs 5,000 tonnes in 2015), representing between a 9 to 20-fold increase. Future tonnages diverted to animal feed could range between 10,000 and 50,000 tonnes (vs. 27,000 tonnes in 2015), representing between a 60% reduction to a 190% increase.

Manufacturing and retail

For manufacturing and retail combined the range of future redistribution tonnages derived from scenario assessments could vary between 99,000 and 270,000 tonnes (vs 47,000 tonnes in 2015), representing between a 2 to 6-fold increase. Future tonnages diverted to animal feed could range between 625,000 and 860,000 tonnes (vs. 660,000 tonnes in 2015), representing between a modest (6%) reduction to a 30% increase.

Table S5 shows the overall prevention potential from the primary scenario (including the prevention of arisings, additional redistribution and diversion to animal feed) by manufacturing sub-sector alongside retail and third party logistics. The top 5 (all retail, plus the bakery, fresh fruit and vegetables, dairy, and ambient manufacturing sub-sectors) represent almost 80% of the total tonnages.

Table S5: *Overall potential for prevention for retail and manufacturing sub-sectors*

Sector	Overall potential for prevention (t)
Retail	93,000
Bakery, cake and cereals	75,000
Fresh fruit and vegetable processing	72,000
Dairy products	60,000
Ambient products	45,000
Pre-prepared meals	24,000
Meat, poultry and fish	20,000
Third party logistics	20,000
Soft drinks and fruit juices	15,000
Confectionery	14,500
Alcoholic drinks	8,000
Milling	1,500
Sugar	100
Overall total	**450,000**

Figure S12 provides a breakdown of the sources of the potential additional redistributable food and Figure S13 provides the same for additional food surplus that could be diverted to animal feed.

Figure S12: *Breakdown of potential additional redistributable food (tonnes) for retail and manufacturing sub-sectors (total = 135,000 tonnes, including 15,000 tonnes originally being sent for animal feed)*

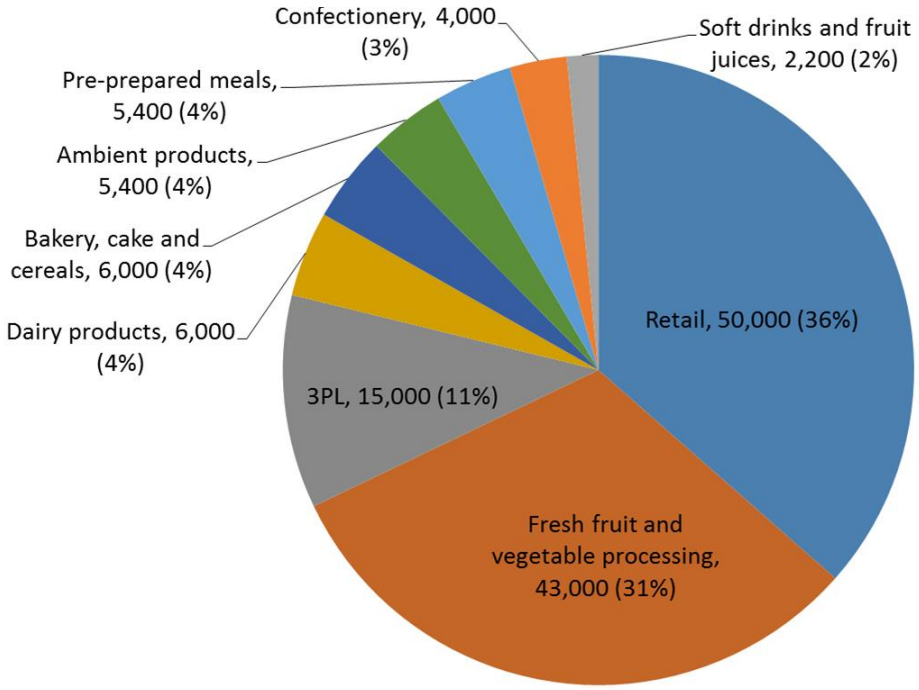


Figure S13: *Breakdown of potential additional surplus for animal feed (tonnes) for retail and manufacturing sub-sectors (total = 140,000 tonnes)*

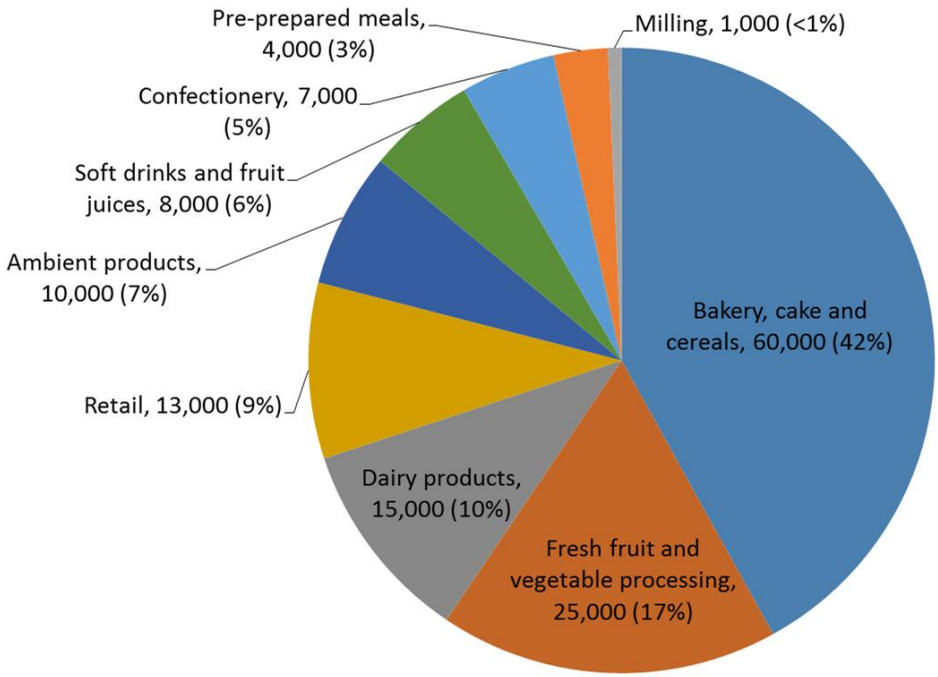


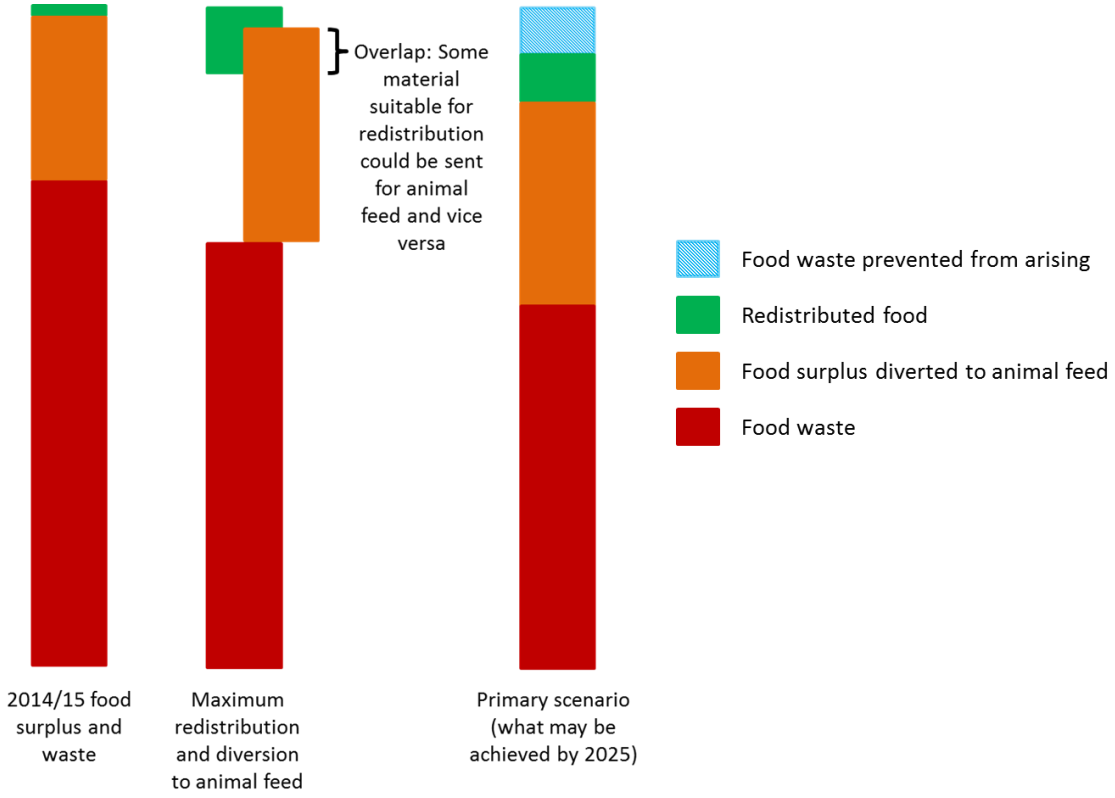
Table S6 shows the contribution to the overall potential prevention tonnage from different sectors and interventions, and clearly shows that all three types of intervention are important contributors to this.

Table S6: *Contribution to the overall potential prevention tonnage from different sectors and interventions (percentages in the table are of the total 450,000 tonnes of food waste that could be prevented)*

	Prevention of food waste arising (t)	Additional redistribution to reduce waste (t)	Additional diversion to animal feed to reduce waste (t)	Overall tonnage preventable (t)
Manufacture	155,000 (35%)	70,000 (16%)	130,000 (29%)	355,000
Retail	30,000 (7%)	50,000 (11%)	13,000 (3%)	93,000
Total	**185,000 (41%)**	**120,000 (27%)**	**140,000 (32%)**	**450,000**

It is important to reiterate that the estimates for maximum redistribution and maximum diversion to animal feed from the scenarios described above are not additive, as there will be material suitable for animal feed within the maximum redistribution estimate and vice versa. Figure S14 illustrates this and how these scenarios relate to the primary one.

Figure S14: *Illustration of how the maximum redistribution, maximum diversion to animal feed and the primary scenarios relate to one another, for manufacture and retail combined*

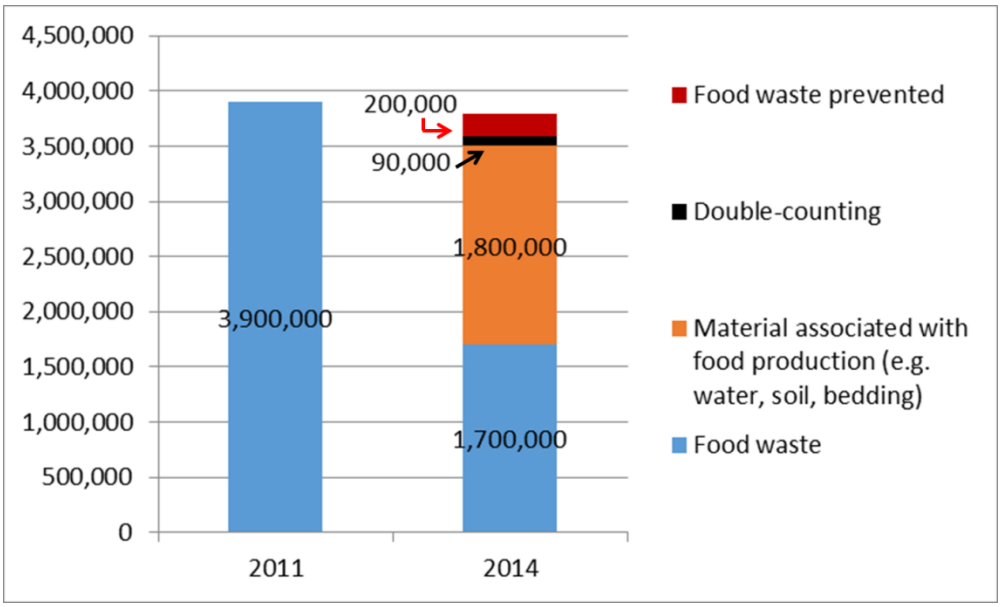


Comparison with previous estimates

This analysis has resulted in a revised estimate for food waste at manufacture for the UK of 1.7 million tonnes. This is significantly below the previous estimate of 3.9 million tonnes, published by WRAP in 2013 (for 2011). The main reason for this, as illustrated in Figure S15, is that the current research has a much better resolution of the different waste streams, which means that a significant tonnage of material associated with food production, but not made up of food, can be excluded from the estimate. This material includes non-food materials such as soil and stones (e.g. from grain milling and sugar beet), water from washing and cleaning and animal faeces and bedding (from meat processing where slaughter houses are integrated with other processing activities on the same site). An element of double-counting relating to animal tissue sent to the rendering sector was also identified and removed from the estimates. In addition efforts made by manufacturers and retailers to reduce waste arisings and amounts of surplus going to waste, for example under WRAP's Courtauld Commitment, have reduced arisings during the intervening period by around 200,000 tonnes. This is based on an analysis of data reported to WRAP by signatories, and an assessment of how signatories and WRAP have worked to influence change amongst businesses not signed up to the voluntary agreement[32].

[32] *This approach is discussed in detail in 'UK food waste – Historical changes and how amounts might be influenced in the future'*

Figure S15: *Illustration of the factors that have contributed to the lower 2014 estimate for manufacturing food waste*



Conclusions and recommendations

Building on the previous research published in 2013[33], this study has produced more detailed estimates of food surplus, food waste and by-products arising from the UK manufacturing and grocery retail sectors. In addition, this analysis has estimated the potential to shift material up the food material/waste hierarchy through prevention at source, increased redistribution and diversion to animal feed. It also shows that the food manufacturing and retail sectors in the UK are highly efficient, with less than 5% of production ending up as food surplus or waste, and that food waste levels are lower than previously reported. By building on efforts made to date, both the retail and manufacturing sectors have a significant potential to work towards better utilisation of food and drink through waste prevention measures with the overall potential to reduce avoidable food waste across these two sectors by 42% or 450,000 tonnes per annum by 2025.

Prevention at source could save almost £300 million a year of food going to waste (155,000 tonnes at manufacture and 3PL, and 30,000 tonnes at retail). In terms of adhering to the food utilisation or waste hierarchy this is the priority for action and there are a suite of resources available from WRAP to help support this. This research has highlighted again that the drivers of food waste arising are many and varied, and whilst some can be addressed through individual company action, others will need the kind of collaboration that Courtauld 2025 aims to foster.

Where food surplus or waste cannot be prevented, there is potential to increase both redistribution and diversion to animal feed.

The majority of the additional material suitable for redistribution within retail arises at store level (45,000 tonnes out of the additional 50,000 tonnes from the primary scenario), whereas currently the majority of material redistributed from retail originates from distribution centres (RDCs). Redistribution from back of store faces extra challenges due to

[33] *Estimates of waste in the food and drink supply chain, WRAP 2013*

the intermittent nature of surpluses arising across a large number of sites, often involving products with limited remaining shelf-life and the need to match the amounts and types of surplus arising with the needs and capabilities of recipients in the local area.

The 2015 estimates for redistribution from retail also pre-date the more recent and significant increase in activities by retailers working with the redistribution sector to expand redistribution from stores. All of the major retailers are carrying out initiatives aimed at store-level redistribution, and/or looking at how to maximise distribution from RDCs and make it easier for their suppliers to redistribute surplus food[34], and many have announced plans to scale these up over the coming years. A comparison between recent pilots and earlier ones[35] suggests that experience and improved guidance are leading to increases in the amounts that can be practically redistributed from stores. Data shared in confidence with WRAP from some of these initiatives suggest that the estimates from the primary scenario modelled within this research are not unrealistic.

Retailers and manufacturers are already doing a lot to ensure suitable food surplus is being made available for redistribution[36], and under Courtauld 3 signatories reported a 74% increase in the amounts being redistributed between 2012 and 2014. There are greater volumes of food surplus suitable for redistribution from manufacturing and 3PL, and encouraging this will be a priority under Courtauld 2025.

Whilst good progress has been made in the redistribution of food surplus that cannot be prevented, and the results of recent trials at back of retail stores look promising, it will be important to monitor progress over time, assess existing and potential new barriers and develop mechanisms to share learnings and overcome these barriers. From discussions with stakeholders involved in this research these barriers are likely to differ between large and small businesses, and retailers and manufacturers. There are however clear opportunities to further raise awareness of what foods are suitable for redistribution, and the benefits this can bring to businesses, staff and communities. WRAP will be developing its 'Your Workplace Without Waste' training and resources to incorporate topics around making best use of surplus food, and through Courtauld 2025 signatory meetings encouraging businesses to make use of these and other materials. This will complement on-going work by the redistribution sector with food businesses. Identifying suitable recipients for surplus food can also be a challenge, particularly if businesses want to use both national and local organisations. There are now a range of guidance materials and initiatives to facilitate this, and case studies to illustrate success.

There are opportunities to increase redistribution through reviewing redistribution sector policies to accepting food beyond their 'best before' date (where there is no food safety risk, and quality if still acceptable – for example whilst some recipients accept fresh fruit and vegetables or bread past the 'best before' date, others do not and most do not take other foods such as ambient goods beyond the date). There are also practical steps that can be taken to help increase the safe redistribution of chilled and frozen food.

The 2015 estimate of food surplus used in animal feed was dominated by two main sources: the bakery and fruit and vegetable sub-sectors which together account for 80% of the total. Additional potential to divert more to animal feed exists across all non-meat sectors, where

[34] For example see M&S launches nationwide surplus food redistribution scheme to support local food charities; Morrisons to roll out programme to find home for unsold food in stores; Tesco commits - no food that can be eaten to go to waste from stores; Waitrose surplus food and food waste disposal; Surplus food redistribution case study Sainsburys, Cardiff; Co-operative Food commits to redistributing a million meals ; Asda - we're tackling food poverty by extending our work with FareShare
[35] For example Food Connection Programme trial vs Piloting retail store surplus food redistribution and use in Wales
[36] A range of case studies can be found at Surplus food redistribution (WRAP), Who do we work with? (Fareshare) and Waste Prevention Case Studies (IGD)

surplus can be safely segregated at source thereby avoiding any risk of contamination from material containing animal by-products that are prohibited from use in animal feed. The estimates of future animal feed potential take into account the increases seen between 2011 and 2015 in amounts of food surplus being used for animal feed production, concluding that further potential exists for additional food surplus diverted to this route. For more complex manufacturing sites with multiple production lines with both 'ABP' and 'non-ABP' areas, this will require a better understanding of the flows of suitable material from production areas and the extent to which they can be safely segregated, in line with animal feed hygiene regulations.

Discussions with retailers and manufacturers highlighted the importance of both their staff and enforcement agency staff having clear and consistent guidance on how to store surplus food prior to sending this for animal feed, and identified this as a key barrier to increasing volumes sent via this route.

For diversion to animal feed, the study also noted considerable interaction with redistribution of surplus, as would be anticipated (as some sources of surplus will be suitable for both). However, whilst some food surplus that is currently being diverted to animal food is suitable for redistribution to people and should take this route, this analysis suggests that diversion of material that is currently being wasted (for example being sent to AD) to animal feed instead would lead to an overall increase in the amount of material available to animal feed producers.

The potential reduction in retail and manufacturing food waste identified in this report, of around 450,000 tonnes or 23% of total food waste, is broadly consistent with that modelled during the development of the Courtauld 2025 food waste prevention target. That target requires a 20% per capita reduction by 2025 across the food system, and takes in to account potential population and production growth. Achieving the target will be challenging for all sectors, but this research shows that the contribution from retail and manufacturing is stretching but realistic, and provides insights that will help deliver against it.

The potential scale of food waste reduction identified in this report, and the contributions from prevention, redistribution and diversion to animal feed are based on an overall assessment of what is realistic at a UK level. There will be significant differences between different businesses in what they may be able to achieve, and what interventions may work best for them, as a result of their product mix, size, location, policies towards mark-downs, progress made to date and so on. The estimates in this report are not therefore targets for individual businesses, but a guide to what the sectors as a whole could achieve – which WRAP will monitor through Courtauld 2025.

Recommendations

This research has applied a new approach to estimating both how much food surplus and waste comes from manufacture and retail, and how much of this might be suitable for a range of waste prevention interventions. It has pulled together data and insights from a wide range of sources, covering a diverse set of sectors and sub-sectors. It clearly identifies the potential for stopping food waste arising, redistributing more to people and diverting more surplus to produce animal feed. It should however be stressed that this forms the foundation upon which to build a more comprehensive understanding of this area, as methodologies evolve, interventions are evaluated and more targeted research is undertaken.

The following represent opportunities to further improve data quality and relevance over time:

- Refine the estimates for how much food waste might be prevented from arising based on a) the evaluation of innovations in processing, equipment, packaging management etc., as these are implemented, b) from monitoring the levels of food surplus and waste arising over time and c) from feedback on the barriers to implementing relevant innovations.
- Refine the estimates for how much of the food surplus and waste might be suitable for redistribution based on learnings from both the providers and recipients of food surplus. Innovations in the types of material that could be turned in to products suitable for use by recipients could lead to an even higher percentage of future food surplus and food that might have been wasted being used to feed people.
- It should also be noted that whilst this research provides more granular estimates of food surplus and waste for the sectors, it does not reveal priorities for action within a sub-sector. Further and more focused 'mapping' will be required for the sub-sectors with the greatest potential to prevent food waste. As a first step WRAP is working with a major dairy business to map material flows from multiple sites and a wide range of products (including milk, soft and hard cheeses, butter, yoghurt etc.), with the objective of identifying the greatest opportunities for both prevention and maximising value from the non-preventable materials.
- Further research into the scale and types of food surpluses and wastes occurring within the third party logistics element of the UK grocery supply chain to understand the scale and type of waste arising and identify the most effective and efficient way of handling any food surplus or waste.
- For the retail sector there is a need to establish more clarity around damages occurring both at stores and within depots and this should be used to highlight waste prevention opportunities by product category.
- Further analysis of existing datasets to show where the food waste is being disposed to (disposal routes) by sub-sector, separating out material that may have already been subject to on-site treatment (and therefore less suitable for subsequent treatment by AD or other options) from untreated sludges (such as those that contain peelings from fruit and vegetables).

The following are also critical for the delivery of the waste prevention opportunities identified in this report:

Collaborative action targeting priority areas:

- This research has identified areas where the greatest potential impacts can be made, and also that collaboration between businesses across the supply chain will be needed to realise the greatest benefits (for example between brands and retailers in tackling some of the in-store food waste, and retailers and manufacturers in addressing some of the opportunities around forecasting). The outputs from this research will inform decision making on where resources should be allocated, for example through working groups under Courtauld 2025, and future 'whole chain resource efficiency' projects[37].
- WRAP will establish a Redistribution Working Group under Courtauld 2025 to understand more about the implications associated with realising some of the redistribution potential identified in this study. It will be particularly helpful to share

[37] *See Whole chain resource efficiency*

insights from retailer back of store and manufacturing trials that have been undertaken in different parts of the UK during 2015 and early 2016.

Awareness raising/behavioural change:

- The study found that there was often a poor understanding across the sector about the sorts of surplus that were within scope for redistribution and how businesses with food surpluses can partner with redistribution organisations. This issue should be addressed through the improved guidance and partnership tools developed by the redistribution sector and WRAP, the use of awareness raising resources such as 'Your Workplace Without Waste' and through greater engagement on this issue with individual businesses and trade associations under Courtauld 2025[38].
- In order to enable greater amounts of food surplus to be diverted to animal feed production WRAP will be working with the FSA and representatives of national and local enforcement bodies to improve the consistency and clarity of both the guidance available to food businesses and the training of staff on the ground.

Maximising value from food waste that cannot be prevented:

- Around 1.5 million tonnes of food waste may not be suitable for prevention (120,000 tonnes from retail, equivalent to 0.3% of product sold in 2014; 1.4 million tonnes from manufacture, equivalent to 2.4% of product sold), at least not within the shorter term. This will need to be assessed for optimal treatment and use. This will need to look at the balance between on-site versus off-site treatment options, both in terms of commercial and environmental benefits.

Methodological improvements:

- A standard protocol for food surplus and waste measurement and more effective key performance indicators (KPIs) for monitoring would be beneficial, to overcome the wide variation in the standard of data on food surplus and waste, which varied from sites that only had basic waste returns provided by their site waste contractors, to those with systems in place delivering line-specific data against a balanced set of KPIs. This should also clarify areas of uncertainty such as the accounting for retail depot vs back of store redistribution and the relationship with third party logistics operators and suppliers. There may also be an opportunity to work with the relevant national regulatory bodies to improve the consistency and relevance (to food surplus and waste) of the data reported to them.
- Linked to the variation in data quality, there were marked differences in the resourcing and commitment to waste reduction from site to site. In some cases roles were split, with waste reduction shared with health and safety, whereas at others sites dedicated waste managers had clear lines of accountability to carry out a programme of work and report on progress. These were also the sites with a clearer picture of the wider costs to the business of avoidable food and drink waste and consequently in a better position to reduce waste more effectively.

[38] *For example see Surplus food redistribution, Your Workplace Without Waste, The FareShare Food Efficiency Framework*

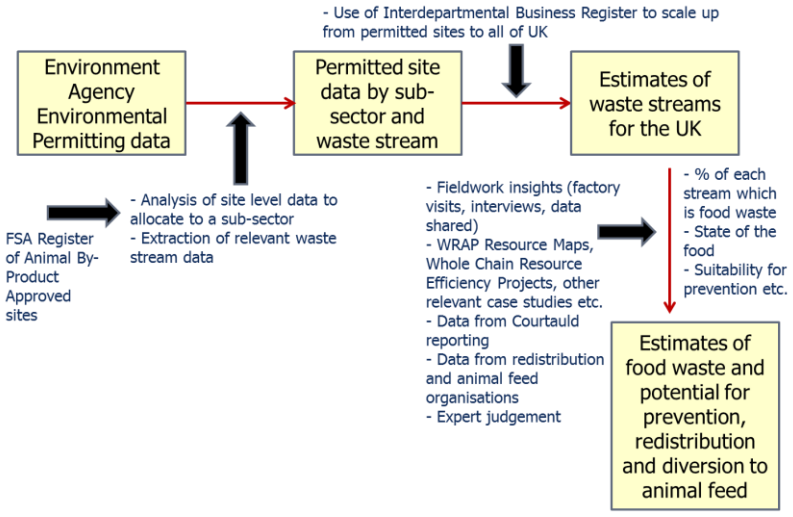
Data sources and methodology

Manufacturing

There is no single data source for the grocery supply chain that provides quantities and characteristics of food surplus or waste. Within this research a range of data sources relating to food and drink manufacturing were used in combination to produce the required estimates. The main contributing elements at a national level were Environment Agency Environmental Permitting (EP) data and the detailed European Waste Catalogue (EWC) codes relating to organic materials associated with the food and drink manufacturing sector. A variety of different data sources were then used to scale-up results to the UK as a whole and derive by-product, food surplus and food waste estimates. These included the Inter-Departmental Business Register (IDBR), UK Manufacturers' Sales by Product Survey (PRODCOM), Food Standards Agency (FSA) listings of approved premises, redistribution sector data provided by FareShare and Company Shop and surveys carried out by the European Feed Manufacturers Federation. Data and insights were also provided by a range of food businesses that participated in this research and anonymised data from Courtauld Commitment 3 signatory reporting. Site level data were combined with UK level estimates for waste, surplus and by-product flows. The method of scaling the data was similar to that used in previous WRAP studies to estimate arisings from the manufacturing sector at UK level (WRAP 2013[39] and WRAP 2014[40]).

In order to derive estimates for preventability and suitability for redistribution and diversion to animal feed, additional information from a range of published and unpublished sources was used, such as from WRAP Whole Supply Chain Resource Efficiency projects[41] and Resource Maps[42], which gave more detail across a number of key product categories (see Figure S15). In addition to data sets and reports, audits and discussions with food manufacturers provided valuable detail on all of the flows relating to food waste, surplus and by-product.

Figure S15 *– Approach to deriving estimates for manufacturing food waste[43]*



[39] *Estimates of waste in the food and drink supply chain, WRAP 2013*
[40] *UK food waste – historical changes and how amounts might be influenced in the future, WRAP 2014*
[41] *WRAP Whole supply chain resource efficiency reviews*
[42] *WRAP Resource maps*
[43] *The Environmental Permitting Regulations amongst other things implement the IPPC (Integrated Pollution Prevention and Control) Directive (EC/61/96) in England and Wales. Sites producing relevant materials above specific thresholds report annually to the Environment Agency*

Retail

A range of different data sources was used for the retail sector analysis, including primary research in the form of a series of store and RDC site visits, food waste audits and discussions with key stakeholders in the UK food retail and redistribution sectors, detailed product category data on food waste collected by supermarkets at UK level, published reports by the Industry Council for Research on Packaging and the Environment (INCPEN)[44] and the British Retail Consortium (BRC)[45] on retail food waste estimates and other material published by retailers on food waste prevention and redistribution initiatives and quantities of food surplus diverted.

The most significant element within the retail food waste evidence gathering was the analysis of food waste product-level datasets supplied by three of the major retailers. This element permitted more detailed appraisal of waste prevention opportunities and the potential to divert material that could not be prevented to redistribution schemes or to animal feed. In order to develop estimates for the sector as a whole (including the small independent retailers) data were scaled up using published estimates for total retail food waste from the BRC and WRAP[46].

Data limitations and uncertainties

The estimates for food surplus and waste reported here are based on the best available evidence, and represent a significant improvement over previous estimates. They are intended to help focus interventions and further research and form part of the process of tracking change at a sector level over time. The food surplus and waste estimates obtained from the evidence gathered by this study are however subject to a range of limitations and uncertainties to be borne in mind by the user. The four main sources of uncertainty likely to have the greatest impact on estimates are adequacy of coverage within 2014 EP data, uncertainties associated with large numbers of small and medium sized enterprises (SMEs) within IDBR, diversity of production processes and final products within some sub-sectors and the sensitivity of food waste estimates to effluent treatment sludge assumptions. These estimates are not intended to be used to benchmark individual businesses or products / product groups within the different sub-sectors. A number of gaps in this research are also acknowledged:

- Limited insights from smaller manufacturers and retailers (but these represent <10% of UK production/sales volume);
- Data for 'on-site' disposal, i.e. to sewer, is excluded (as it was in the previous WRAP research) due to the absence of usable national data for this stream and the challenges associated with quantifying the food component in effluent; and
- Availability of data varies by manufacturing sub-sector, and in particular data is limited for the alcoholic beverages and confectionary sub-sectors.

Results for manufacture and third-party logistics (3PL) are combined in the summary tables and figures in the Executive Summary, but estimates for the manufacturing sub-sectors and 3PL are presented separately in the main report.

[44] *Checking out food waste, 2013*
[45] *The Retail Industry's Contribution to Reducing Food Waste*
[46] *Handy facts and figures on waste in the UK - WRAP*

Glossary

3PL	Third Party Logistics operator
ABPs	Animal By-products
AD	Anaerobic digestion
APHA	Animal and Plant Health Agency
BOM	Bill of Materials
BRC	British Retail Consortium
CIP	Cleaning In Place
COD	Chemical Oxygen Demand
DAF	Dissolved air filtration
DC	Distribution Centre
EA	Environment Agency
EP	Environmental Permitting (previously Integrated Pollution Prevention and Control)
EWC	European Waste Catalogue
FSA	Food Standards Agency
IDBR	Inter-Departmental Business Register
INCPEN	Industry Council for Research on Packaging and the Environment
ISB	In-store Bakery
IVC	In-vessel composting
KPI	Key Performance Indicator
MOQ	Minimum Order Quantity
Mt	Million tonnes
NDA	Non-disclosure agreement
PRACTICALLY AVOIDABLE FOOD WASTE	This is the fraction of the theoretically avoidable food waste that the research suggests could be practically prevented over the course of Courtauld 2025 (i.e. to 2025), based on a realistic assessment of technological and other barriers
PRODCOM	UK Manufacturers' Sales by Product Survey (PRODCOM)
QA	Quality assurance
RDC	Regional Distribution Centre
SKU	Stock Keeping Unit
THEORETICALLY AVOIDABLE FOOD WASTE	This is the fraction of total food waste that could in theory be edible (with or without further processing). This excludes for example preparation waste that is unsuitable for consumption.
TOTAL FOOD WASTE	This is a measure of all food waste, both avoidable (also referred to as edible by some) and unavoidable (or inedible) as defined by the EU-funded FUSIONS project
UKFFPA	UK Former Foodstuffs Processors Association
WRAP	Waste & Resources Action Programme

Acknowledgements

We would like to thank all of the organisations that participated in this research for their co-operation and willingness to share their ideas and data which has allowed us to gather insights into, and gain a better understanding of, the food wastes and surpluses arising across the UK grocery sector.

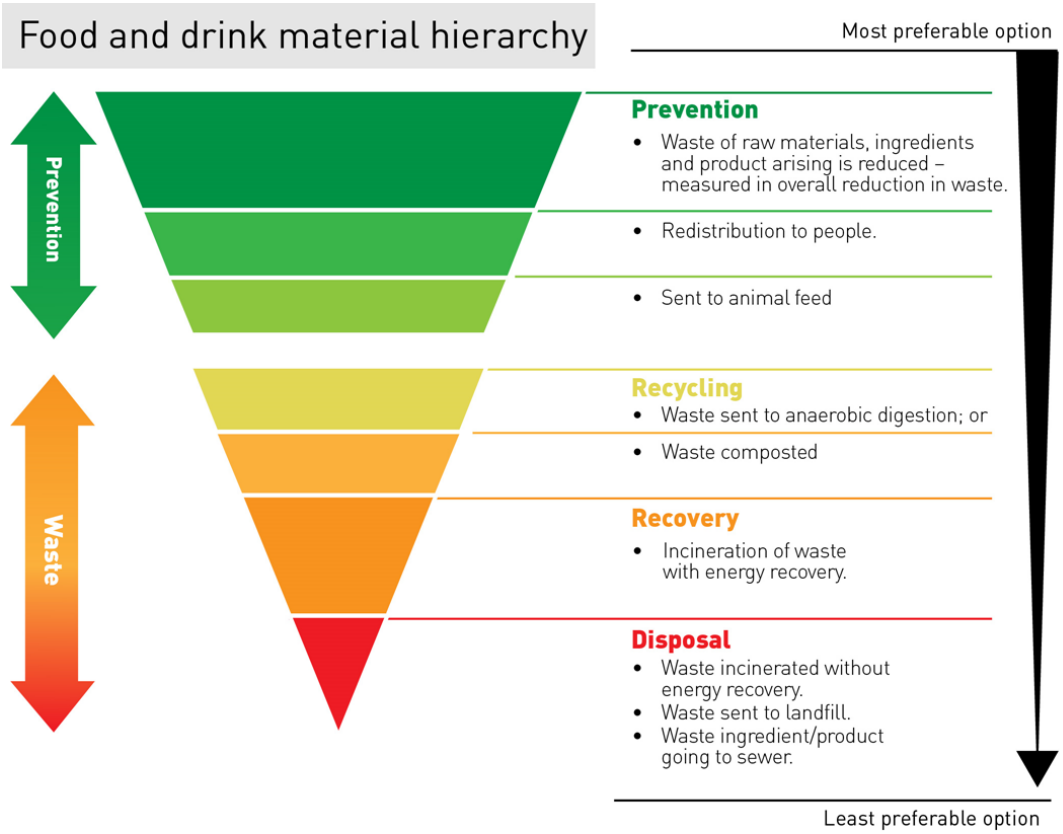
Contents

1.0 Project aims, scope and definitions

1.1 Introduction

This project addresses the need to improve the quality and granularity of food surplus and waste data for the grocery supply chain. Although previous work has highlighted the scale of arisings[47], additional information is needed to provide greater focus on priorities for the sector, to reduce the costs and environmental burden of food waste. These opportunities need to prioritise waste prevention and shift more of what cannot be prevented higher up the food and drink material hierarchy (see Figure 1.1).

Figure 1.1: Food and drink material hierarchy



Source: WRAP, 2016

Where food surplus and waste cannot be prevented at source, surplus should be used to feed people first, through redistribution networks (either charitable or commercial). Any foodstuffs that cannot be sent for human consumption, for commercial or practical reasons, may be suitable as a source of nutrition for use in the animal feed sector. Both redistribution and diversion to animal feed are higher up the food material hierarchy than sending food waste to anaerobic digestion or to composting facilities.

1.2 Aims and objectives

The main aim of the research is to add understanding of food surplus and waste in the UK grocery supply chain and to provide policy and business relevant insights, particularly in relation to the delivery of Courtauld 2025[48], an ambitious 10-year voluntary agreement that

[47] *WRAP (2013), Estimates of waste in the food and drink supply chain*
[48] *See Courtauld Commitment 2025*

brings together a broad range of organisations involved in the food system to make food and drink production and consumption more sustainable.

The key objectives are to:

- Produce estimates of the amount of food surplus, waste and related materials at retail and manufacture (including third party logistics);
- Quantify the amount of surplus and waste that might be prevented from arising, suitable for redistribution and/or diversion to animal feed; and
- Identify the most significant causes of food surplus and waste.

1.3 Boundaries and sectors

The study included UK-based food manufacturers and grocery retailers. It did not extend to hospitality and foodservice or wholesalers. The agriculture sector and households were also outside of the project scope.

The scope is illustrated in Figure 1.2, showing the main points of food surplus/ waste arising at the different supply chain stages from manufacturing to retail stores, including through third-party logistics operations (3PLs) and regional distribution centres (RDCs). Unlike the 2013 WRAP report, the scope did not include wholesale markets[49] or the estimation of packaging waste.

Whilst not within the original scope of this study, the research team were aware that both food manufacturers and retailers make significant use of 3PLs, whereas some big brands also operate their own distribution hubs and warehousing. High level analysis of the scale of food waste and surpluses occurring within this sector was therefore included within this research in order to begin to build a better understanding of the ownership and fate of waste or surplus generated and/or managed by these companies and also how they interact with retailer RDCs, particularly in relation to retailers returning materials to suppliers.

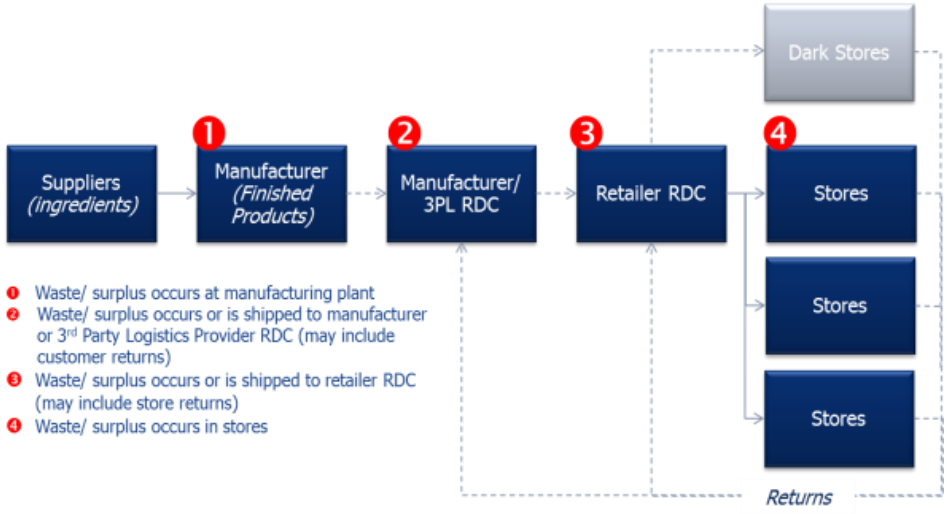
In order to provide a structure for the research design, food and drink manufacturing activity was clustered into a number of industry sub-sectors, partly based on Standard Industry Classification 2007 and product characteristics:

1 Milling
2 Fruit & vegetables
3 Meat, poultry & fish
4 Dairy products
5 Bakery, cakes, biscuits & breakfast cereals (referred to in text as 'bakery')
6 Soft drinks & fruit juices
7 Confectionery
8 Ambient products
9 Pre-prepared meals
10 Alcoholic drinks
11 Sugar

These 11 sub-sectors formed the basis of the fieldwork sampling and analysis. The 'sugar' sub-sector was not targeted in the fieldwork due to the low proportion of the sector's food waste associated with it, as identified by the WRAP 2013 analysis. The sub-sector was included in the overall analysis of food surplus and food waste arisings based on regulatory and other data sources.

[49] The 2013 WRAP report included an estimate of 17,000 tonnes of food waste from wholesale, less than 10% of the current estimate for food waste in grocery retail

Figure 1.2: Project scope in relation to food waste / surplus hotspots across a UK grocery supply chain



1.4 Terminology relating to food waste, surplus and by-product

1.4.1 Food waste and surplus definition

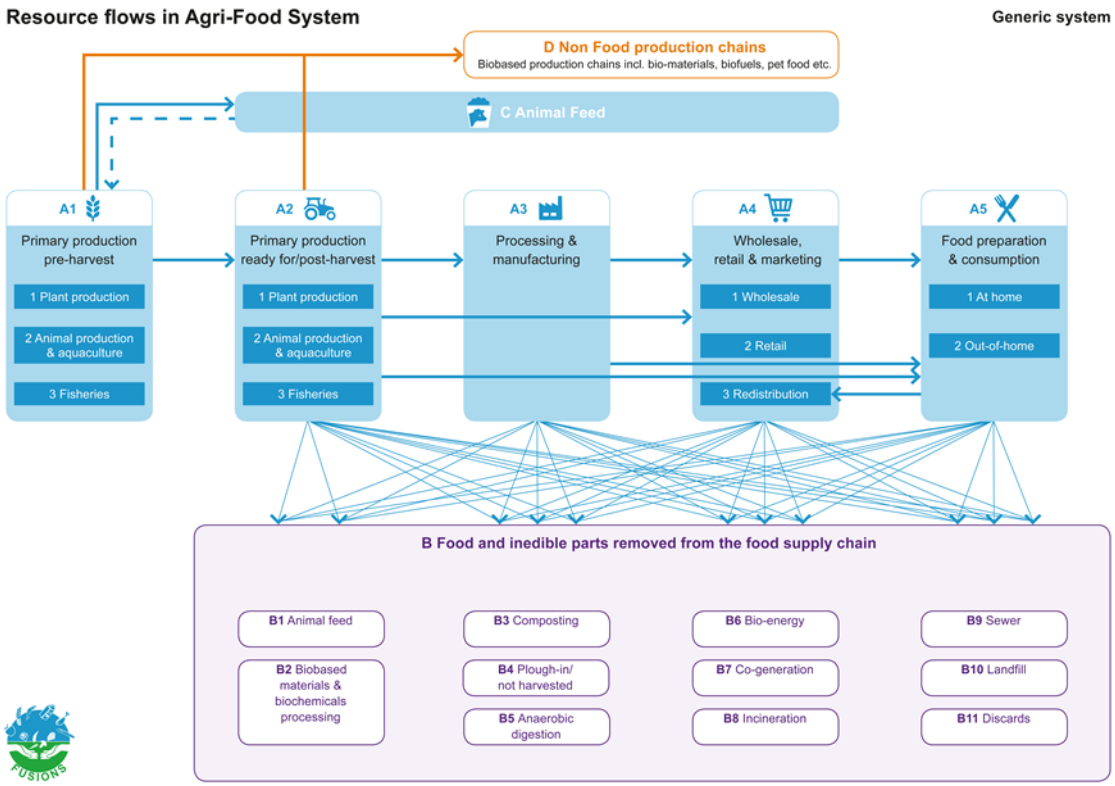
Within the project scope, food waste and surplus definitions were aligned with European definitions developed by the European Commission funded FUSIONS[50] project. Food waste is any food, and inedible parts of food, removed from the food supply chain to be recovered or disposed of (including composted, crops ploughed in/not harvested, anaerobic digestion, bio-energy production, co-generation, incineration, disposal to sewer, landfill or discarded to sea). The FUSIONS definitional framework (Figure 1.3) identifies all food and drink and associated materials removed from the food supply chain and classifies them in terms of whether or not they are converted or valorised (B1 in Figure 1.3) or disposed (B2 in Figure 1.3).

Within this classification redistribution is shown within the primary food supply chain, and is not classified as a waste. Material lost from the human food supply chain but diverted for use as animal feed appears in the secondary applications chain (valorisation and conversion), is also not classified as a waste and flows back into the food supply chain through processing into animal feed and then animal products for human consumption.

Similarly, by-products or co-products from manufacturing are not classified as wastes but are products generated during the process of making the intended primary products; these are then sold into secondary markets (e.g. spent grain from brewing used in animal feed).

[50] FUSIONS Definitional Framework

Figure 1.3: FUSIONS definitional framework for food waste



1.4.2 Alignment with definitions used within businesses

Individual businesses often have their own 'in-house' terminology for food waste, surpluses and by-products based upon current practices. For example, retailers might refer to products that have been 'priced to clear' as part of their waste reporting and manufacturers might regard food surplus sent to animal feed as a waste stream even though it is sold for that use. Terminology used throughout this project therefore required careful standardisation to fit correctly within the framework shown in Figure 1.3.

Within the grocery supply chain a wide variety of different terminology is used to describe 'food surpluses' and 'food waste', including the following examples:

- 'Food surplus' or 'surplus stock': food/drink that is surplus to market requirements; includes cancelled orders, over-runs, delivered 'overs', over-orders, end of line, end of promotion;
- Short shelf-life stock that does not meet minimum life on receipt criteria specified by customers;
- Rejects, out-grades and down-grades, considered unsuitable for production/ processing or unsuitable for intended market;
- Surpluses of raw ingredients, not used in time;
- Production errors, trial / sample products, off-spec. mixes, formulations with missing ingredients;
- Offcuts, trimmings and peelings;
- Wrongly labelled or wrongly coded packaging; and
- By-products sold to secondary markets.

1.4.3 Redistribution

Surplus food and drink is commonly redistributed via charities such as FareShare who use the surplus food to feed people, working with a wide variety of recipient organisations. In addition, food and drink surplus is sold to organisations like Company Shop, who buy food for sale onto secondary markets operating through controlled membership stores. Both of these routes for managing food surplus are included within the scope of 'redistribution' as they effectively ensure that food surplus that may have become waste is instead consumed by people. Redistribution within this study does not include food donated by customers at retail stores or food produced with the express purpose of being given away.

2.0 Data sources

2.1 Introduction

There is no single source of data for the grocery supply chain that provides quantities and characteristics of food waste or food surplus. WRAP Courtauld Commitment reports and food waste reported by trade bodies, such as the Food and Drink Federation (FDF) and the British Retail Consortium (BRC) provide overall estimates only and do not therefore meet the needs of the current study. The following sections describe the datasets used to construct more detailed estimates, making use of a number of existing data sources in conjunction with targeted primary fieldwork (described in Section 4.4) and additional data collection.

2.2 Manufacturing sector

The 2011 estimates published by WRAP in 2013[51] used a number of data sources relating to food and drink manufacturing, which were used in combination to produce estimates of surplus and waste (Table 2.1). The main contributing data elements were Environmental Permitting (EP) data and anonymised data from WRAP's Courtauld Commitment 3. Use was also made of anonymised FDF surveys, data from animal feed and rendering sectors, as well as data reported by the redistribution sector.

Table 2.1: Data sources relating to food and drink manufacturing used in current and previous (2013) studies

Data source	Current study	2013 study
Environmental Permitting (EP) data	2014 EP data for England; detailed analysis of European Waste Catalogue (EWC) codes	2011 EP data for England; overall analysis of organic waste streams; used as a major component of overall food waste estimates
Courtauld Commitment signatories data	Courtauld Commitment 3 anonymised data used to cross-check some sub-sector estimates	Used as a major component of overall food waste estimates
Food and Drink Federation food waste member surveys	The survey has not been updated recently, but is due to be repeated in 2016	2008 Survey (anonymised) used as a minor component in the overall estimates
Defra 2009 commercial and industrial waste survey	Not used, due to age of the data and lack of more granular data for food waste	Used to estimate food waste arisings from SMEs within manufacturing sector and to estimate overall share of food waste accounted for by firms within EP data
WRAP Whole Chain Resource Efficiency projects (WCRE) and Resource Maps	Used in conjunction with site visits to characterise waste/surplus and identify waste prevention opportunities: WCRE projects; beef, pork, pre-prepared meals, apples, onions, potatoes	Not used

The approach to data in the current study builds on the previous work but focuses on data sets capable of providing greater granularity. For instance, the 2013 WRAP study did not analyse the detailed European Waste Catalogue codes relating to the food and drink manufacturing sector reporting under the EP regime. In addition, WRAP Whole Chain

[51] *Estimates of waste in the food and drink supply chain, WRAP 2013*

Resource Efficiency projects[52] and Resource Maps[53] have provided much more detailed coverage of surplus and waste across a number of key product categories such as for beef and potatoes.

2.2.1 Primary research

Data obtained from site visits, audits and discussions with food manufacturers was designed to provide detail on all of the flows relating to food waste, surplus and by-product. Opportunities for waste prevention and potential to expand redistribution and diversion to animal feed were also a focus of the primary research element. Further details about the approach adopted for the primary research and the information captured with regard to the manufacturing sector can be found in Section 4.4.2.

2.2.2 Environmental Permitting data

The previous (2013) WRAP study used EP waste returns for 2011 held by the Environment Agency as part of the process of estimating waste arisings. More recently, work carried out for WRAP to assess future trends and prevention potential developed an approach to extracting greater detail relevant to food waste from the EP returns[54].

The current study obtained 2014 data from the Environment Agency and developed an approach to extract more detailed analysis of organic waste streams arising from the sector. These were the latest available data (December 2015) with 2015 estimates likely to be available in mid-2016.

Businesses requiring an Environmental Permit are required to report on levels of waste on an annual basis, known as 'national operator waste returns'. Within the food and drink sector, thresholds[55] apply to the levels of finished product that a site produces per day, and sites operating above these thresholds require an Environmental Permit. The thresholds are set at a lower level for sites that treat and process meat (75 tonnes/day), compared with vegetable materials (300 tonnes/day) or milk (200 tonnes/day). Permitted sites are therefore biased towards larger manufacturing sites and those sites subject to Animal By-Products Regulations (slaughterhouses and meat cutting units), as shown in Figure 2.1.

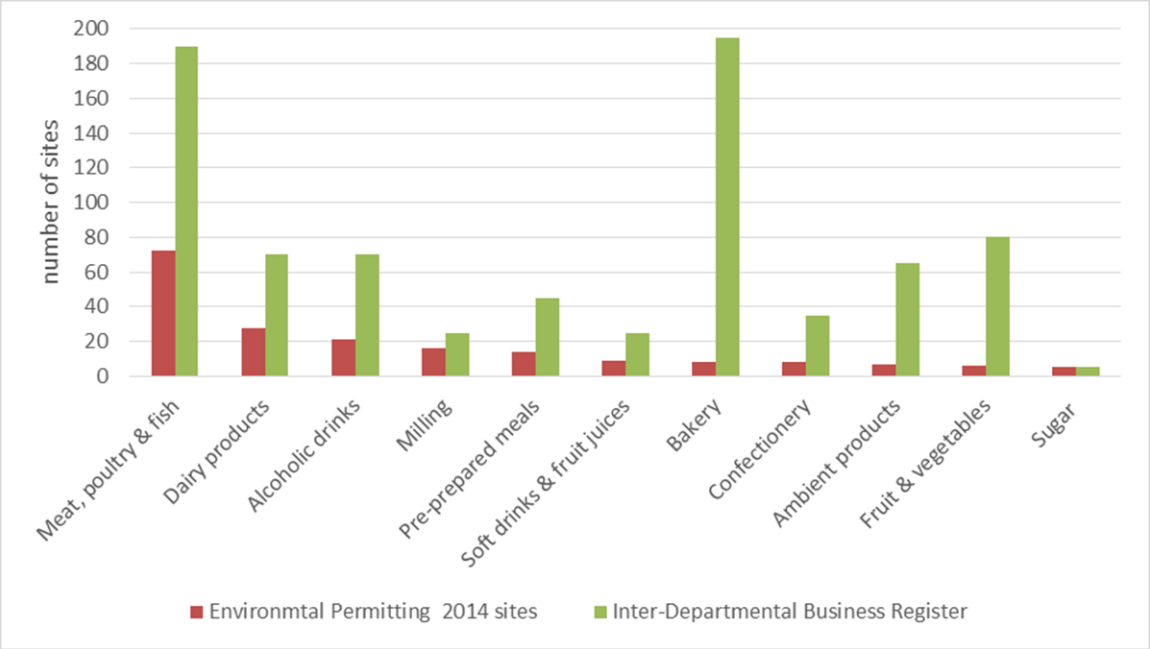
The 2014 EP data contain returns from 250 sites that represent 33% of UK food and drink manufacturing sites employing more than 100 staff, on the basis of number of sites. Analysis carried out for the previous study estimated that 86% of waste produced by the sector was accounted for by sites employing more than 100 staff.

The EP returns include the following fields relating to the nature of waste moved off-site:

- Annual quantity arising;
- A European Waste Catalogue (EWC) code;
- A description of the waste, e.g. "materials unsuitable for production or consumption";
- Its physical state (liquid, solid, sludge, powder or gas); and
- A disposal or recovery route in the form of a code, e.g. "D01 - Deposit into or onto land".

[52] *WRAP Whole supply chain resource efficiency reviews ; some of the studies used in this analysis have not yet been published by WRAP*
[53] *WRAP Resource maps*
[54] *UK food waste – Historical changes and how amounts might be influenced in the future*
[55] *See Food and Drink Sector 'how to comply with your EP*

Figure 2.1: Number of food and drink manufacturing sites covered by Environmental Permitting 2014 (England) and Inter-Department Business Register (>100 employees; UK)



Whilst the EP returns comprise key data for this research project, they do not describe the root causes of the waste nor any other background. To supplement these data, food manufacturers participating in the current study were invited to inform the research by providing their waste data and - to put that data into context - corresponding input, production and by-product data.

As the waste streams reported under EP represent wastes transferred from the site, they contain a mix of wastes arising directly from the manufacturing processes and/or secondary streams, such as outputs from on-site treatment processes. The data do not include residues from food/drink processing discharged to sewer, by-products, including animal tissues sent to rendering or quantities of food surplus redistributed.

Company policy and a large variation in manufacturing techniques across the grocery supply sector means that no two manufactures measure, collate and monitor waste or surplus in identical ways. Systems range from sophisticated automated real-time monitoring, to manual measurement techniques based on bin estimation to estimates made from purchase and sales data, to no system at all.

2.3 Retail sector

A range of different data sources were used for the retail sector analysis conducted as part of this project:

- Primary research in the form of a series of site visits, food waste audits and discussions with key stakeholder in the UK food retail and redistribution sectors;
- Detailed 'bottom-up' product category data on food waste collected by supermarkets at UK level, based on stock keeping units (SKUs) with waste tonnage estimated from standard product weights;
- BRC Estimates for food waste within the retail sector, 2014[56];

[56] *The retail industry's contribution to food waste, 2015*

- Published report by the Industry Council for Research on Packaging and the Environment (INCPEN)[57] on retail food waste estimates of the top 20 wasted food types across three major grocery retailers;
- Press releases relating to current retail sector redistribution initiatives and quantities of food surplus diverted[58]; and
- Public domain information on Tesco's declaration and tracking of food waste, with details of the methodology used to compile the data[59].

The most significant element within the retail food waste evidence gathering was the analysis of 'bottom-up' datasets supplied by three of the major retailers. This element permitted more detailed appraisal of waste prevention opportunities and the potential to divert material that could not be prevented to redistribution schemes or to animal feed.

2.4 Other data sources

A variety of different data sources were used to support estimates and scale-up results:

- The Inter-Departmental Business Register (IDBR) was used for scaling up results for the manufacturing sector – this provided detailed size banding data (number of employees) for the number of local business units within each Standard Industrial Classification (SIC) code relevant to the UK food and drink manufacturing sector;
- Estimates of UK food and drink manufacturing production tonnages and sales value were obtained from the UK Manufacturers' Sales by Product Survey (PRODCOM), 2014 Provisional Results[60].These data were used in macro-level assessments of food surplus/ waste and by-product arisings, for instance for whey sold as a by-product from dairy processes;
- Food Standards Agency (FSA) listings of approved premises[61] for meat, fish and poultry detailing slaughter houses, meat cutting units and processing plant were used to differentiate sites that were slaughter houses from those that included meat cutting and other processing stages. This background information was used to edit EP data in order to differentiate the different categories of meat processing sites;
- Redistribution sector: data were provided by FareShare and Company Shop in the form of overall estimates and assessments of redistribution from manufacturing, 3PLs and retail sectors. For some supply chain elements it was possible to derive average quantities of food surplus collected per site. These were used in conjunction with data from site visits, to inform current redistribution estimates as well as to scale-up redistribution potential to the UK level; and
- Animal feed estimates for the UK were derived from surveys carried out by the European Feed Manufacturers Federation Survey 2012[62] which provided a breakdown of materials processed by the sector by food product category. Updated estimates were obtained from the UK Former Foodstuffs Processors Association (UKFFPA)[63].

[57] *Checking out food waste, 2013*
[58] *See footnote 27 in the Exec Summary*
[59] *Tesco's food waste methodology. No other retailers have released similar data.*
[60] *PRODCOM 2014 provisional*
[61] *Approved meat premises, FSA*
[62] *Feed Use of Former Foodstuffs converting food into food, FEFAC, 2012*
[63] *Introducing the UKFFPA*

3.0 Overall approach

3.1 Overview

The project consisted of six main phases of activity and was conducted from March 2015 to January 2016. Figure 3.1 illustrates the overall approach adopted for this project.

Figure 3.1: Overall project approach

- **Phase 1**: The definition of the overall project scope and initial engagement with the project team and key stakeholders including Company Shop, FareShare and members of WRAP's project steering group (which included representatives from the BRC, FDF, UKFFPA, Defra, retailers and manufacturers). Two training workshops were held, one with FareShare and the other with Company Shop, in order to raise the research team's understanding of current food redistribution issues and the criteria for identification of surplus suitable for redistribution during site visits.
- **Phase 2**: Identification of participants, points of contact and industry bodies to approach to help with recruitment.
- **Phase 3**: During this phase, the methodology for gathering data from the manufacturing sites was tested out. This involved engagement with the first batch of manufacturing sites, including representatives from bakery, ambient and milling sub-sectors. Due to challenges in arranging the initial pilots, there was not as much time between these pilots and the full fieldwork activity as originally planned. However, key learnings from these pilots were still captured by the research team and incorporated into subsequent fieldwork (see Section 4.4.2).
- **Phase 4**: Slightly different approaches were adopted to gathering evidence from manufacturers and retailers. This was due to the nature of the information required and the nature of operations within these two different sectors. For the manufacturing sector, evidence was gathered via a series of site visits, discussions with key stakeholders and analysis of existing data sets (see Section 2.2). For retail participants, greater emphasis was placed on the analysis of existing data sets and less observational analysis was conducted (see Section 2.3).
- **Phase 5**: This involved collation of site observations and data provided by participating sites and a parallel work stream coding, editing and analysing the 2014 EP dataset.
- **Phase 6**: The development of a final project report for WRAP summarising the research activities undertaken and detailing the results of the research.

4.0 Methodology

4.1 Introduction

Manufacturing: the methodology built on the previous estimates produced in 2013 and the work done in 2014 that explored the Environmental Permitting datasets in further detail, looking at trends, waste prevention potential and the different treatment and disposal methods applied to wastes originating from manufacturing sites[64].

The key aspects of methodology developed for the current study were to:

- Make maximum use of the existing datasets from the Environment Agency to provide a basis for making UK level estimates, using the same scaling approach as developed for the two previous studies;
- Link site visit waste audit data and insights from 37 sites, with the high level analysis from WRAP Resource Maps and Whole Chain Resource Efficiency projects to gain an understanding of food surplus (not recorded in regulatory data), off-site waste movements and on-site processes; and,
- Identify root causes of waste and prevention opportunities and potential for additional redistribution and diversion to animal feed.

Retail: the approach relied on access to detailed, 'bottom-up' datasets collected by three participating retailers across all UK stores and depots. Site audits and interviews with store staff provided insights into the nature of retail food waste and scope for using more food surplus, particularly from stores.

The main elements were:

- Site-based data and observations from seven site visits to stores and one RDC, interviews with key stakeholders and participation in 'waste huddles' in order to understand how food waste interacts with 'mark down' policies and how staff identify suitable food redistribution in the case of stores with redistribution systems in place;
- Analysis of datasets provided by three major retailers; and,
- Scaling using BRC reported totals and WRAP estimates for total waste generated by the sector in 2014.

4.2 Key criteria for defining avoidable and preventable food waste

4.2.1 Avoidability of food waste

The avoidable fraction of household food waste contains material that was, at some point prior to its disposal, edible[65]. This may include food that has gone mouldy at the time of disposal as well as food rejected by consumers for a variety of different quality and date-related reasons. It does not include waste such as egg shells, bones which are unavoidable.

In relation to food manufacturing and processing, the identification of the avoidable element of food waste is more complex than is the case for either retail or household food waste. As the manufacturing sector ranges between primary processing (e.g. flour, meat, vegetables) through to more complex product manufacturing, the nature of avoidable food waste changes. This is a reflection of the extent to which food waste contains raw inputs to production that are rejected because they are inedible (not usually eaten or regarded as inedible, such as husks) or unsuitable for the intended product (for example, wheat grain

[64] *UK food waste – Historical changes and how amounts might be influenced in the future*
[65] *WRAP Household food and drink waste in the UK 2012*

that is of insufficient quality for bread flour). This is more likely to be the case with primary processing industries. For example, in meat processing, animal tissue waste will contain a high proportion of inedible material (bone, connective tissue), whereas a pizza manufacturer will have inputs to production that are finished edible products procured from other parts of the sector (cheese, flour, sliced ham, vegetables and herbs). The meat processing sector also has a high proportion of inedible material, in the form of animal by-products mostly sent to rendering (and therefore not classified as a waste).

The avoidability of food waste was assessed through a combination of manufacturing sector site visits (where audits identified wastes and surplus at the point of arising), evidence from WRAP whole chain resource efficiency reviews/ resource maps and detailed analysis of waste categories reported within the 2014 EP data relating to the off-site movement of wastes. The results of these assessments are discussed in Section 6 and within the Appendices for each industry sub-sector.

4.2.2 Food waste prevention potential

Limiting the amount of food surplus and waste by preventing its occurrence should always be the first consideration, however some operations within the sector will always produce waste (for instance juicing or peeling processes). In carrying out site visits and talking to participating organisations, a general approach was developed to the collection of information on waste prevention potential (Table 4.1) by likelihood of implementation across three broad categories:

- Better operational practices: examples include application of Lean practices to food manufacturing or the application of continuous improvement methodologies to production processes, improved product handling procedures, changes to shut-down/ production line break-down procedures, batch change-overs;
- Improved control of existing processing operations: such as making less 'off-spec' product through better control of raw material additions, avoidance of spoilage through improved temperature control, better stock control systems ('first-in-first-out' systems), better waste measurement and feedback into workplace practices and unit processes; and
- Innovative process technology: even with the best process control and suitably skilled staff, ultimately waste prevention potential may be constrained by the food/drink manufacturing technologies deployed. A new technology introduced to a production process may improve yields and reduce waste, but putting the technology in place may require significant investment. Participating sites were asked about any existing or future initiatives planned. Technological improvements may require specialist long-term studies and a detailed knowledge of the specific new technologies available within a particular sub-sector.

In determining the estimate of how much food waste might be prevented from arising for this report, a conservative approach was adopted, and categories 1 and 2 from Table 4.1 were included, whereas 3 was excluded.

Table 4.1: Waste prevention potential: framework for site assessments

Waste prevention opportunity	Description: where, what?	Type of intervention required	Estimate of potential (tonnes/ year)	Likelihood of implementation
	Specific production line/ area? Any previous related interventions and their impact?	Operational practices (detail) Process Control (detail) New technology (detail)	'x' tonnes/ year	A broad assessment, where possible to distinguish more immediate and longer term waste prevention potential: 1= Highly likely : easily implemented in short-term (within the next year) 2= Quite likely but not so easily implemented in short-term 3= Longer-term potential: requires investment/ major modifications to process (2-5 years)

4.3 Key criteria for food surplus

A number of criteria for the identification of food surpluses with redistribution potential were developed following the discussions and workshops with FareShare and Company Shop. Criteria were also developed for use in relation to the assessment of diversion of surplus to animal feed. The intention was to apply these as part of the site visits to help identify and quantify food surpluses that could potentially be redistributed for human consumption or diverted for use in animal feed.

4.3.1 Ease of redistribution criteria

Beyond the basic requirements of food safety and nutrition, there are no agreed definitions of what sorts of food surplus are suitable for redistribution. This is partly due to differences between redistribution organisations and the capacity and infrastructure that is available to them. It is also influenced by the different ways in which the surplus is being used. Those that use food surplus to cook meals will have different criteria from those selling surplus food through commercial redistribution channels or those operating food banks that primarily handle packaged ambient products[66].

The research developed criteria that reflected the practicality and suitability of using food surpluses in redistribution. It was assumed that the necessary processes and infrastructure could be put in place by suppliers of surplus or redistribution organisations. The criteria therefore reflect the potential for redistribution based on the characteristics of the surplus rather that any local context, such as redistribution capacity or commercial factors that might determine the likelihood of the surplus being made available.

[66] *See WRAPs Redistribution Framework*

Ease of use of food surplus for redistribution:

Readily redistributable: highly usable, 'customer ready', requires little or no alteration and the food differs very little to product sold in retail stores.

More difficult to redistribute: loose product/ bulk ingredients requiring packaging, product may require relabelling/ overprinting, part formulated products that requires some further work.

Not readily redistributable: requires significant further processing before it can be redistributed, such as product with short shelf-life that requires immediate freezing on-site.

Food unsuitable for redistribution: on grounds of food quality, food safety, 'use by' date expired (for higher risk food types), not containing material suitable for human consumption

4.3.2 Animal feed diversion potential

The main food surpluses suitable for animal feed include bread, cereals and biscuits. There is also potential to divert out-graded fruit and vegetables for use as stock feed. The issues relating to the suitability for use in animal feed are in certain cases difficult to assess on the basis of observation alone (for instance, where ruminant gelatine might be present in a bakery product).

In order to build-up a picture of the potential to divert material away from waste and into use as feed, the following criteria were applied:

Assessment of food surplus potential for use in animal feed:

High potential to use: no risk from ABPs in any food on site: ABP free; surplus is nutritious and fit for use as feed.

Medium potential, but needing work: ABPs risk in some food products/ ingredients on site: but site can be easily zoned and material can be reliably separated from any foods containing prohibited ABPs.

Limited potential: high risk of cross-contamination with prohibited ABPs on site: material that might be suitable for animal feed cannot be easily/ reliably segregated.

No potential: material is unsuitable: as it contains ABPs that cannot be used, following Animal and Plant Health Agency guidance/ FSA guidance, and/ or is unfit for use on other grounds.

4.3.3 Overlaps between waste prevention, animal feed and redistribution

Waste prevention, redistribution and diversion to animal feed are overlapping options in many cases, but priorities should be set according to the food waste or utilisation hierarchy (Figure 1.1). Surplus bakery products, for instance, may be suitable for redistribution or for use in animal feed and a proportion could be prevented through better process management or technologies.

The interaction between options was considered in relation to the potential to change current practices across manufacturing and retail sectors. Scenarios were developed to explore the interaction between options. Scenarios 1 and 2 were used to define the upper limits for additional redistribution and diversion to animal feed. The third scenario reconciles

these two, prioritising redistribution but acknowledging that some surplus may be more likely to be effectively diverted to animal feed (reducing the risk that it becomes waste). A fourth scenario considered the implementation of waste prevention measures on the combined scenario to produce an assessment of the maximum waste prevention activity across the sectors and the primary estimates for additional redistribution and animal feed.

Table 4.2: Scenarios used to assess interactions between waste prevention and food surplus options within the manufacturing and retail sectors

	Scenario characteristics	Scenario outputs
Scenario 1: Maximum redistribution potential	redistribution potential prioritised over diversion to animal feed	'high' estimates for redistribution 'low' estimates for animal feed diversion
Scenario 2: Maximum animal feed potential	animal feed potential prioritised over redistribution	'high' estimates for animal feed diversion 'low' estimates for redistribution
Scenario 3: Combined scenario	prioritises redistribution but acknowledging that some surplus may be more likely to be effectively diverted to animal feed (reducing the risk that it becomes waste)	intermediate estimates combining redistribution and animal feed potential
Scenario 4: Combined scenario with waste prevention maximised	identified waste prevention interventions implemented and applied to Scenario 3	'primary' estimates for redistribution and animal feed diversion; taking into account full implementation of waste prevention potential identified during fieldwork and within the range of data sources and reports described in Section 2

4.4 Fieldwork

4.4.1 Overview

Site visits at food manufacturing and retail sites were designed to inform the higher-level datasets through:

- Gaining a deeper understanding of material flows and current measurement techniques;
- Gathering information on the wider context for food waste and its root cause e.g. back of store food waste in retailers and how this relates to compiled waste data sets;
- Observing site data collection points in the context of the food or drink manufacturing processes;
- Observing the operations as a whole with an aim to understanding what might not be covered by the data; and,
- Discussing the key research issues with site management/ staff, especially with regards to the queries around data.

Participating manufacturing sites were initially asked to provide data ahead of the site visit so that the research team could prepare. However, in many cases, it was not clear to the site teams what elements of their data would be most useful for the project and equally challenging for the research team to know exactly what to request without knowing further

details of the data held. In addition, it needed to be recognised that assisting a research project is additional work for busy manufacturing site staff and they may not have had time for prolonged discussions. For these reasons of practicality and trust-building with regards to often highly-confidential data, a site visit was the most effective first step in gaining relevant datasets. The data was often then provided during the site visit or sent shortly afterwards.

Site-specific terminology regarding surplus, by-products and waste was noted during the site visits and kick-off calls and the circumstances that led to it becoming surplus (or waste) recorded, along with relevant background information, for example the area of plant, production trial, and rejected ingredients not suitable for re-working.

4.4.2 Food and drink manufacturing fieldwork

The objectives of the food and drink manufacturing fieldwork were to:

- Develop a more detailed understanding of material flows and establish the context for the data analysis across the food manufacturing sub-sectors;
- For each food surplus and waste material stream, identify the most significant causes of their production and point of arising within the process stages;
- Understand how much of the various waste streams might be preventable;
- Identify materials suitable for redistribution or diversion to animal feed that might otherwise become waste;
- Understand any actual/ perceived barriers to the diversion of food surpluses to redistribution/ animal feed; and
- Capture other relevant information to support the qualitative element of the research, e.g. studies already undertaken at the site, information about product specifications in order to understand QA rejects, query seasonal aspects of waste and other unpredictable causes of waste that would not have been apparent on the day of the audit.

Figure 4.1 outlines the approach for the fieldwork at the manufacturing sites based on the outcomes from the pilot studies.

Figure 4.1: Fieldwork process

4.4.3 Sample selection and recruitment

A quota of 42 participating sites was spread across the main industry sub-sectors (Table 4.3). The number of participants sought in each varied between 2 to 5, reflecting the need to allocate more resource to cover more diverse sub-sectors and those of most interest from the perspective of potential food surplus (e.g. pre-prepared meals, bakery, meat, ambient and confectionery). It was decided to exclude the sugar manufacturing sector as it was well characterised within the 2014 EP data and the waste/ surplus flows were easily understood from existing data.

A list of businesses from EP data was drawn up and classified by industry sub-sector as the basis for initial contacts to approach for possible participation in the study. This was then expanded to include general requests for participation through trade associations, such as the FDF, the Chilled Food Association and Dairy UK, industry fora and WRAP's contacts through Courtauld Commitment signatories. Despite assistance from a wide range of organisations, recruitment to the project was challenging and it was difficult to book fieldwork within a constrained time period, as many sites had other commitments, such as site audits and peak production periods.

In total 37 sites participated, with quotas fulfilled in five of the 10 sub-sectors. 34 of these sites were audited whereas three opted to share their site data only. Table 4.3 provides information about the split of participants across the 10 sub-sectors.

Table 4.3: Number of manufacturing participants by sub-sector

Industry Sub-Sector	Quota set	# Site Visits	# Data Only Sites
Bakery & cakes	5	3	1
Meat, fish and poultry	5	3	
Milling of grain	3	3	
Pre-prepared meals	5	6	
Dairy	4	6	
Ambient stable foods	5	4	
Alcoholic drinks	2	2	1
Fruit & vegetables (fresh & frozen)	4	4	
Soft drinks	4	2	1
Confectionary	5	1	
TOTAL	**42**	**34**	**3**

Working directly with staff from the participating sites, the research team collected quantitative and qualitative data relating to food surplus and waste. The data gathered included:

- Total annual tonnages of ingredients/ inputs to production;
- Total annual output of finished saleable product;
- Total amount of waste/surplus raw materials, the reason for these and the fate of these materials;
- Total amount of production waste, the reason for the waste and the fate of this material;
- Total amounts of quality rejects, the fate of these and the reason for reject (e.g. product damage/ packaging defects etc.,);
- Any products redistributed or sold on site because of low shelf life/ damage;
- Waste prevention activities and future plans; and
- Any other waste data available e.g. re-work and customer returns.

Information was requested by product line and by business process. However, the level of granularity available was heavily dependent on the existing measurement approaches used at the various sites. As a result, there was considerable variation in terms of the granularity and completeness of the data captured by different organisations ranging from aggregated waste management company data (by month/ by lift across a limited number of waste streams) to detailed, line-specific data (by day/ by shift recording weight/ product/ reason code) at key points in the manufacturing process.

In addition to collecting quantitative data to support the scaling-up analysis, based on the EP dataset, discussions were also conducted with key members of staff in order to gain the maximum insight into waste/ food flows, potentials for change and identification of scope for waste reduction. For sites with on-site treatment, decisions relating to food waste/ production residues discharged to sewer versus on-site treatment were also discussed. With current flows to waste or diversion to animal feed that were identified as having potential for redistribution, barriers to this from the manufacturer's perspective were also explored.

4.4.4 Grocery retail fieldwork

Site visits within the retail sector involved three of the major supermarkets and a fourth participated on a data sharing only basis. Although the major component of the work was to integrate and analyse the detailed food waste datasets at national level, the choice of sites to audit was designed to cover a range of store formats, as indicated in Table 4.4.

Table 4.4: Retail site visits undertaken

	Distribution Centre (DC) food waste	Retail waste in store
Significance in relation to total retail food waste arisings	For most retailers only a small proportion of food waste is likely to occur at Regional Distribution Centres, however, surplus arising at this point is more readily redistributable as it is likely to have longer shelf life than surplus at store and represent a larger point source than likely to arise at individual stores.	Likely to be the majority of food waste relating to damage in store and food that is 'out of code'. A range of store formats included in order to explore any differences in wastage rates and the nature of food surpluses.
Number of sites to sample for waste audit/ interview	1 x Regional Distribution Centre including chilled, ambient, produce	3 x large format stores 1 x intermediate 3 x convenience stores

4.4.5 Third party logistics

The storage and transportation of food and drink is an integral element of the grocery supply chain in the UK. These activities are either managed in-house by the retailers and manufacturers themselves or are outsourced to third party logistics (3PL) companies.

Food and drink logistics providers are responsible for a significant proportion of the storage and movement of products from manufacturers to retailers across a number of different temperature bands (i.e. ambient, produce, chilled and frozen). A number of 3PLs also offer contract packing (co-packing) services and are, therefore, involved in the direct handling of food and drink products e.g. bagging, labelling, flow-wrapping and late customisation. As a result, this sector has an important role to play in the effective handling of food surplus and waste across the UK.

These organisations were outside the original remit of this research, however in recognition of their importance within the UK grocery supply chain, high level analysis of this sector was included in this analysis, through a site visit to a chilled warehouse operated by one of the UK's largest food and drink logistics providers and discussions with a number of stakeholders within this section of the supply chain; as well as discussions with redistribution organisations that source food surplus from 3PLs.

5.0 Data analysis, uncertainty and scaling

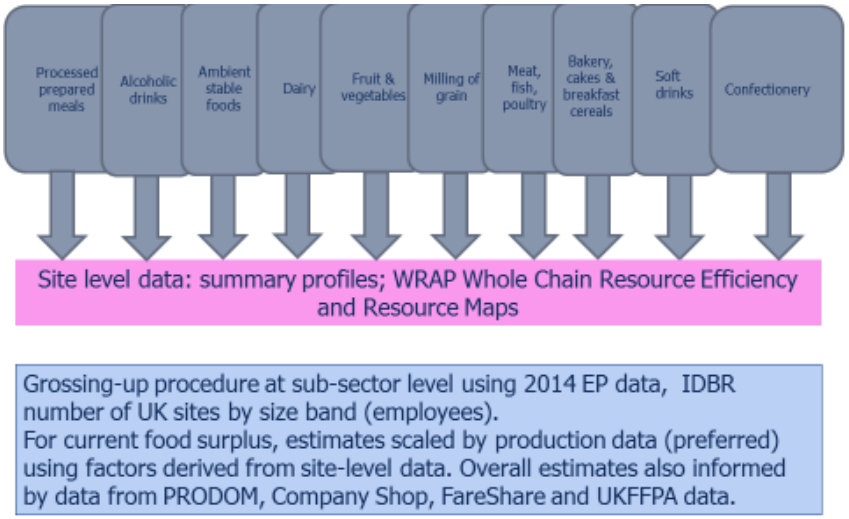
5.1 Food and drink manufacturing sector

The procedure for combining site level data and estimation of UK level estimates for waste, surplus and by-product flows is illustrated in Figure 5.1. This method of scaling the data was broadly similar to those used in previous WRAP studies to estimate arisings from the manufacturing sector at UK level (WRAP 2013[67]and WRAP 2014[68]) and involved the following main steps:

- Classification of EP sites into food and drink manufacturing sub-sector by SIC code;
- Size banding of each site by number of employees;
- Scaling of waste arisings to UK level for each sub-sector by means of the Inter-departmental Business Register's counts of local business units within each size band; and
- Reporting of UK level estimates by European Waste Catalogue code and by treatment and disposal method.

Additional elements from site visits and the other data sources described in Section 2.2 were used to support estimates of food surplus. For each set of site visits a summary of main findings from the audits and discussions was written up for each of the main sub-sectors. These are provided in the Appendices.

Figure 5.1: Scaling of results



Other datasets were used to inform estimates at a UK level and triangulate with estimates derived from site level data. For instance, the diversion of bakery products into the animal feed sector was analysed from both site level ratios of annual production to quantity diverted to animal feed, as well as using the estimates from the UKFFPA.

An assessment of the uncertainties associated with using the EP data to produce UK level estimates of waste arisings from the UK food and drink manufacturing sector is provided in Table 5.1.

[67] *Estimates of waste in the food and drink supply chain, WRAP 2013*
[68] *UK food waste – historical changes and how amounts might be influenced in the future, WRAP 2014*

Table 5.1: Use of 2014 Environmental Permitting data as a framework for grossing-up UK waste arisings – assessment of uncertainties

Main sources of data uncertainty	Comments/ mitigating actions
Coverage errors caused by bias towards meat and dairy production, with lower levels of representation of other industry sub-sectors, such as fresh fruit and vegetable processing. The thresholds are set at a lower level for sites that treat and process meat (animal raw materials capacity > 75 tonnes/day), compared with vegetable materials (>300 tonnes/day) or dairy sites milk (receiving > 200 tonnes/day). Only data for England were used in the analysis.	All main industry sub-sectors are represented in the 2014 EP data (Figure 2.1), but some with 10 or fewer sites. The data contains 1,097 waste streams from 520 food and drink processing/ manufacturing sites. It is not known to what extent sites within particular sub-sectors that meet the threshold criteria are not captured by the EP Regulations. The EP data is a more current source of waste arisings estimates than national waste production surveys and not subject to sampling error or problems of trying to extrapolate annual arisings from data collection from restricted fieldwork periods. An analysis of the implications of low coverage is presented in Table 5.2.
Incorrect application of EWC codes in site returns: for instance 'sludges from on-site treatment' versus 'sludges from washing and cleaning'; there is a risk of certain codes being used inter-changeably in particular sub-sectors.	For participating sites visited as part of the fieldwork that were also subject to EP reports, a good degree of compatibility was found between site observations and EP reporting
Confusion over reporting units (kg and tonnes)	A number of checks were carried out on outlying data units, checking against returns made in previous years (2007-2013) and returns from similar sites.
The waste types and treatment methods applied by sites requiring Environmental Permits may not be representative of the sector as a whole	Larger sites are more likely to invest in more advanced on-site treatment units such as small-scale AD. These sites will therefore produce more effluent treatment sludges than smaller manufacturing sites. However, sites within the sector employing more than 100 staff are thought to represent more than 86% of the waste arisings, based on an assessment of the Defra commercial and industrial waste survey, 2009. This minimises the impact of any distortion as the coverage accounts for a relatively high proportion of larger firms (33% of those employing more than 100 staff).
The use of employee size bands to scale data, linking to IDBR local business unit counts at UK level assumes that company size is a good proxy for total waste quantities. This relationship is uncertain and with a greater degree of automation at some manufacturing sites, the use of employee numbers as a proxy for waste generation is weakened.	Choice of scaling variables is dependent on data being available at national level that can also be readily obtained at the site level. Number of employees per site is easier to obtain than site production data or a number of other variables that might be better correlated with waste arisings.

Uncertainties associated with food and drink waste estimates within the manufacturing sector

The food waste and surplus estimates obtained from the evidence gathered by this study are subject to a range of limitations and uncertainties, linked to the coverage issues highlighted in Table 5.1 and a number of other factors relating to the EP data. These limitations need to be borne in mind by the user, but cannot be stated in terms of formal statistical confidence intervals as extensive additional data collection would be required to assess the impacts of each limitation in turn. Table 5.2 provides an assessment of the four main sources of uncertainty likely to have the greatest impact on estimates and highlights sources of

uncertainty for each sub-sector, followed by a discussion of mitigating factors. The four main uncertainties identified were:

1 Adequacy of coverage within 2014 EP data:
The threshold values (Table 5.2) for the raw material handling capacity at manufacturing sites determine which require Environmental Permits. A higher proportion of qualifying sites are found within meat, poultry and fish, dairy products, pre-prepared meals, milling and sugar sub-sectors (which combined represent 58% of the manufacturing total food waste). Least well represented within the EP data are bakery, ambient products and fruit and vegetables processing sites (which represent 26% of the manufacturing total food waste). These sub-sectors required larger scaling factors to produce UK estimates, potentially reducing confidence in the estimates obtained;

2 Uncertainties associated with a large number of SMEs within the IDBR:
SMEs are poorly represented within the EP data but represent a significant proportion of total business units within the manufacturing sector. However, results from the 2009 Defra survey of commercial and industrial wastes estimated that sites employing fewer than 100 staff accounted for 14% of total waste arisings. It was not possible to carry out further analysis of the 2009 data to explore variation across sub-sectors due to the limited number of food and drink SMEs within the 2009 sample. No comparable dataset has been collected since. Of all manufacturing sub-sectors, alcoholic drinks and the bakery products have the highest proportion of small production sites according to IDBR statistics (due to the large number of micro-breweries and small craft bakeries). However there is insufficient evidence to suggest that the overall assumption about the proportion of waste arising at larger production plants does not hold true for these sub-sectors;

3 Diversity of production processes and final products:
Certain sub-sectors, such as sugar and milling, use simple inputs and processes to produce a limited range of end products. Other manufacturing sub-sectors, such as pre-prepared meals and ambient products, are more complex and greater variation in production processes between sites. There is a higher level of uncertainty surrounding estimates made for more diverse sub-sectors as these are more difficult to characterise where datasets are more limited. Ambient product manufacturing is not well represented within the EP data and is also a highly diverse sub-sector; and

4 Sensitivity of food waste estimates to effluent treatment sludge assumptions:
Food and drink waste that is captured by on-site wastewater treatment systems cannot be directly quantified within the EP returns (which only include quantities of waste moved off-site). The relationship between food and drink waste arising from within production processes and the sludges arising from effluent treatments is uncertain. The consistency of sludges may vary by site, treatment technology and in the extent to which inputs comprise non-food materials and non-product water (from washing and cleaning). However, there are physical handling constraints that limit the variability of sludges transported off-site. Sludges with suspended solids content higher than 10% will be more difficult to land-spread as they will no longer be pumpable. Conversely, a higher water content would be less economically efficient, due to higher transportation costs. Food waste estimates for sub-sectors with a higher proportion of total weight from effluent sludges have higher uncertainty compared with estimates based on solid materials rejects. Dairy, fruit and vegetables and alcoholic drinks are the three sub-sectors where estimates have the highest sensitivity to assumptions made about effluent treatment sludges (and these three represent 37% of the manufacturing total food waste).

The assumed percentages of food waste in the treated sludge were informed by insights obtained from the site visits and food industry experts, knowledge of the types of materials

being generated at the sub-sector sites (for example for meat, poultry and fish there will be significant volumes of body fluids, liquids from rendered fats, cooking liquors etc.) and discussions with waste treatment and technology experts. There are also physical and financial limitations associated with transporting, pumping and utilising such sludges. Increasing the assumed percentage of food waste in these sludges to near the maximum likely would increase the overall estimate of food waste from the sector by around 10%, but not change the sub-sector ranking. A 25% reduction in the assumed food waste contribution to effluent treatment sludges across the manufacturing sector would reduce the overall food waste estimates by 11%, whilst reducing the assumed percentage by half would cut the overall food waste estimate by around 23% - but have little effect on the ranking of sub-sectors (alcoholic drinks moves down from 4th to 6th).

Overall, the sub-sector with the highest combined level of uncertainty across the four factors is fruit and vegetable processing, which is the fifth highest ranking in terms of total food waste arisings (8% of total food waste). The five sub-sectors with higher certainty of estimates include meat, poultry and fish and dairy, the first and second rankings in terms of total food waste. Together with pre-prepared meals, milling and sugar these account for 58% of total food waste.

Specific comments relating to overall confidence in the results for those sub-sectors with at least one of the elements in the table below identified as red are:

- Dairy. As effluent treatment sludge forms more than 90% of the organic waste containing food waste within the EP returns from dairy businesses the overall estimates of food waste from this sub-sector are more sensitive to changes in the assumptions regarding the percentage of effluent sludge that is derived from product. However this sub-sector is well represented in the EP data (28 sites out of 70 with >100 employees), and was well covered in the fieldwork (5 businesses). These facts combined with the insights from discussions with industry, waste and technology experts result in an overall positive assessment of confidence around the sub-sector food waste estimates.
- Ambient products. This is a diverse sub-sector with relatively poor coverage within the EP returns (representing 11% of UK sites with > 100 employees). Confidence in the food waste estimates is increased as the sub-sector's UK profile is dominated by larger production sites rather than SMEs and 90% of organic wastes associated with food waste are in the form of rejected materials, rather than effluent treatment sludges. Furthermore, the estimates were informed by 4 site visits, discussions with industry stakeholders and information from WRAP site waste prevention reviews from a further 3 sites.
- Alcoholic drinks. Drink waste estimates for this sub-sector are sensitive to assumptions associated with effluent treatment sludges, as they account for 64% of organic wastes containing drink waste. The estimates are also subject to uncertainties associated with a large number of production sites employing fewer than 100 staff (e.g. micro-breweries operating below EP capacity thresholds). However, confidence in the estimates is increased as the coverage of the EP returns is good, relating to 21 sites that cover a good cross-section of larger production facilities. An extensive library of WRAP drinks sector resource efficiency reports was also used to improve confidence in the estimates.
- Fruit and vegetables. For this sub-sector uncertainties associated with estimates of food waste arisings have been highlighted in relation to poor coverage within EP data (6 of 80 sites with> 100 employees). In compiling the estimates, further sources of information to improve confidence in the estimates were used from site visits and interviews (2 visits, 2 data sharing only), WRAP whole chain resource efficiency reviews relating to potatoes

and onions and WRAP fruit and vegetable resource map (involving 34 suppliers and 11 fresh product categories). Wastes from the preparation and packing of fruit and vegetables are relatively homogenous and predictable, consisting of outputs from a limited range of processes, including cleaning, grading, cutting/ trimming/ peeling processes.

- Bakery. The bakery sub-sector (which for the purposes of this study includes biscuits and breakfast cereal manufacturing) contains a large number of small businesses alongside a few larger production sites. Coverage within the EP returns is limited, with only 8 of the 195 local business units employing 100 or more staff included. Despite these limitations, the bakery sector operates a limited range of production processes from which wastes of a predictable nature arise. The food waste estimates are based predominantly on materials rejected from production, with low levels of uncertainty associated with effluent treatment sludges. 94% of the organic fraction containing food waste relates to solid, non-sludge, materials. Evidence to further support the estimates was collected from 4 site visits, discussions with industry stakeholders and the animal feed processing sector.
- Pre-prepared meals. Although there is good coverage of this sub-sector within the EP returns (14 of 45 sites with more than 100 employees) it includes a highly diverse set of manufacturing sites producing a range of products and associated waste types. For this reason 5 site visits were conducted to cover a range of different product types (e.g. chilled and frozen products, including sandwiches, pizza and pies). In addition to discussions with industry, including the Chilled Food Association, evidence was also reviewed from WRAP site waste prevention reviews from 9 production sites covering the main pre-prepared meal product types (sandwiches, lasagne, beef pies and pizzas). Apart from uncertainties associated with the diversity of products, low levels of uncertainty are associated with the three other factors included within the uncertainty assessment.

Table 5.2: Uncertainty assessment for waste estimates associated with food and drink manufacturing sub-sectors

Sub-sector (ranked in descending order of total food waste tonnage)	Overall uncertainty rating	Adequacy of coverage within EP data	Uncertainties associated with large number of SMEs within IDBR	Diversity of production processes and final products	4. Sensitivity of food waste estimates to effluent sludge assumptions
	1 = higher certainty 5 = lower certainty	1 = good coverage 5 = poor coverage	1 = lower uncertainty 5 = higher uncertainty	1= lower diversity 5 = higher diversity	1 = lower sensitivity 5 = higher sensitivity
Meat, poultry and fish	2	1	3	2	3
Dairy products	2	1	2	2	5
Ambient products	3	4	2	4	1
Alcoholic drinks	3	2	4	2	4
Fruit and vegetables	3	4	3	2	3
Bakery	4	5	5	2	1
Pre-prepared meals	2	2	2	5	1
Soft drinks and fruit juices	3	2	3	3	3
Confectionery	3	3	3	3	1
Milling	1	1	2	1	1
Sugar	1	1	1	1	3

5.2 Food and drink retail sector

In order to obtain estimates for the retail sector as whole (non-participating retailers, including the small independent retailers) data were scaled-up using published estimates for total retail food waste from the BRC and WRAP, described in more detail in Section 6.3.1.

The main analytic task was to reconcile differences between retailers in the categorisation of different food products, in order to produce compatible datasets on which to carry out the assessments of food surplus/ waste scenarios. Whilst it was not possible to construct a totally consistent dataset, it was found that particular food product categories (in-store bakery and fresh produce) dominated food waste profiles across the available retailer data. The lack of complete alignment across datasets therefore had a limited influence on the results. Table 5.3 provides a summary of data uncertainties and limitations in relation to the use of three retail food waste datasets to estimate detailed UK arisings for the grocery retail sector as a whole.

Table 5.3: Use of 'bottom-up' food waste datasets from three retailers to estimate detailed food waste profile for UK grocery retail sector.

Main sources of data uncertainty	Comments/ mitigating actions
Coverage errors, datasets limited to participating retailers only	Different retailers have different policies in relation to food waste e.g. moving products from depot to store, variation in reduce to clear policies. These factors will have implications for the reliability of extrapolation of the assessment from three retailers across the sector as a whole
Data are collected and classified differently between retailers and use different methods of generating weight data from SKU data	Although the bottom-up data sets are collected using different methodologies, the overall profile of 'most wasted products' does not differ greatly between the different datasets
Extrapolation across all retailers from data relating to three major retailers	Differences in the profile of store formats and location between different retailers cannot be controlled for in this analysis, which has extrapolated across the sector on the basis of market share. However, as the three participating retailers represent a significant share of the UK grocery sector, the significance of any extrapolation errors is greatly reduced

6.0 Results and analysis

6.1 Total food surplus and waste in manufacturing and retail

Food waste in the manufacturing and grocery retail sectors amounts to 1.9 million tonnes per annum (Table 6.1), with 88% arising in the manufacturing sector. Overall, around 56% of food waste arisings could be defined as avoidable. In addition, the wholesale sector (although not estimated within the current study), produces 17,000 tonnes of food waste according to the previous estimates (WRAP 2013).

Grocery retail and manufacturing sectors currently produce an estimated 710,000 tonnes of food surplus of which 47,000 tonnes is kept directly within the human food supply chain through redistribution, with the majority diverted to produce animal feed (660,000 tonnes).

Table 6.1: Food and drink surplus and waste in grocery retail and manufacturing, UK estimates (tonnes/year) 2014

	Manufacturers*	Grocery Retailers	Total
Total food waste	1,700,000	210,000	1,900,000
of which: avoidable food waste	870,000	210,000	1,100,000
Total food surplus diverted	680,000	32,000	710,000
of which: food surplus to redistribution	42,000	5,000	47,000
food surplus to animal feed	635,000	27,000	660,000

* Includes data from Third-Party Logistics (3PL) providers, who contribute an estimated 5,000 tonnes to the overall redistribution figure for manufacturing and 3PL

Value of food that is wasted:

- In the UK retail sector food with a potential sales value of around £650 million ends up as waste, equivalent to 0.6% of 2014 household expenditure on food and drink.
- In the UK manufacturing sector food with a potential sales value of around £1.25 billion ends up as waste, or about 2% of total sales value of UK food and drink sector manufacturing, based on PRODCOM 2014 estimates.

Details of the approach to estimate the value of food wasted can be found in Appendix K.

Potential to shift material further up the food and drink utilisation hierarchy:

- The analysis identified significant additional potential to promote greater resource efficiency within the grocery supply chain through waste prevention, including through additional redistribution and diversion to produce animal feed;
- It is estimated that 450,000 tonnes of avoidable food waste across grocery retail and manufacturing could be prevented at source or reduced through diversion of surplus away from waste options towards redistribution or animal feed. This total potential is equivalent to 42% of 2014 avoidable food waste;
- The largest component of overall waste reduction potential (185,000 tonnes/year; 150,000 tonnes from manufacturing, 5,000 tonnes from 3PL and 30,000 tonnes from retail) is estimated to be from activities that prevent waste arising in the first place, such as improved whole supply chain efficiency measures, product life extension and more focused waste prevention work at site level, through mapping and hotspots analysis;

- Keeping more material within the human food supply chain through redistribution of food surplus is estimated to have potential to reduce food waste arisings by an additional 120,000 tonnes/ year (55,000 tonnes from manufacturing, 15,000 tonnes from 3PL and 50,000 tonnes from retail). The total amount of additional surplus suitable for redistribution is higher, at 135,000 tonnes, as some material that is currently being diverted to animal feed would be suitable for redistribution; and
- Diversion of material that cannot be prevented or readily redistributed, to animal feed accounted for 144,000 tonnes of waste reduction potential (130,000 tonnes from manufacturing and 13,000 tonnes from retail).

These findings represent the primary estimates from a series of scenario assessments described in Section 4.3.3, and are shown in Table 6.2:

- Row 1: provides estimates of the potential for prevention of waste arisings in relation to manufacturing (including 3PLs) and retail, based on site visits and other relevant findings from waste prevention reviews and other sources;
- In rows 2 and 3: estimates for additional redistribution and diversion to animal feed have been calculated, taking into account the implementation of waste prevention in row 1 and prioritisation of redistribution over animal feed; and
- Estimates are based solely on the characteristics of food surpluses and do not include consideration of commercial implications, current availability of redistribution infrastructure or any other factors that determine how businesses within the grocery supply chain might allocate food surplus/ waste arisings in the future.

The greatest potential to reduce food waste at source is found within the manufacturing sector, representing 84% of the total potential identified, equivalent to 18% of avoidable food waste from this sector. For the retail sector, the opportunity is smaller (30,000 tonnes/ year) but significant in relation to avoidable food waste (14% of the retail total).

The assessment found that retail food waste contained 37% of the additional redistribution potential identified across the grocery supply chain. This finding is consistent with the fact that retailers only handle finished product, whereas avoidable food wastes from manufacturing activities contain a mix of materials, including rejects from different stages of production which are more likely to be unsuitable for redistribution.

Diversion of additional surplus to animal feed has greatest potential within the manufacturing sector, equivalent to 15% of the sector's avoidable food waste. Potential is more limited in relation to retail food surplus (about 6% of avoidable food waste) due to animal by-product segregation issues and assumptions in the scenarios that restrict suitable material to surplus bakery products.

Table 6.2: Waste prevention* potential across retail and manufacturing, UK estimates (tonnes/ year)

	Manufacture ***(Section 6.2)*** ***and Third-Party Logistics providers**** ***(Section 6.3)*** ***(tonnes per year)***	**Retailer** ***(Section 6.3)*** ***(tonnes per year)***	**Total (tonnes per year)**
Food waste prevention at source (tonnes per annum)	**155,000**	**30,000**	**185,000**
Increased redistribution of food surplus	**70,000** food waste reduction {plus reduction of surplus to animal feed: 15,000}	**50,000** food waste reduction	**120,000**
Increased diversion of food surplus to animal feed	**130,000** food waste reduction	**13,000** food waste reduction	**143,000**
Total food waste reduction potential	**355,000**	**93,000**	**450,000**

* Includes prevention of arisings, additional redistribution and diversion to animal feed
** contributes 5,000 tonnes to the estimate of food waste prevented at source and 15,000 tonnes to the estimate of additional redistribution

6.1.1 Outputs from the scenario modelling

The food utilisation or waste hierarchy has been reflected in the primary estimates shown in Table 6.2, in which identified waste prevention measures have first been implemented and redistribution then prioritised over animal feed. The scenarios used to construct these primary estimates also provide 'high' and 'low' values for redistribution and animal feed, taking into account the interaction between these options.

Figure 6.1 and Figure 6.2 illustrate the range of values for retail and manufacturing for these options, including additional and current surpluses. These are discussed in more detail in Sections 6.2 and 6.3:

- The overall range for **additional** redistribution: primary estimate 135,000 tonnes/ year (ranges from 52,000 to 220,000 additional tonnes depending on the scenario)
- The overall range for **additional** animal feed: primary estimate 143,000 tonnes/ year (range -37,000 to 190,000 tonnes depending on the scenario; with the 'maximum redistribution' scenario leading to a reduction in surplus going to animal feed compared to the levels diverted in 2015)

Figure 6.1: Current and additional redistribution potential (tonnes/year), outputs from scenario assessments indicating high/low range and primary estimates

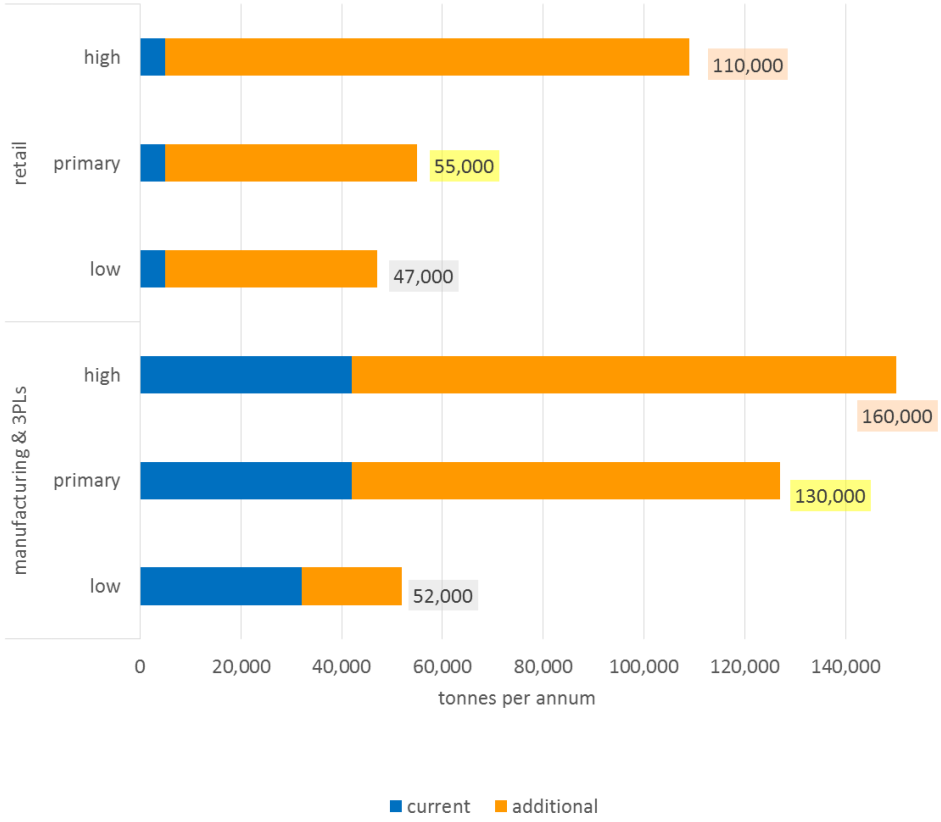
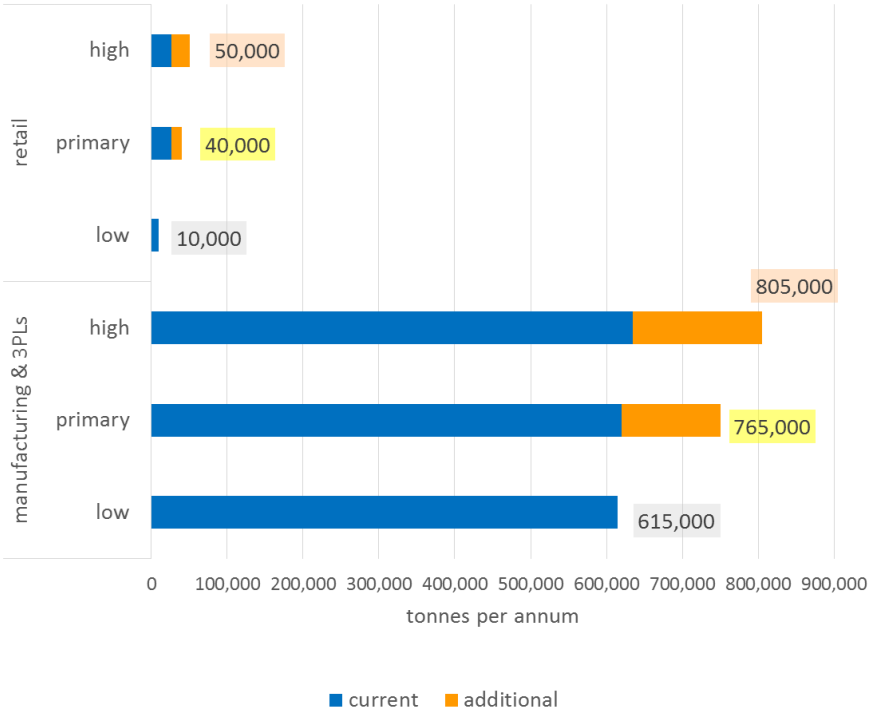


Figure 6.2: Current and additional potential for diversion to animal feed (tonnes/year), outputs from scenario assessments indicating range and primary estimates



6.2 Food and drink manufacturing

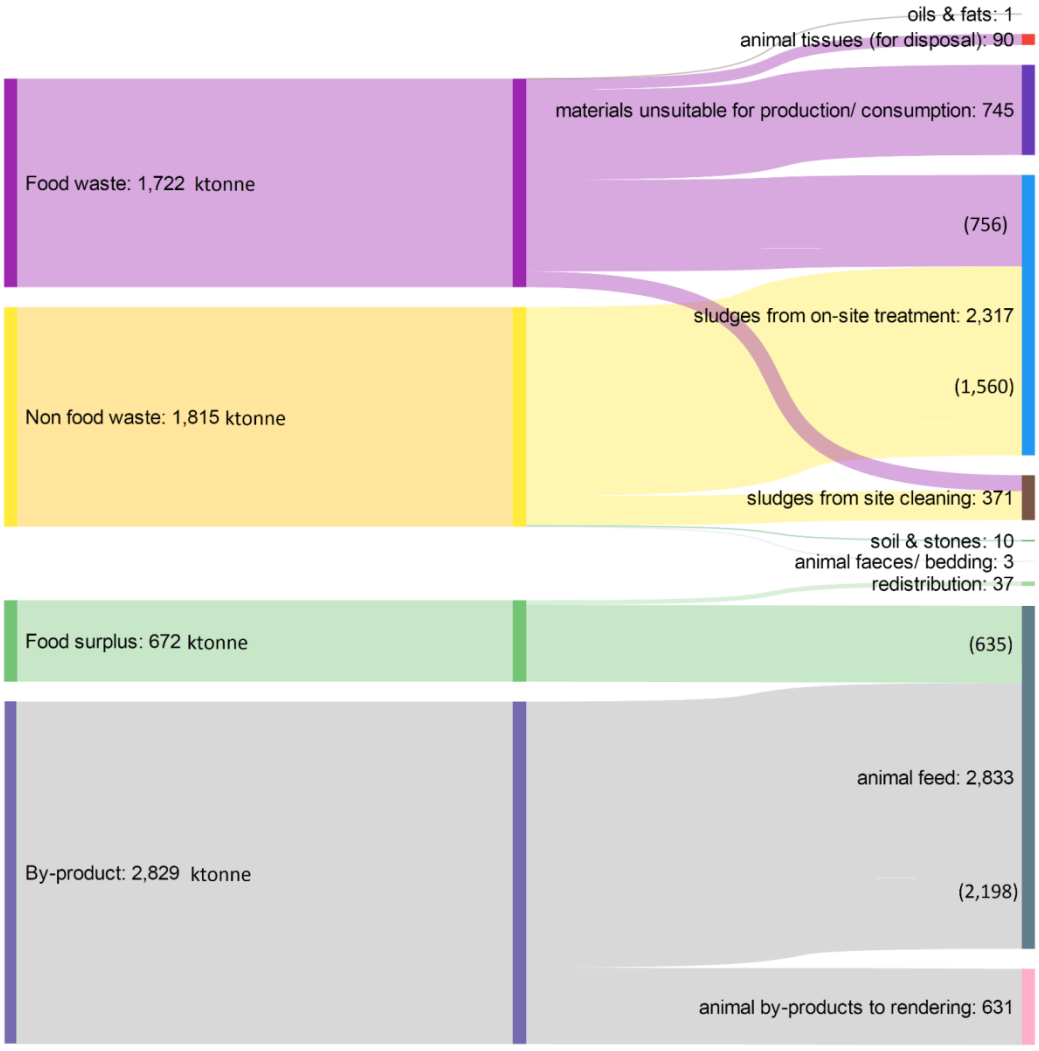
This section provides an overview of the surpluses and wastes occurring across the UK food and drink manufacturing sector and outlines the potential to reduce waste and maximise the use of food surpluses across the sector. These estimates have been compiled from more detailed information relating to each of the main industry sub-sectors, details of which can be found in Appendices A to J.

6.2.1 Overall surplus, waste and by-product flows

Figure 6.3 shows the main surplus, waste and by-product flows associated with UK food and drink manufacturing, using the data sources, methodology and approach described in Sections 2.0 to 4.0.

Organic wastes associated with food and drink manufacturing processes in 2014 are estimated at 3.5 million tonnes per annum, with the largest fraction, over 2.3 million tonnes, consisting of sludges from on-site treatment processes. Materials rejected as unsuitable for production or consumption (0.75 million tonnes) and sludges from cleaning processes (0.35 million tonnes) accounted for most of the remainder.

Figure 6.3: Main food surplus, organic (food and non-food) waste and by-product flows from manufacturing (excluding 3PL), 2014 estimates based on EP data and other sources



Food waste is estimated to be 1.7 million tonnes within the 3.5 million tonnes of organic waste streams. This estimate is significantly lower than the previous estimate of 3.9 million tonnes published in 2013 (based on 2011 data)[69]. The main reasons for this, illustrated in Figure 6.4 are as follows:

- Previous estimates did not have resolution of the different organic waste streams recorded under the Environmental Permitting Regulations, verified by a programme of site visits;
- Organic waste streams not containing food waste that previously contributed to the total have been excluded, including non-food materials such as soil and stones (e.g. from grain milling and sugar beet), water from washing and cleaning and animal faeces and bedding (from meat processing where slaughter houses are integrated with other processing activities on the same site);
- In addition efforts made by manufacturers and retailers to reduce waste arisings and amounts of surplus going to waste, for example under WRAPs Courtauld Commitment, have reduced arisings during the intervening period by around 200,000 tonnes. This is based on an analysis of data reported to WRAP by signatories, and an assessment of how signatories and WRAP have worked to influence change amongst businesses not signed up to the voluntary agreement[70]; and
- An element of double-counting relating to animal tissue sent to the rendering sector was also identified and removed from the estimates.

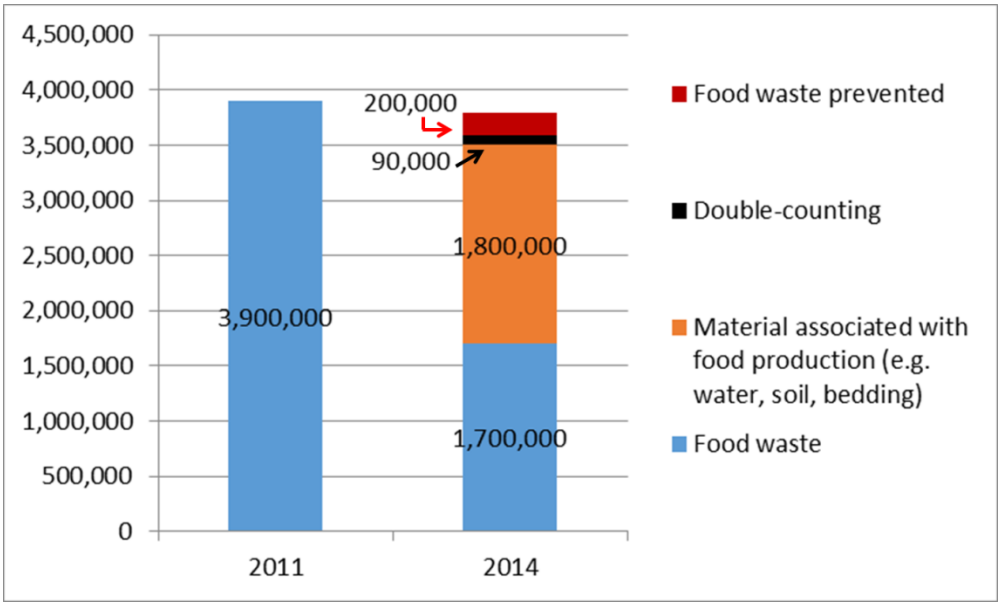
An important element of this revised estimate is exclusion of non-food and drink elements and non-ingredient water that contributes to the weight of sludge tonnages, the major component of non-food wastes. The main considerations were:

- Significant non-food waste elements include water from site cleaning (flushing of pipes, tanks, or pushing liquid products through process stages), soil washings and materials not intended for human consumption (e.g. non-food vegetable materials such as weeds, straw, chaff and stalks); and
- The extent to which the sludges generated by each sub-sector contain food or non-food materials has been estimated, taking account of observations from site visits and information from various data sources, including industry case studies from installed treatment units within the sector[71].

In sub-sectors producing liquid products or using liquid ingredients (e.g. soft drinks and alcoholic drinks, dairy and fruit juices) the inputs to on-site treatment processes will also contain significant quantities of production rejects and residues (e.g. finished product, ingredients and food related materials, such as deposits removed from processing units).

[69] *Estimates of waste in the food and drink supply chain, WRAP 2013*
[70] *This approach is discussed in detail in 'UK food waste – Historical changes and how amounts might be influenced in the future'*
[71] *For example: ADBA industrial and food waste AD projects*

Figure 6.4 : Comparison between 2011 and 2014 food and drink waste estimates from UK manufacturing sites (tonnes)



By-products associated with the manufacturing sector and used in secondary markets elsewhere in the food sector or within animal feed are estimated to be 2.8 million tonnes, mostly associated with materials sent to animal feed from brewers' grains, milling (e.g. wheat grain unsuitable for bread flour) and from the dairy sector (e.g. whey). A full estimation of animal by-products sent to rendering, including from abattoirs etc., was not included within the scope of the current study; however this was estimated to be 2.25 million tonnes in 2011, in the 2013 WRAP report.

Food surplus accounts for 670,000 tonnes[72], mainly former foodstuffs sent to animal feed (635,000 tonnes; an increase on the 445,000 tonnes reported in 2013, due in part to significant efforts to capture additional material by the former foodstuffs processing sector[73]). 37,000 tonnes of surplus is redistributed by food charities and commercial redistribution organisations[74]. A separate estimate of redistribution from within the manufacturing sector was not included in the 2013 study, but was likely to have been less than 10,000 tonnes in 2011.

Figure 6.5 provides a summary of treatment and disposal methods applied to food waste from manufacture. There are three main routes:

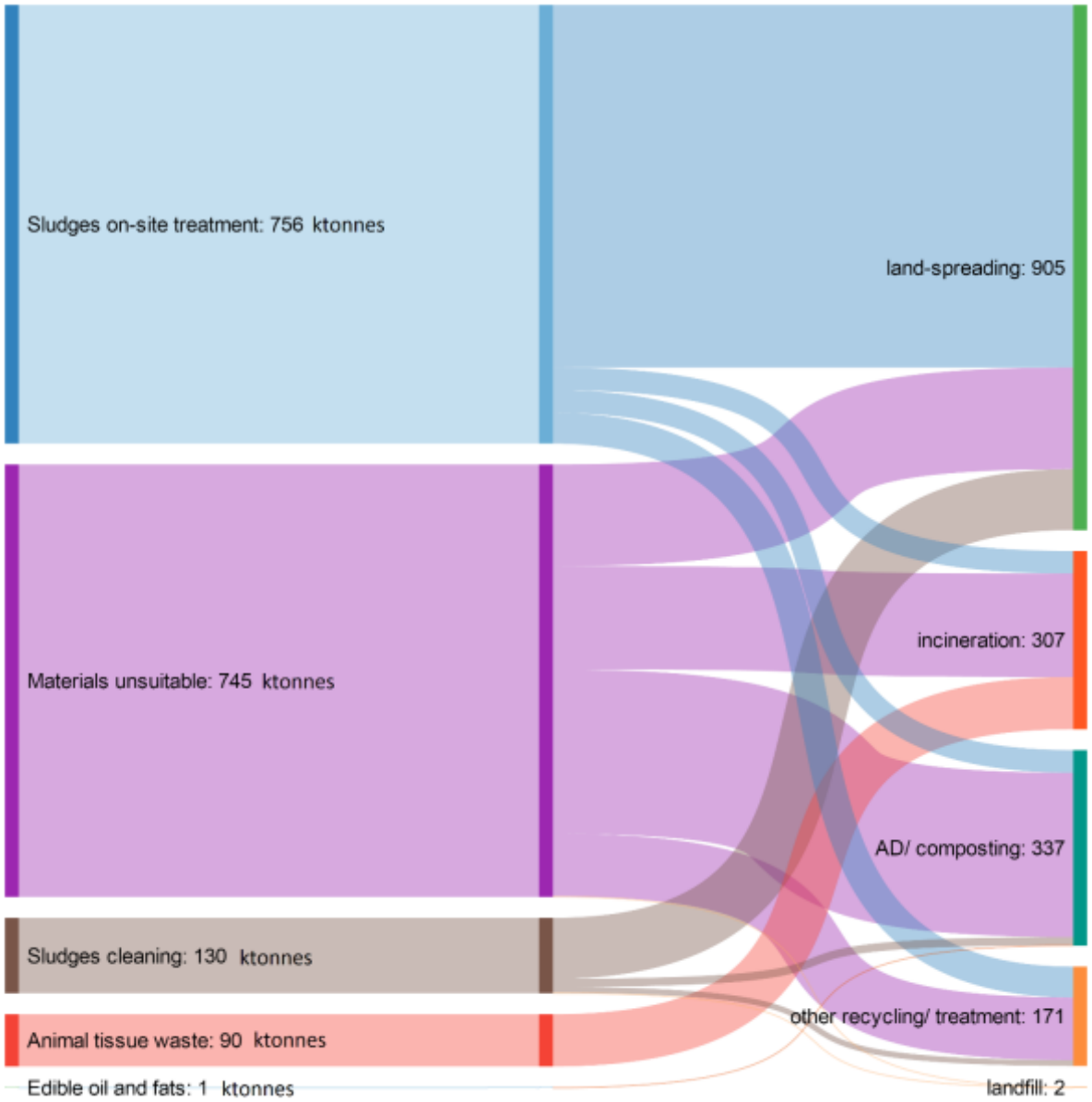
- Land-spreading or land-injection are the predominant routes for treatment of food waste from the sector, accounting for 900,000 tonnes, applied to highly liquid sludges and sludge cakes from both on-site treatment plants and from site cleaning processes. There is likely to be significant variation in the extent to which these sludges are dewatered prior to treatment and disposal;
- The quantity of sludge from on-site treatment has increased over recent years as the sector has invested in more on-site treatment capacity in response to steadily increasing

[72] These are estimates for manufacturing only. For manufacturing and 3PL combined (as shown in the Executive Summary and Table 6.1) the estimate would be 680,000 tonnes overall surplus, 42,000 tonnes to redistribution and 635,000 tonnes to animal feed)
[73] See: UKFFPA
[74] An additional 5,000 tonnes is redistributed from third party logistics companies, see Section 6.3

trade effluent charges[75]. The sludge volume will vary by on-site treatment process, with anaerobic treatment producing less sludge than aerobic treatments. Sludge weights cannot therefore be easily equated with food ingredient or product inputs, introducing and extra level of uncertainty in 'waste metrics' applied to the sector; and

- Apart from land-spreading, the other main off-site treatment methods are energy recovery or biological treatment methods, including anaerobic digestion (AD) and in-vessel composting (IVC). Only 2,000 tonnes was estimated to be sent to landfill, reflecting the 'zero food and packaging waste to landfill' policies across much of the manufacturing sector[76].

Figure 6.5: Treatment and disposal methods applied to food waste flows from UK food manufacturing sites (excluding 3PL), 2014 estimates based on EP data



[75] See: *UK Food waste – historical changes and how amounts might be influenced in the future, WRAP 2014*
[76] *FDF Five-fold Environmental Ambition: Progress Summary 2015*

6.2.2 Food surplus, waste and by-product flows in relation to total UK production

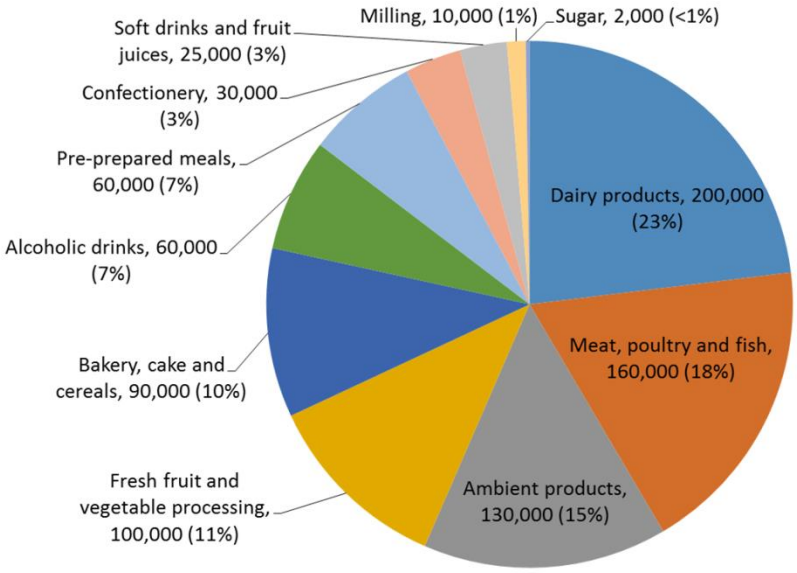
A summary of industry sub-sector estimates of food waste arisings is provided in Table 6.3, ranked by total food waste. Over 50% of total food waste occurs in two sub-sectors: 'meat, poultry and fish' and dairy.

The extent to which food waste could be defined as avoidable varied by sub-sector, with a higher proportion of avoidability in the ambient products (70%), bakery (79%) and pre-prepared meals (72%) sub-sectors. Figure 6.6 shows the avoidable food waste tonnage split between sub-sectors, with dairy, 'meat, poultry and fish' and ambient accounting for 68% of the tonnage.

Table 6.3: Food waste arisings across food and drink manufacturing sub-sectors, UK estimates (tonnes/year)

	Total food waste (tonnes)	% of total food waste	Avoidable food waste (tonnes)	% of total avoidable food waste	Avoidable food waste as % of food waste within sub-sector
Meat, poultry and fish	540,000	31%	160,000	18%	30%
Dairy products	340,000	20%	200,000	23%	58%
Ambient products	185,000	11%	130,000	15%	70%
Alcoholic drinks	150,000	9%	60,000	7%	40%
Fresh fruit and vegetable processing	140,000	8%	100,000	12%	69%
Bakery, cake and cereals	110,000	7%	90,000	10%	79%
Pre-prepared meals	83,000	5%	60,000	7%	72%
Soft drinks and fruit juices	77,000	4%	25,000	3%	32%
Confectionery	49,000	3%	30,000	3%	61%
Milling	35,000	2%	10,000	1%	29%
Sugar	2,000	< 1%	1,000	<1%	25%
Total	**1,700,000**	**-**	**870,000**	**100%**	**-**

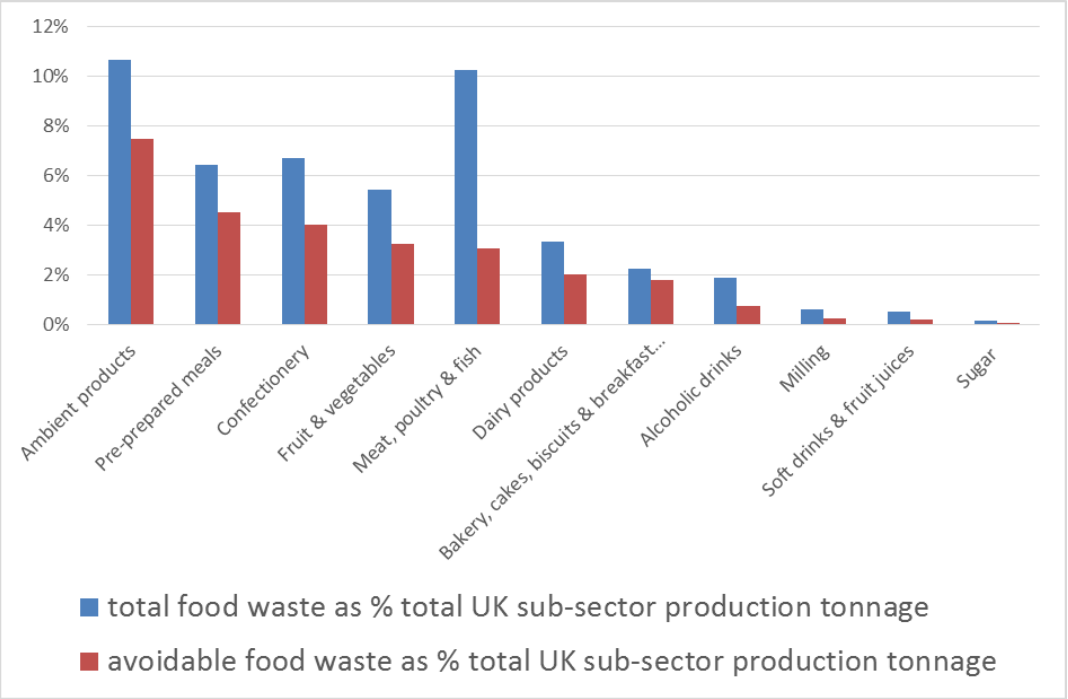
Figure 6.6: Avoidable food waste by manufacturing sub-sector, tonnes/year



6.2.3 Food waste, surplus and by-product flows in relation to total UK production

The scale of material flows is easier to envisage in relation to the total annual production of finished products from UK food and drink manufacturing, which amounted to 58 million tonnes with a sales value of £69 billion in 2014[77]. Avoidable food waste is equivalent to 1.5% of output tonnage; however the proportion varies widely by industry sub-sector (Figure 6.7), with the highest proportion in ambient and pre-prepared meals sub-sectors. Generally, the wastage rate is higher in sub-sectors which produce more complex end products involving multiple ingredients and production lines.

Figure 6.7: Food waste (total and avoidable) as a proportion of UK food and drink manufacturing production tonnes



(adapted from PRODCOM data, provisional, food waste estimated from EP2014 data)

6.2.4 Main causes of food waste within the manufacturing sector and assessment of waste prevention potential

The site visits identified a range of different causes of food waste at manufacturing sites. Discussions with site operators focused on food waste prevention interventions that were in place and any planned activities or future investments. Further information was obtained from other sources, such as WRAP Whole Chain Resource Efficiency assessments and Resource Maps (published and unpublished).

Potential root causes of food surplus and waste varied considerably across the sectors, depending on the product and the nature of the manufacturing operation. Table 6.4 provides a generic summary of the main roots causes identified and Table 6.5 provides a summary of waste prevention potential across manufacturing sub-sectors.

[77] PRODCOM 2014 provisional estimates

Table 6.4: Root causes of food waste

Potential Root Causes of Waste/ Surplus (General Food Manufacturing):

- Start-up rejects
- QA issues
- Spills
- Contamination
- Short life
- Under/ over-filling
- Ingredient issues
- Poor formulation/ mixing
- Batch change-overs
- Clean down
- Packaging misalignment
- Customer returns
- Technical issues e.g. burning/ conveyor belt misalignment
- Technology replacement & commissioning
- Handling errors

Table 6.5: Waste prevention potential across manufacturing sub-sectors

	Causes and drives	Potential solutions
Milling	Product waste is a minor stream compared to inedible waste arising from input materials e.g. chaff, straw, stones and metal Natural variation in the quality of input materials is the main issue	Highly efficient with most factors causing loss related to natural variability of input materials
Fruit and vegetables	Pack house manual grading losses and grading errors high ('good product ending up in out-grades') Over-peeling of prepared vegetables Retailer spec difficult to achieve resulting in high down-grade losses Damage in handling/ bruising (may be due to poor temperature conditioning of produce) Poor demand forecasting and information flows along the supply chain, a factor in creation of surpluses Seasonal factors and higher than expected crop yields also a factor	Development of alternative markets (soup, pies, etc.,) may reduce surpluses Interaction with retailers to help identify alternatives Improvements is sharing information along supply chain
Meat, poultry and fish	Bill of materials (BOM) end issue in meat slicing: interaction with down-grade markets limits the waste Strict retailer product spec leading to significant proportion of product to down-grade markets (not a waste issue, but a loss in value) Need for improved monitoring and analysis to reduce floor waste and losses in fish crumbing plant: a priority	Better carcass utilisation Further diversification of export markets to improve overall carcass utilisation Reduced floor waste through , less feathering of sliced meats Value stream mapping of processed meat production, from abattoir to processing and packaging stages
Dairy products	Milk and dairy product sent to effluent treatment plant in wash water during cleaning in place (CIP) procedures Liquid product lost to drain, not measured adequately	Minimisation of recoverable materials being lost to waste water and requiring treatment: e.g. collection of solid materials, such as curd particles, using a brush instead of directing them to the drain with a water spray Use of off-cuts in cheese making in alternative markets

Bakery, cakes, biscuits and breakfast cereals	Need for closer monitoring of waste levels caused by over-baked/ off-spec production, Bulk purchase of ingredients can cause issues with shelf life Unexpected de-listing of products can result in waste of ingredients.	Review and extend product life on some lines Prioritise tracking/ reducing waste Calculate true cost of waste, product value
Soft drinks and fruit juices	Losses associated with 'push water' used to move product through production process Product giveaway Set-up losses and run-down losses Over-production of soft drinks End of promotion may result in product destruction Defects in bottle tops (appearance) caused QA rejects	Introduce process modification to reduce filling errors Improvements to juice extraction yield Improved demand forecasting Increases in batch sizes where possible to reduce set-up and run-down losses
Confectionery	Highly automated lines Product loss during breakdowns through lack of buffering capacity in overhead hoppers	Reduction in floor waste through better checks on belt alignment Improvements to rework process to reduce waste
Ambient products	A proportion of product consigned to wash water	Improvements to rework process to reduce waste
Pre-prepared meals	Very varied waste streams reflecting different ingredients & product categories Sandwich making: over-ordering of ingredients caused by min. order volumes not used in time, Missing ingredients in pizza caused by human error, limited rework potential Poor layout of production area, due to plant operating over-capacity, resulting in excessive floor waste	Review of procurement policies for ingredients, address MOQ issue Line-level waste monitoring combined with value stream mapping

Estimation of the total potential for food waste prevention across the manufacturing sector is difficult given the number of different factors involved, the range of potential actions that can be taken and uncertainties over their impacts and effectiveness. Some opportunities are relatively 'easy wins' and relate to better housekeeping, changes in procurement of ingredients and more effective measurement and monitoring of food waste. Others require long-term investment, technological innovations and increased collaboration up and down the food supply chain. Many organisations have already implemented waste prevention programmes. However, there is still significant scope for improvement across the sector as a whole. As an indication of potential for prevention, estimates are shown in Table 6.6. These are based on:

- Opportunities identified within each sub-sector (see Appendices A to J for more details for each);
- An assessment of the total quantity of food waste in relation to production volumes, based on 2014 PRODCOM data;

- More general industry factors, such as greater prioritisation of food waste reduction across the sector (e.g. via better measurement and monitoring, staff commitment etc.) and product life extension; and
- Whole supply chain initiatives to address significant issues, such as poor demand forecasting, particularly in relation to fresh produce.

In total this assessment identified 150,000 tonnes of food waste that could be prevented from arising in production, i.e. 17% of total avoidable food waste. As Table 6.6 shows, dairy, ambient products and meat were sub-sectors with the highest potential waste prevention tonnage.

Table 6.6: Potential to prevent food waste arising by manufacturing sub-sector, ranked by tonnage

Sub-sector	Potential to prevent food waste arising (tonnes)	Waste prevention potential as % of total avoidable food waste within sub-sector
Dairy products	40,000	20%
Ambient products	30,000	23%
Meat, poultry and fish	20,000	13%
Fresh fruit and vegetable processing	17,000	17%
Pre-prepared meals	15,000	25%
Bakery, cake and cereals	10,000	11%
Alcoholic drinks	8,000	13%
Soft drinks and fruit juices	5,000	20%
Confectionery	4,500	15%
Milling	500	5%
Sugar	100	20%
UK total	**150,000**	**17%**

6.2.5 Manufacturing sector food waste prevention scenarios

Various factors will influence the implementation of interventions to prevent food waste and the timescales for these, and a range of scenarios were developed to reflect this. These included one maximising the amount of food that may be suitable for redistribution (including some that may be challenging due to very short shelf-life), one that maximises surplus to animal feed (assuming more of the material that is suitable for animal feed is diverted to the former) and a scenario that reconciles these two, prioritising redistribution but acknowledging that some surplus may be more likely to be effectively diverted to animal feed (reducing the risk that it becomes waste). A final scenario includes the implementation of actions to prevent food waste arising. These give rise to a range of potential tonnages that may be prevented, and may be suitable for redistribution or diversion to animal feed. The results from the primary scenario (which balances prevention, redistribution and diversion to animal feed) and the data from all scenarios are summarised in Table 6.7.

Table 6.7: Food surplus and waste tonnages from manufacturing scenarios[78]

Scenario	Prevention of arisings (t)	Additional redistribution (t)	Additional diversion to animal feed (t)	Resulting avoidable food waste levels (t)	Resulting total food waste levels (t)	Resulting surplus to redistribution (t)	Resulting surplus to animal feed (t)	Resulting overall surplus (t)	Resulting overall food waste and surplus (t)
1 - Maximum redistribution	0	100,000	-20,000	790,000	1,600,000	140,000	615,000	750,000	2,400,000
2 - Maximum animal feed	0	-10,000	170,000	710,000	1,600,000	27,000	805,000	830,000	2,400,000
3 - Reconciled redistribution / animal feed	0	75,000	140,000	655,000	1,500,000	110,000	770,000	880,000	2,400,000
4 - As (3) with prevention (Primary scenario)	150,000	70,000	130,000	520,000	1,400,000	110,000	765,000	870,000	2,200,000

[78] Excludes third party logistics, which would add a maximum 20,000 tonnes of redistribution potential (scenario 1), and 15,000 tonnes additional redistribution under scenarios 3 and 4, and 5,000 tonnes of food waste prevented from arising under scenario 4. Data within the table are rounded to 2SF

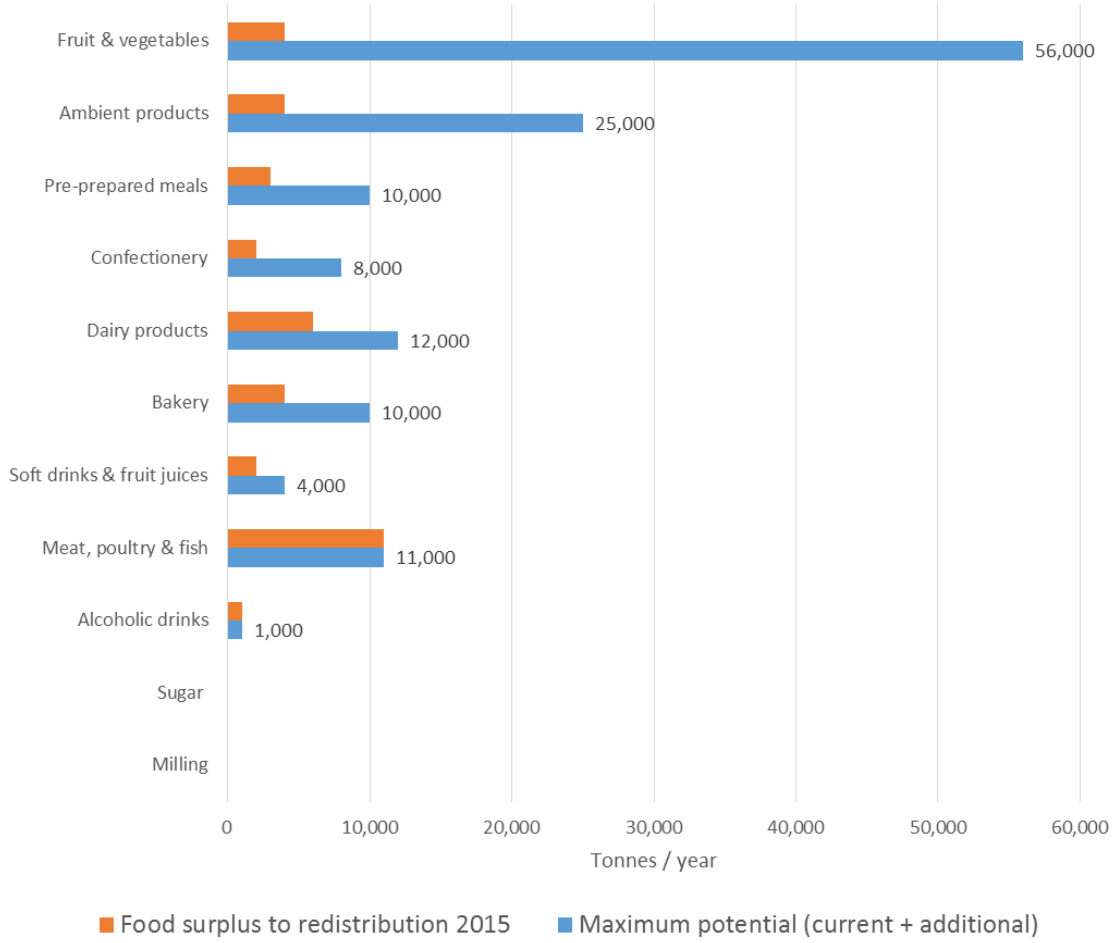
Scenario 1: maximum redistribution potential of food surplus within the manufacturing sector

Estimated current redistribution from the manufacturing sector is 37,000 tonnes, including both charitable redistribution (e.g. national, such as FareShare, and local charities) and commercial redistribution routes (through organisations such as Company Shop). This total does not include quantities donated by the public.

As shown in Figure 6.8, 2015 redistribution activity, totalling 37,000 tonnes is spread across all industry sub-sectors, apart from sugar and milling.

The potential to expand from this base was explored through site visits, discussions with site managers and representatives from the redistribution sector. The analysis presented in Figure 6.9 highlights the maximum potential for redistribution (Scenario 1), representing a total of 140,000 tonnes[79]. The greatest potential is from the fresh fruit and vegetables, confectionery, bakery and dairy sub-sectors. This is based on the characteristics of the surpluses likely to be available, rather than on any commercial considerations associated with businesses with surplus food or the infrastructure capacity within the redistribution sector.

Figure 6.8: Redistribution of food surplus from manufacturing sector: current estimates and maximum potential for the UK



[79] *This excludes the maximum potential from 3PLs which would add another 20,000 tonnes to this figure (see Section 6.3)*

The calculation of maximum redistribution potential prioritises redistribution over existing diversion to animal feed. Figure 6.9 shows how additional redistribution of surplus food might impact on existing flows across the different sub-sectors.

The highest potential exists in the fruit and vegetable sub-sector. Additional redistribution displaces food that would have been wasted as well as surplus currently used in animal feed. At the other end of the spectrum, within the meat, poultry and fish processing sector, extra redistribution is likely to take surplus from existing down-graded product markets rather than waste or surplus, so it has been excluded from the analysis. In this sub-sector the high value of the product means that the amounts of physical food waste or surplus are limited and 'waste' is associated with 'waste of value' rather than physical waste.

Figure 6.9: Redistribution of food surplus from manufacturing sector (Scenario 1): additional redistribution and predicted interaction with food waste and current surplus to animal feed (tonnes/year)

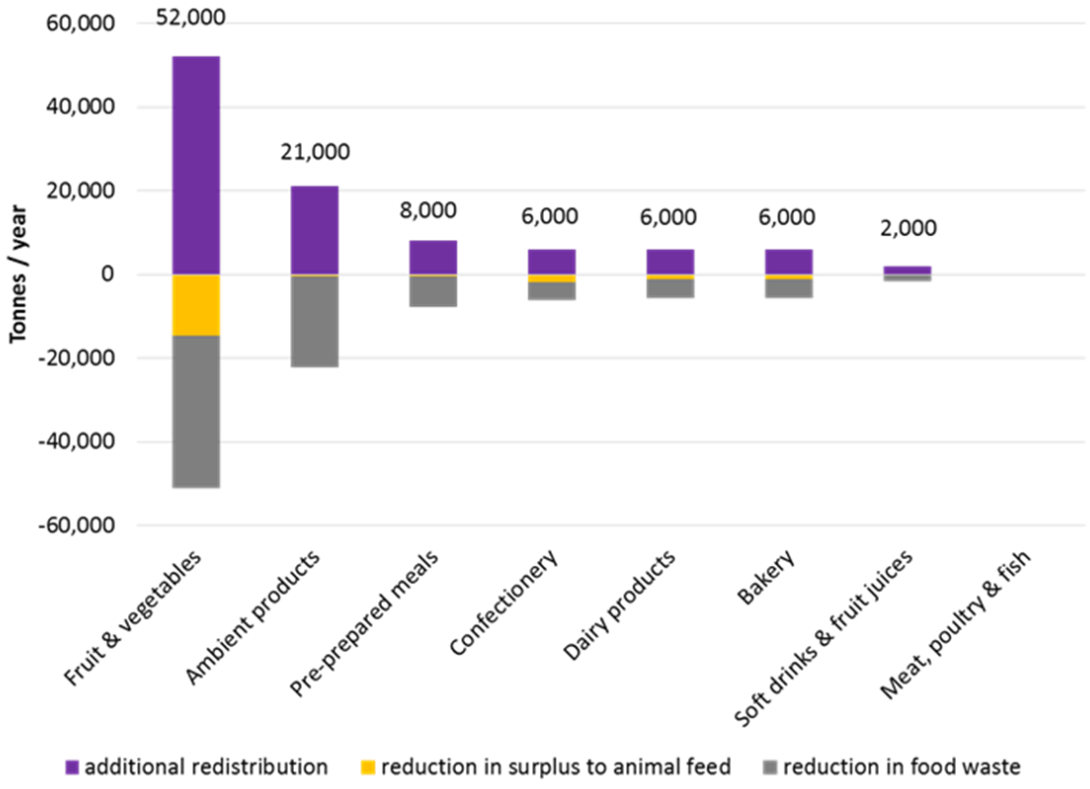
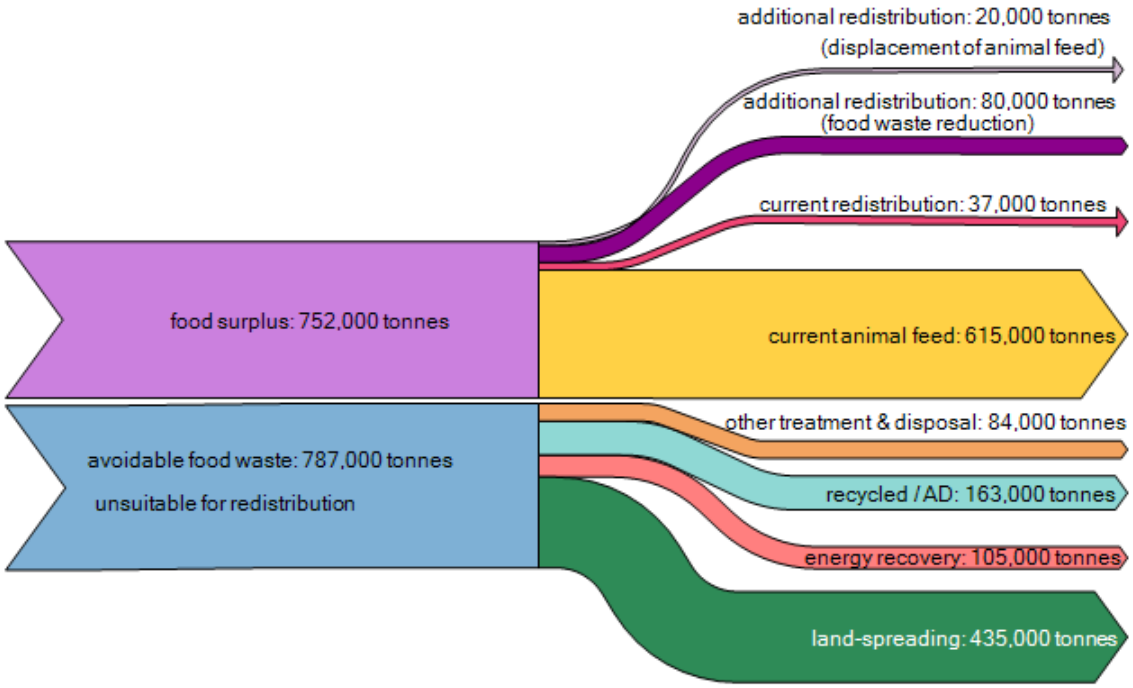


Figure 6.10 illustrates the food surplus and waste flows under the maximum redistribution scenario: with 20,000 tonnes of food surplus diverted from animal feed to redistribution and 80,000 tonnes of reduced waste arisings.

Figure 6.10: Maximum redistribution of food surplus from manufacturing sector (Scenario 1), flow of food waste and food surplus (tonnes/year)



Scenario 2: Maximum potential for diversion of food surplus to animal feed

The amount of food surplus from the manufacturing sector used in animal feed, either through general feed markets or direct to farm routes, is estimated to be 635,000 tonnes for the UK in 2015. This is generated by two main sub-sectors: 'bakery' and 'fruit and vegetables' (Figure 6.11), which together account for 80% of the surplus used in animal feed.

Ambient product and pre-prepared meal sectors are less likely to use this route, due to the restrictions on the use of food surplus as feed for farm animals, where there is a risk of ineligible ABPs being present. A particular problem in this respect is that bakery products containing ruminant gelatines cannot be used in animal feed[80].

The maximum potential for diversion of food surplus to animal feed is estimated to be 805,000 tonnes, drawing additional tonnage from all sub-sectors that have suitable feed material currently being sent for disposal. This scenario draws 10,000 tonnes of food surplus away from current levels of redistribution, but most of the additional surplus is from reduction of food waste arisings (Figure 6.12).

[80] *Supplying and using ABPs as farm animal feed, APHA guidance*

Figure 6.11: Use of food surplus from manufacturing in animal feed (Scenario 2) current estimates and maximum potential for the UK

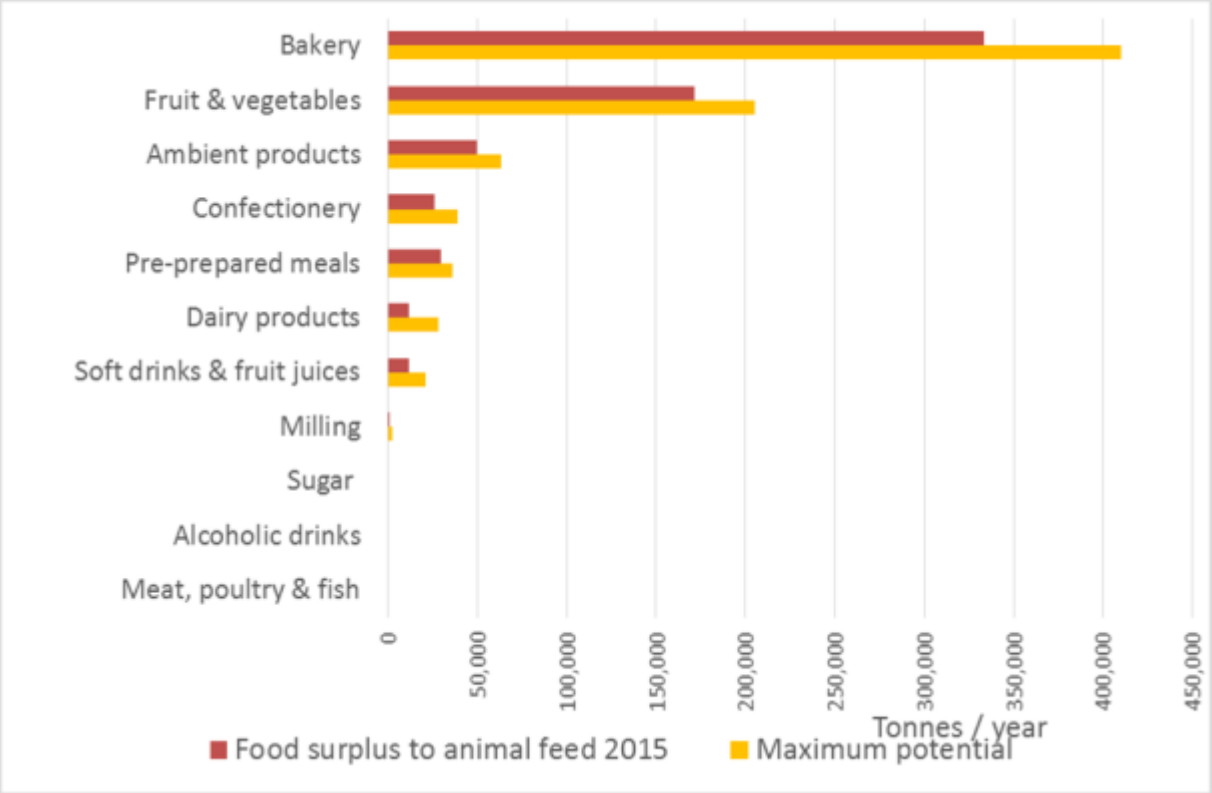
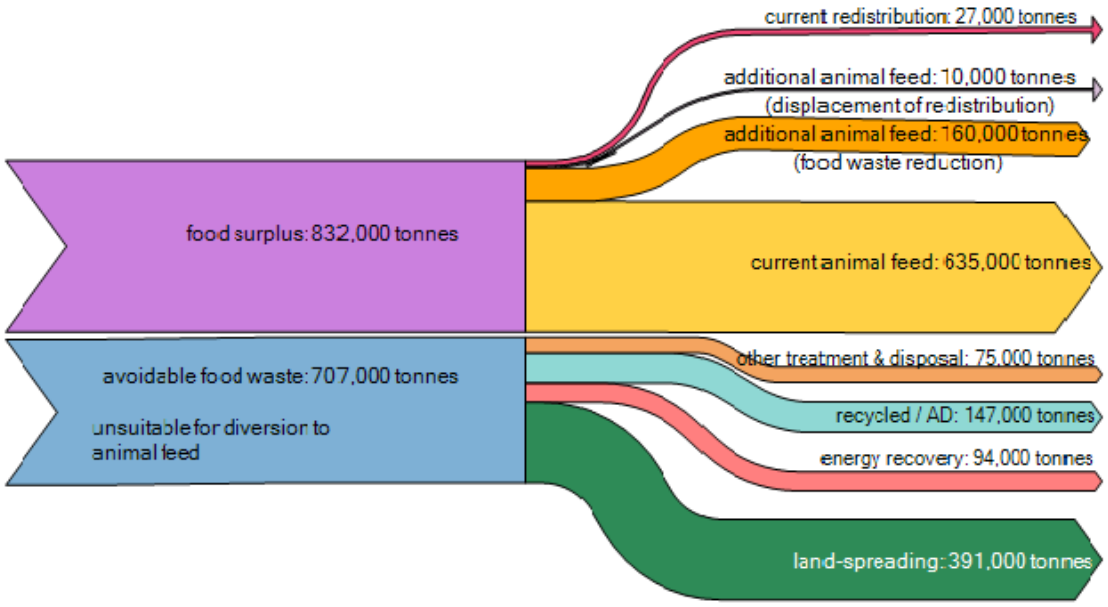


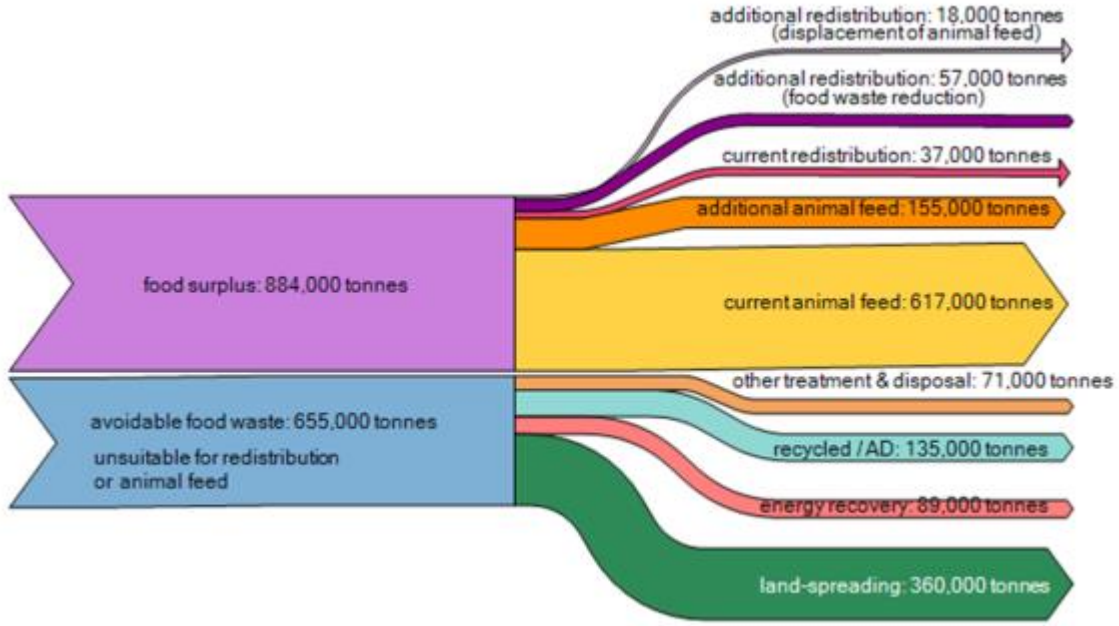
Figure 6.12: Maximum diversion of food waste surplus to animal feed from manufacturing sector (Scenario 2), flow of food surplus and waste (tonnes / year)



Scenarios 3 and 4: combined redistribution and animal feed scenarios with waste prevention optimised

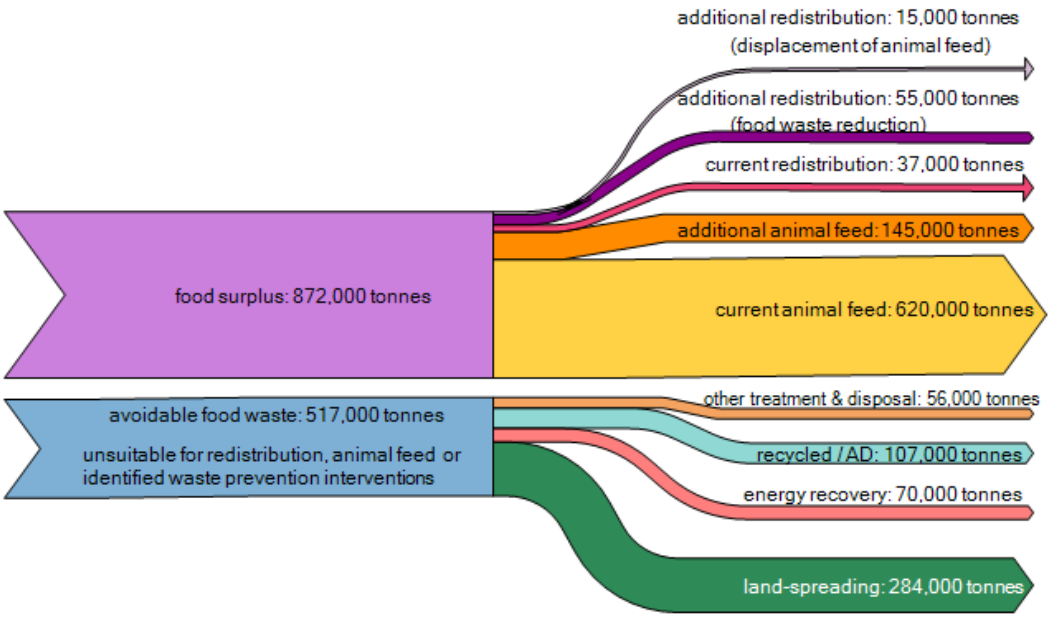
Taking the estimates from maximum redistribution and animal feed from scenarios 1 and 2, the combined scenarios are shown in Figure 6.13 and Figure 6.14. Both scenarios prioritise redistribution over animal feed, using judgements based on sub-sector site visits and data relating to the nature of current redistribution and diversion to animal feed (Appendices A to J). On this basis, scenario 3 reconciles the prioritisation of redistribution over animal feed, resulting in an overall increase of food surplus relative to scenarios 1 and 2. Scenario 4 applies the waste prevention interventions described in Section 6.2.4 to produce the optimised scenario with maximum overall waste prevention. This scenario provides the primary estimates used within Table 6.2 in conjunction with waste prevention and additional redistribution associated with the 3PL sector[81].

Figure 6.13: Combined scenario for food surplus redistribution and diversion to animal feed for manufacturing sector (Scenario 3), flow of food surplus and waste (tonnes/year)



[81] *See section 6.3 for more detail*

Figure 6.14: Waste prevention optimised scenario for manufacturing sector (Scenario 4), flow of food surplus and waste (tonnes/year)



6.3 Third party logistics

A range of different disposal routes are used for food surplus and waste occurring in 3PL operations, including anaerobic digestion and some redistribution to humans (estimated to be 5,000 tonnes per annum). The initial research conducted during this project suggests that more food could be redistributed rather than being sent to routes such as AD, where some products on a pallet have been damaged and others have not. However it is believed that in many instances the processes and protocols for separating these products, gaining approval from the manufacturer and engaging with the redistribution sector are not sufficiently well defined and, in the case of short-life products, may not happen rapidly enough to allow the products to be redistributed appropriately.

Whilst the information on food surplus / waste occurring as part of 3PL operations gathered during this project cannot be assumed to be fully representative of the wider industry in the UK, it does provide a range of useful insights into this sector, including:

- Food waste occurs in relatively small volumes compared with throughput;
- There are a number of different causes of food waste e.g. handling errors, packaging failures and product life issues. In the case of chilled products, any breaks in the chill chain will also result in food being wasted;
- Ownership of the stock often remains with the product manufacturers and it is the manufacturers that therefore decide how any damaged or returned items should be handled; and
- Relationships between 3PLs and redistribution organisations are currently limited.

As with the food manufacturers, 3PLs are keen to prevent food waste and are interested in understanding the various opportunities available for handling any surpluses.

The scale and types of food surplus / waste occurring within the third party logistics element of the supply chain are not well documented and are not covered by EP data. However,

using the limited information from redistribution organisations and an assessment of the possible interaction between 3PLs and retailer distribution centres, it is estimated that:

- There is potential to redistribute 15,000 tonnes of food surplus, currently sent mainly to AD (provided that suitable agreements are in place with suppliers and all of the other caveats that apply to redistribution estimates in relation to the use of food surplus at manufacturing and retail stages). Given the limited amount of data available on the 3PL sector, this estimate is based on data obtained from redistribution organisations extrapolated across the number of 3PL depots across the UK;
- In line with the waste prevention measures identified for the retail sector, it is estimated that 5,000 tonnes of food waste could be prevented through reduced product damage, product life extension and better demand forecasting along the supply chain (there is limited evidence to support this estimate and so it should be regarded as indicative only); and
- There is considerable overlap between retail RDCs, product returns and 3PLs, as consignment rejects at RDCs are often returned to a 3PL warehouses, or may form part of what is redistributed from RDCs on behalf of retail suppliers; this overlap has not been fully defined and is not so far reflected in standard reporting protocols for the retail sector.

It is recommended that further work be conducted to understand the scale and type of surplus / waste arising within the food and drink logistics sector and to identify the most effective and efficient way of handling these.

6.4 Grocery retail

6.4.1 Overview

The UK retail sector is dominated by a small number of large players with the top eight outlets accounting for over 90% of the market share and the four major retailers (Tesco, Asda, Sainsbury's and Morrisons) accounting for over 70% of market share.[82]

It is estimated that 210,000 tonnes of food was wasted from stores and RDCs within the retail sector in 2014. Members of the British Retail Consortium (BRC)[83] reported wasting 180,000 tonnes in 2014, compared to 200,000 reported in 2013[84]. WRAP estimates a further 30,000 tonnes of food waste was generated by smaller retail businesses[85].

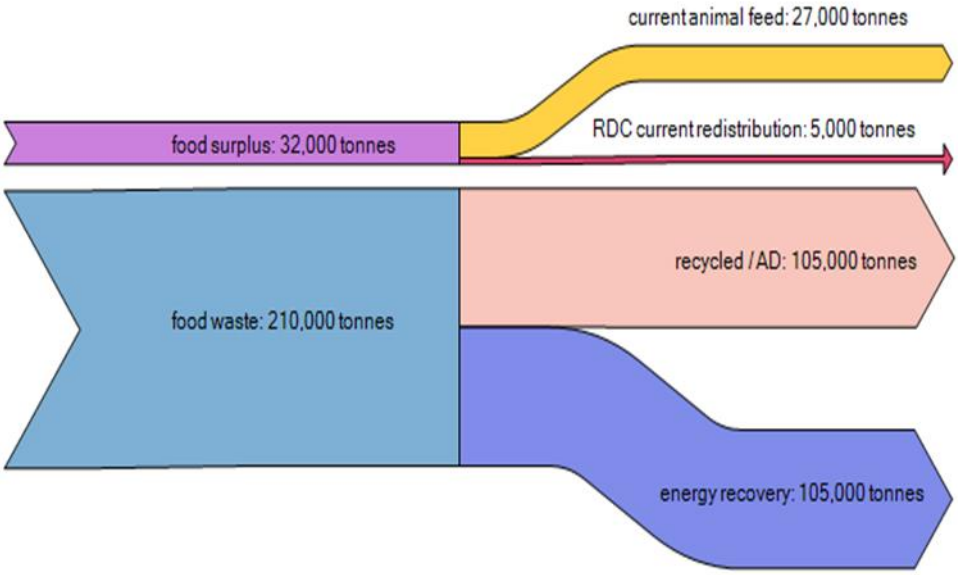
Limited amounts of published information are available on the food wasted in retail outlets and depots. The first actual figures for the sector were published by the BRC in 2013; however no breakdown by food category, type of outlet, reason for wastage or fate is currently provided. The only retailer to have made its food waste figures public is Tesco, which reported generating 55,400 tonnes of food waste in the 2014-15 financial year in its UK operations[86]. However this includes surplus which is sent to animal feed, which is not classified as food waste under the FUSIONS definition or within this report.

6.4.2 Findings summary

Figure 6.15 shows the current material flows for the UK retail sector. This includes independent retailers and discount retailers as well as the stores reporting under the BRC initiative.

[82] *KantarWorldpanel (2015), Grocery Market Share (12 weeks ending 6.12.2015). [Accessed 8th January 2016]*
[83] *The participating retailers were: Asda, The Co-operative Food, M&S, Morrisons, Sainsbury's, Tesco, and Waitrose*
[84] *BRC (2015), The Retail Industry's Contribution to Reducing Food Waste.*
[85] *WRAP (2015), Estimates of Food and Packaging Waste in the UK Grocery Retail and Hospitality Supply Chains.*
[86] *Tesco (2015), Annual Report and Financial Statements 2015.*

Figure 6.15: Flow of retail food surplus and waste in 2014



Although detailed figures on the management method of these waste streams are not available, information provided to WRAP by Courtauld signatories suggests that around half of this waste is recycled, principally via AD and composting, whereas the rest is recovered through thermal treatment[87].

In addition it is estimated that around 32,000 tonnes of food surplus is sent to either animal feed (27,000 tonnes) or redistributed (5,000 tonnes). Current retail redistribution initiatives have mainly focused on RDCs sending food to redistribution that would otherwise have been returned to suppliers, although a proportion may relate to damage caused within depots.

Surpluses in distribution centres can relate to a number of different causes, such as over-orders, surplus seasonal products, non-conformity with agreed 'minimum shelf-life on receipt' criteria and over-delivery by suppliers. There are no published estimates on this route and much of the public-domain information on current redistribution from depots reports quantities in terms of 'meals served' rather than total tonnage of surplus diverted. The estimates have therefore been derived from a combination of interviews with retailers, site visits and conversion of 'meals served' statistics to tonnes redistributed.

6.4.3 Main causes of retail food waste and assessment of waste prevention potential

The main causes of retail food waste relate to either product damage or product that is 'out of code'. The high-level retailer statistics do not differentiate between the range of issues beneath these general headings that contribute to wastage. However, observations during store site visits provide an indication of this, albeit from a series of single day 'snap shot' visits and interviews with staff.

Table 6.8 provides selected examples of retail food waste encountered during the site visits and/or identified during interviews with the store and depot teams. These instances of food waste highlight the range of underlying factors associated with 'out of code' and 'damaged product', as well as a number of cases that do not readily fit either category.

[87] *WRAP (2015), Estimates of Food and Packaging Waste in the UK Grocery Retail and Hospitality Supply Chains.*

'Out of code' products can be explained partly by a surplus in store (possibly through poor ordering or unforeseen local factors) or by a failure of product 'mark down' policies to clear the products within date. The mark-down policies operated by the retailers differed in terms of the level of flexibility given to store staff to set the timing and the extent of price reductions that could be applied. Although greater flexibility was generally more effective at reducing food waste, this places greater responsibilities on staff, at the expense of time available for serving customers or other duties. At the larger participating stores, 'waste huddles' reviewed all items of food waste accumulated during the day. A proportion of items were products that had not been marked down because they had been missed, including items that had been hidden behind other products in the store.

Table 6.8: Examples of food waste encountered during retail store visits

Out of code: examples	Damaged product: examples	Other reasons: examples
Date expired product hidden behind younger stock and missed by staff during mark-down	Crushed/ misshapen packaged bread loaves	End of promotion stock – ambient product, tins of biscuits
Too much product of the same date code ordered at the same time (e.g. due to shelf space and merchandising requirements) and batch not cleared in time, unable to clear using mark-down pricing	Multipack yoghurt product, with one broken item	Over-ordered Christmas cakes, consumer demand lower than anticipated
Marked-down product from a set of aisles placed in clearance well, poorly positioned	Caster sugar/ flour / rice bags split as a result of customer handling	Previous day's bananas given to redistribution to make room for new stock
Major road works around store: counters left with unsold fish and meat	Broken/ split bananas/ slight blackening on broccoli	End of line clearances
ISB: master-baker on half-day leave, baked too much bread in morning to cover absence	Wine bottles dropped in aisle	Class (I) bagged vegetables including a single non Class (I) item: all discarded
Soft fruit in punnets: date expired (use by date) but still good to use	Damaged egg boxes containing broken eggs discarded along with other boxes stained by leakage	
Newly opened store, food waste high in fresh produce, at counters and deli as ordering systems not well aligned to customer demand	Ice cream with ice damage caused by 'temperature abuse' in supply chain	

Instances of food waste caused by damage covered a number of circumstances ranging from complete product destruction (e.g. broken jars and bottles) to superficial damage to packaging and/ or products. For certain more fragile products or those which are less robustly packaged, damage is the main reason for waste occurring (drinks, eggs, ambient products such as sugar and flour).

Assessment of food waste prevention opportunities through improved in-store handling and packaging innovations to reduce damage suggests that an estimated 15,000 tonnes of waste

could be prevented across the retail sector. This represents a 15% reduction in total damaged product. Further work on factors that cause damage within different food product categories would be needed to focus this effort and also to establish the extent to which damage occurs in RDCs, where improvements to tertiary packaging may be needed.

An element of surplus product in store that contributes to product not sold in time relates to poor demand prediction, by retailers nationally and at the local store level. Some of the instances found during site visits related to particular unforeseen (or poorly managed) local circumstances. Stores that have recently opened tend to experience higher quantities of food waste as they establish a more precise profile of customer demand and get better at ordering the appropriate quantities that are likely to sell. Similarly, events such as road works, competitor activity and unpredicted periods of cold or warm weather, can disrupt demand prediction. Better models for predicting demand fluctuations across a range of episodic and more regular and seasonal factors would be needed to reduce an element of food surplus relating to this aspect. Across the retail sector, as a minimum a further 5,000 tonnes of prevented food waste could be anticipated through better demand forecasting.

Data from WRAP's report on product life extension[88] was used to estimate the potential to reduce quantities of date expired product contributing to retail food and drink waste. For each main product category, quantities of date expired losses were estimated from the retailer datasets. The waste reduction potential was then calculated using estimates of waste reduction in date expired losses from extending available life by one day contained within the WRAP report. For the UK retail sector the waste reduction potential was 10,000 tonnes per annum, or approximately 10% of 'out of code' food and drink waste.

The set of measures to reduce retail food waste in Table 6.9 represent 30,000 tonnes of potential, equivalent to 12% of retail food waste and surplus.

Table 6.9: Retail prevention of food waste arising: overall summary

Food waste prevention measures	Tonnes per annum prevented
Product damage reduction through improved handling and packaging design	15,000
Improvements in ordering and demand prediction	5,000
Product life extension	10,000
Total	30,000

6.4.4 Scenarios developed to assess utilisation of food surpluses

As for manufacture various factors will influence the implementation of interventions to prevent food waste and the timescales for these, and a similar range of scenarios were developed to reflect this. These included one maximising the amount of food that may be suitable for redistribution (including some that may be challenging due to very short shelf-life), one that maximises surplus to animal feed (assuming more of the material that is suitable for animal feed is diverted to the former) and a scenario that reconciles these two, prioritising redistribution but acknowledging that some surplus may be more likely to be effectively diverted to animal feed (reducing the risk that it becomes waste). A final scenario includes the implementation of actions to prevent food waste arising. These give rise to a range of potential tonnages that may be prevented, and may be suitable for redistribution or diversion to animal feed. The results from the primary scenario (which balances prevention, redistribution and diversion to animal feed) and the data from all scenarios are summarised in Table 6.10.

[88] *Reducing food waste by extending product life*

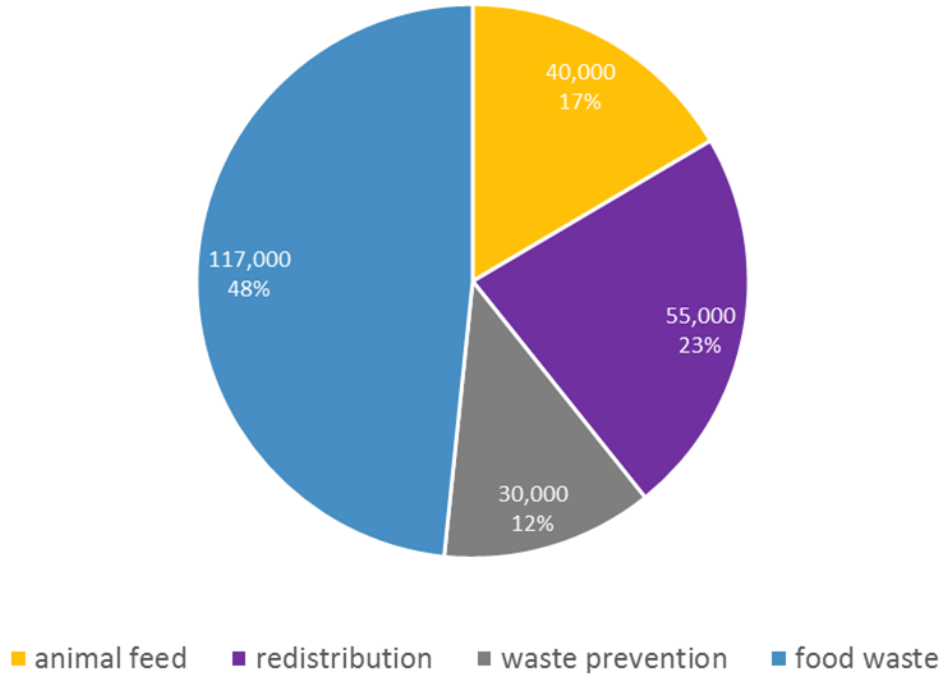
Table 6.10: Food surplus and waste tonnages from retail scenarios[89]

Scenario	Prevention of arisings (t)	Additional redistribution (t)	Additional diversion to animal feed (t)	Resulting food waste levels (t)	Resulting surplus to redistribution (t)	Resulting surplus to animal feed (t)	Resulting overall surplus (t)	Resulting overall food waste and surplus (t)
1 - Maximum redistribution	0	100,000	-17,000	123,000	110,000	10,000	120,000	242,000
2 - Maximum animal feed	0	42,000	24,000	144,000	47,000	51,000	98,000	242,000
3 - Reconciled redistribution / animal feed	0	52,000	16,000	142,000	57,000	43,000	100,000	242,000
4 - As (3) with prevention (Primary scenario)	30,000	50,000	13,000	117,000	55,000	40,000	95,000	212,000

[89] *Data within the table are rounded to 2SF*

The primary estimates produced from the primary scenario 4 suggest that 52% of current retail food surplus and waste could be prevented at source or diverted to redistribution and animal feed (Figure 6.16). In constructing these estimates the detailed food product categories within the retailer food waste datasets were used to explore the upper and lower limits of redistribution and animal feed, coupled with site visits and discussions with retailer and redistribution organisations.

Figure 6.16: Overall potential for retail prevention of food waste arising, redistribution and diversion to animal feed (Scenario 4)



6.4.5 Scenario 1: maximum redistribution

The food waste data provided by three retailers, including waste generated in store and at RDCs, permitted the differentiation of 'use-by' and 'best before' dates, food removed from sale/depot due to damage and by food product category. Through site visits at participating retailers and interviews with key stakeholders, a number of criteria were developed and applied to the data to estimate total redistribution potential for the retail sector for food surplus at back of store and at RDCs (as described in Section 4.3.1).

Back of store redistribution potential

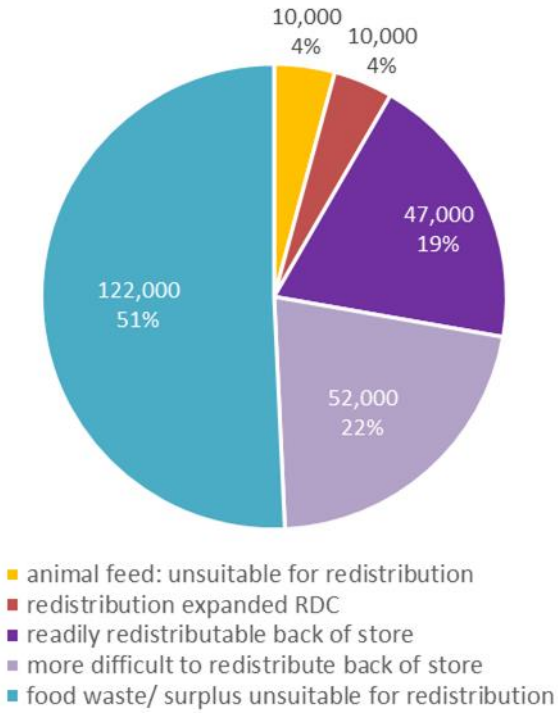
According to Scenario 1, 58% of food waste generated in the retail sector is considered to be unsuitable for redistribution (Figure 6.17) either because it is damaged or because its shelf-life has expired and it would therefore be unsafe for redistribution. The latter mainly comprises food products at retail stores with expired 'use-by' dates, (e.g. meat, fish and poultry), which pose a health risk after date expiry and should not be consumed beyond such dates. In addition a percentage of fresh produce is included in this category as these are found to be too ripe to be consumed or mouldy.

There was no differentiation within the retail datasets around the extent or nature of any product damage. In the light of this, it was necessary to assess the extent to which damaged product would still have packaging integrity or might involve an element that could be safely recovered (e.g. damaged multipacks). Overall, as a result of site visits and discussions with redistribution organisations it was assumed that 75% of the 102,000 tonnes of food waste arising due to damages would be unsuitable for redistribution, but that 25% of damaged

products with 'best before' dates could be safely redistributed. This precautionary approach reflects damage that doesn't compromise food packaging integrity, as well as where product recorded as 'damaged' is actually withdrawn from sale for other reasons, such as mis-labelling or clearance of discontinued product lines.

As Figure 6.17 shows, 45% of the surplus and waste materials generated by the retail sector is suitable for redistribution, with approximately equal proportions of 'readily redistributable' and food surplus that is 'more difficult to redistribute". If it is assumed that the majority of retail food waste is dominated by back of store rather than depot losses, the data can be used to represent the profile of what might be available for back of store redistribution.

Figure 6.17: Maximum redistribution (Scenario 1), % retail food surplus/waste by type



The readily redistributable food is mainly composed of long lasting ambient products, e.g. canned and dried foods, and part-baked bakery products. Frozen products are also safe to be redistributed, provided the products are handled correctly and maintained at the required temperatures at all times, or if defrosted, used within the stated period. Around half of fresh fruit and vegetable products are also thought to be readily redistributable, with most of the remainder classified as damaged products. A small percentage of the latter were assumed to be suitable for redistribution after further processing. For example, these products could be used for baking, smoothies or soups. In addition, loose produce may need repackaging before it can be safely redistributed.

18% of bakery product was classed as 'readily redistributable' as this proportion is likely to be edible for up to 48 hours after baking. This was based on discussions with the redistribution sector and store visits. The majority of this surplus was classified as 'redistributable but in need of some work', for example, through freezing in store or soon after collection. The estimates produced under the 'maximum' redistribution scenario include any In Store Bakery (ISB) bread that may be currently segregated by retailers for diversion to animal feed.

The overall estimates are very sensitive to assumptions associated with ISB and fresh produce, as these account for a high proportion of total food surplus / waste across all of the retailers participating in the study and was also evident from the store site visits. These findings may not be representative of the sector as a whole, as the proportion of overall sales accounted for by fresh produce and ISB products in non-participating retailers may differ.

Retail food surplus redistributed from depots

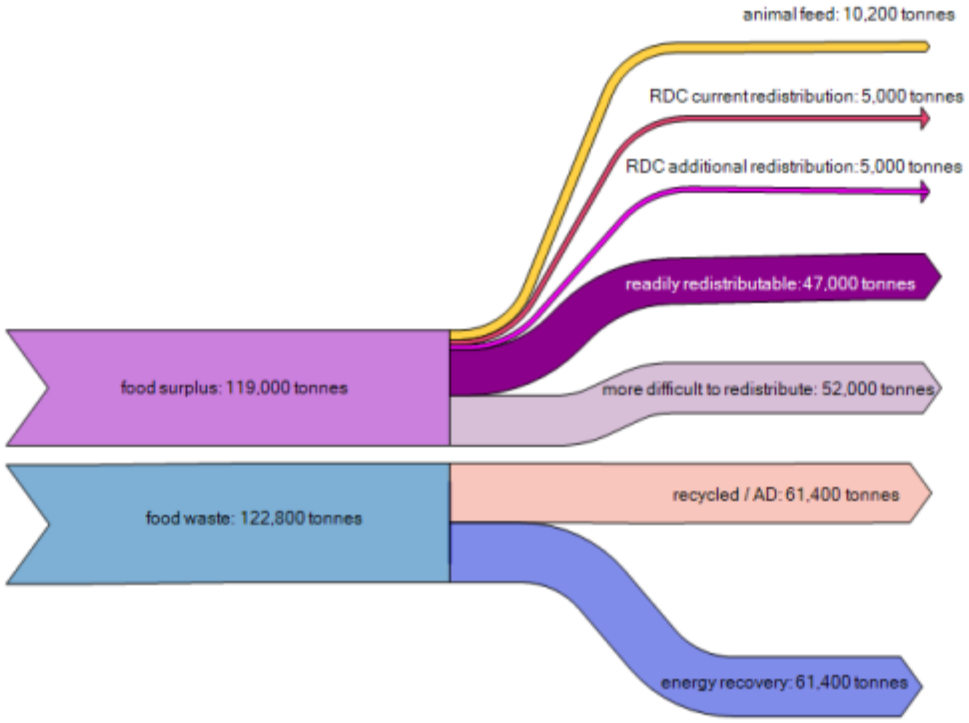
Surpluses arising within depots are easier to redistribute as they are likely to have more remaining shelf-life than unsold food surplus arising at retail stores. Depots also represent more significant point sources of surplus, compared with smaller quantities arising from a large number of stores. Based on current levels of redistribution across retail depots and the recent announcements about expansion plans from many of the retailers, an overall estimate was made of additional depot food redistribution. This also considered the expansion to a full range of food temperatures, extrapolating data obtained from existing sites across all UK RDCs. This assessment identified an additional 5,000 tonnes of surplus suitable for redistribution. It is likely that the majority of these surpluses if not redistributed would otherwise have been returned to suppliers or their 3PLs, rather than become food waste at the RDC.

The maximum redistribution scenario (Figure 6.18) demonstrates the full extent of retail redistribution potential, based solely on the assessment of food surplus characteristics, rather than any commercial or capacity limitations. It also prioritises redistribution over animal feed for surplus bakery products, thus reducing the current diversion of ISB to animal feed.

This scenario results in 49% of the food materials flow, including both surplus and waste (242,000 tonnes), being classified as a food surplus and 51% remaining as a food waste. The expanded total redistributed (110,000 tonnes) includes 52,000 tonnes of more difficult to redistribute items, 47,000 tonnes of more readily redistributable food surplus, as well as the expansion of redistribution from RDCs.

These overall findings are subject to a number of significant caveats associated with the datasets used. These have been summarised in Section 5.2.

Figure 6.18: Maximum redistribution (Scenario 1), flow of food surplus and waste generated by the retail sector



6.4.6 Scenario 2: maximum diversion to animal feed

Using a similar approach to the redistribution analysis, scenario 2 maximises diversion to animal feed, using the detailed retailer datasets and extrapolating the results to the retail sector as a whole. For illustrative purposes, the analysis prioritised diversion to animal feed over redistribution[90] (Figure 6.19), whilst diverting only food surplus eligible for use in feed in terms of Animal By-Product Regulations. With diversion to animal feed expanded across the retail sector, the maximum potential was slightly less than double the current surplus that is sent to animal feed at 51,000 tonnes per annum (Figure 6.20). Under this scenario 47,000 tonnes of food surplus were redistributed as they were ineligible for use in animal feed. It should be noted that this estimate is highly sensitive to assumptions about the proportion of unsold ISB products within retail food waste, particularly in relation to those not participating in the project.

[90] *Note: this may be relevant more in the shorter term until efforts to prevent more surplus/waste arising are embedded and infrastructure established to redistribute more*

Figure 6.19: Maximum diversion to animal feed (Scenario 2), % retail food surplus/waste by type

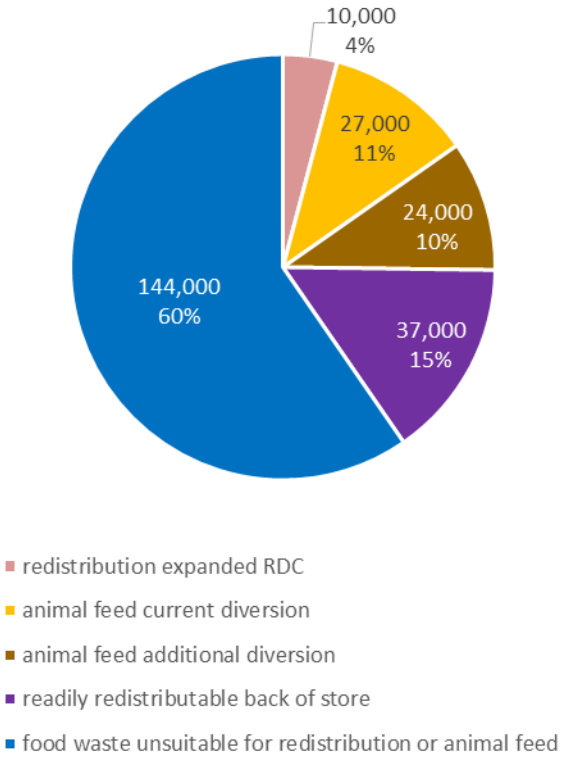
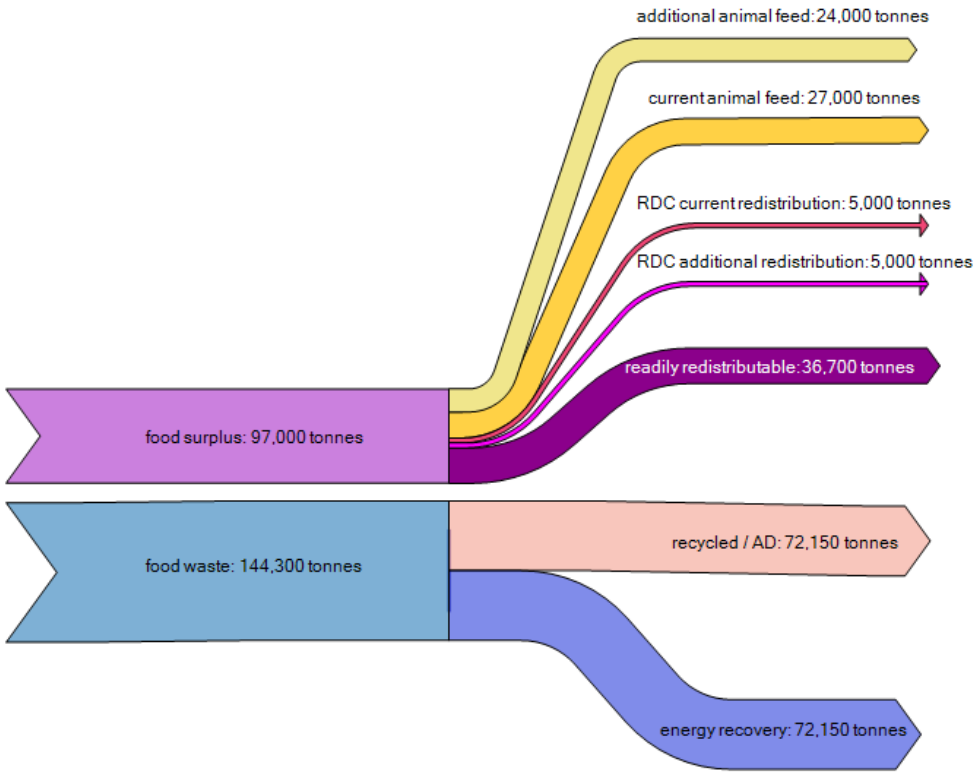


Figure 6.20: Maximum diversion to animal feed (scenario 2), flow of food surplus and waste generated by the retail sector



6.4.7 Scenario 3: combined redistribution and animal feed

The third scenario takes account of the overlap between the maximum redistribution and maximum animal feed scenarios, using the following criteria:

- More difficult to redistribute bakery categories are sent to animal feed (in compliance with all ABP requirements);
- Readily redistributable bakery categories are allocated to redistribution;
- The remaining material is classified as food waste i.e. unsuitable for either redistribution or animal feed; and
- None of the 'more difficult to redistribute' food surplus is redistributed (Figure 6.21), as the majority of it consists of unsold ISB products suitable for animal feed. In this scenario a total of 41% of unsold food from the retail sector becomes food surplus used in redistribution or animal feed.

Figure 6.21: Retail sector combined redistribution and animal feed (Scenario 3)

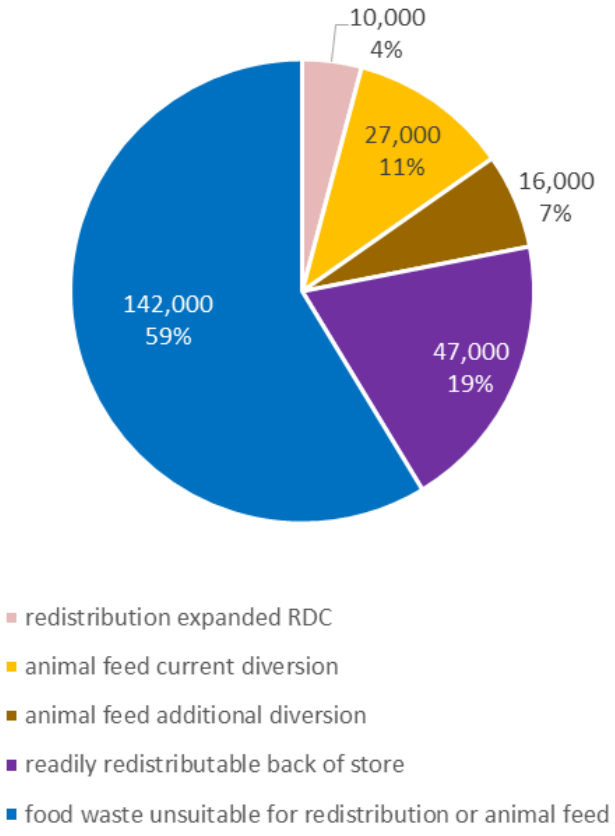
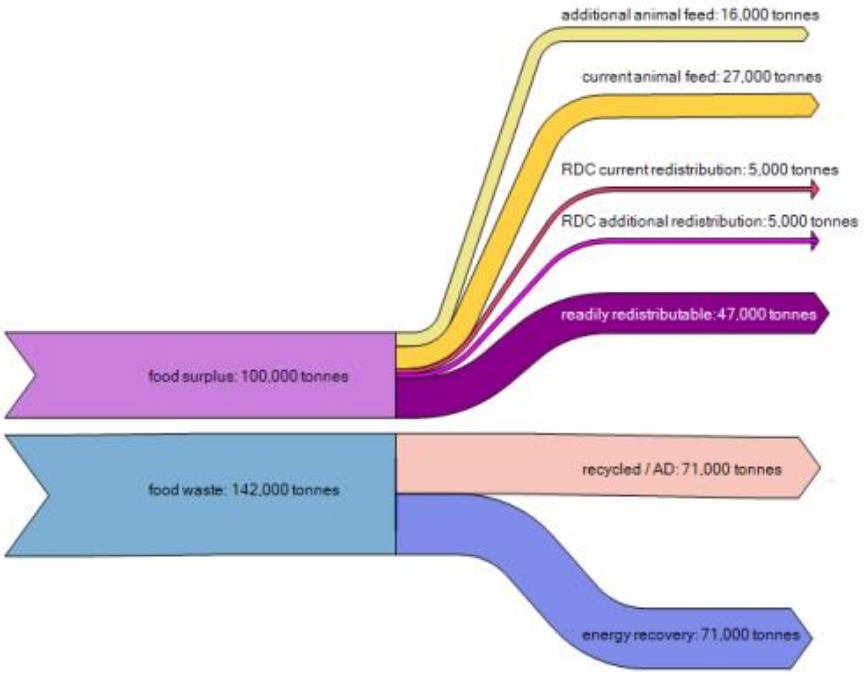


Figure 6.22 shows flows of food surplus and waste generated by the retail sector in the combined scenario.

Figure 6.22: Retail sector combined redistribution and animal feed (scenario 3), flow of food surplus and waste generated by the sector



6.4.8 Scenario 4: primary scenario: food waste prevention, redistribution and animal feed

The final assessment involved examining the interaction between food waste prevention measures (e.g. extended shelf-life, damage reduction and improved demand forecasting) and scenario 3 redistribution and diversion to animal feed. As much of the animal feed diversion potential was associated with ISB, it was assumed that the waste prevention measures such as product like extension and damage reduction would not significantly reduce the surplus available for animal feed (Figure 6.23, Figure 6.24 and Table 6.11). A reduction in food redistribution potential was linked to extended product life and better retailer ordering systems and demand forecasting.

Figure 6.23: Retail sector combined redistribution and animal feed with waste prevention optimised (scenario 4), flow of food surplus and waste generated by the sector

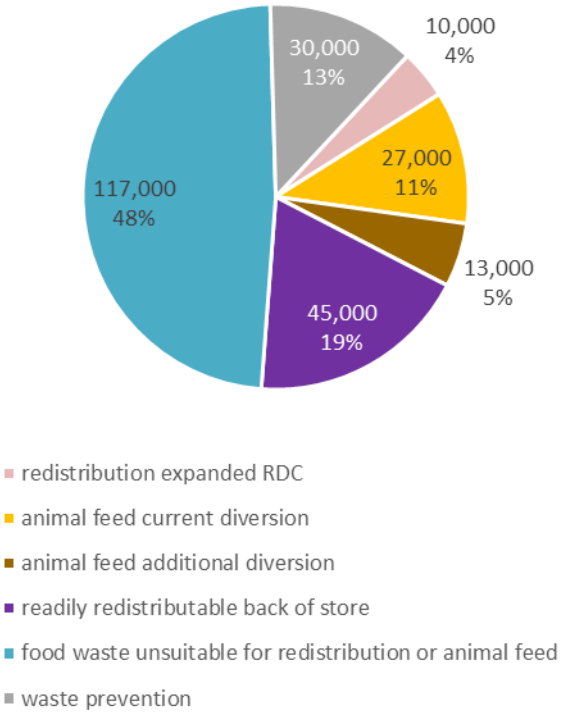


Figure 6.24: Retail sector combined redistribution and animal feed with waste prevention optimised (scenario 4), flow of food surplus and waste generated by the sector

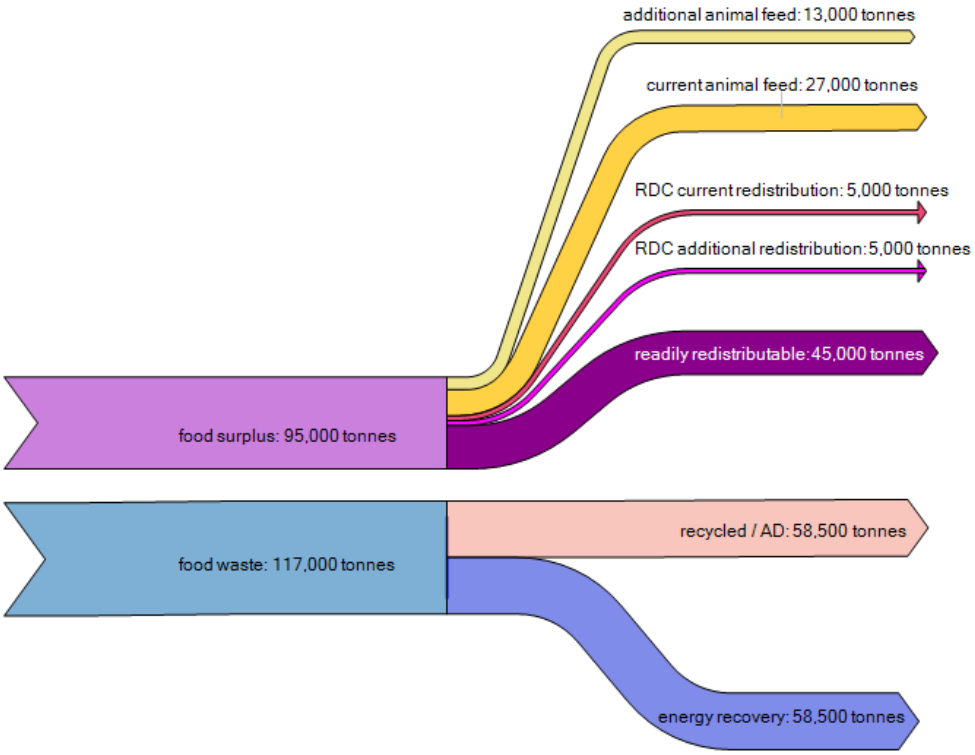


Table 6.11: Retail food waste prevention: overall summary of additional redistribution and diversion to animal feed

	Scenario 3; no additional waste prevention measures implemented additional redistribution and diversion to animal feed	Scenario 4, additional waste prevention measures fully implemented, additional redistribution and diversion to animal feed
Redistribution	52,000	50,000
Animal feed	16,000	13,000

7.0 Conclusions and recommendations

Building on the previous research published in 2013[91], this study has produced more detailed estimates of food surplus, food waste and by-products arising from the UK manufacturing and grocery retail sectors. In addition, this analysis has estimated the potential to shift material up the food material/waste hierarchy through prevention at source, increased redistribution and diversion to animal feed. It also shows that the food manufacturing and retail sectors in the UK are highly efficient, with less than 5% of production ending up as food surplus or waste, and that food waste levels are lower than previously reported. By building on efforts made to date, both the retail and manufacturing sectors have a significant potential to work towards better utilisation of food and drink through waste prevention measures with the overall potential to reduce avoidable food waste across these two sectors by 42% or 450,000 tonnes per annum by 2025.

Prevention at source could save almost £300 million a year worth of food going to waste (155,000 tonnes at manufacture and 3PL, and 30,000 tonnes at retail). In terms of adhering to the food utilisation or waste hierarchy this is the priority for action and there are a suite of resources available from WRAP to help support this. This research has highlighted again that the drivers of food waste arising are many and varied, and whilst some can be addressed through individual company action, others will need the kind of collaboration that Courtauld 2025 aims to foster.

Where food surplus or waste cannot be prevented, there is potential to increase both redistribution and diversion to animal feed.

The majority of the additional material suitable for redistribution within retail arises at store level (45,000 tonnes out of the additional 50,000 tonnes from the primary scenario), whereas currently the majority of material redistributed from retail originates from distribution centres (RDCs). Redistribution from back of store faces extra challenges due to the intermittent nature of surpluses arising across a large number of sites, often involving products with limited remaining shelf-life and the need to match the amounts and types of surplus arising with the needs and capabilities of recipients in the local area.

The 2015 estimates for redistribution from retail also pre-date the more recent and significant increase in activities by retailers working with the redistribution sector to expand redistribution from stores. All of the major retailers are carrying out initiatives aimed at store-level redistribution, and/or looking at how to maximise distribution from RDCs and make it easier for their suppliers to redistribute surplus food[92], and many have announced plans to scale these up over the coming years. A comparison between recent pilots and earlier ones[93] suggests that experience and improved guidance are leading to increases in the amounts that can be practically redistributed from stores. Data shared in confidence with WRAP from some of these initiatives suggest that the estimates from the primary scenario modelled within this research are not unrealistic.

Retailers and manufacturers are already doing a lot to ensure suitable food surplus is being made available for redistribution[94], and under Courtauld 3 signatories reported a 74%

[91] *Estimates of waste in the food and drink supply chain, WRAP 2013*

[92] *For example see M&S launches nationwide surplus food redistribution scheme to support local food charities; Morrisons to roll out programme to find home for unsold food in stores; Tesco commits - no food that can be eaten to go to waste from stores; Waitrose surplus food and food waste disposal; Surplus food redistribution case study Sainsburys, Cardiff; Co-operative Food commits to redistributing a million meals ; Asda - we're tackling food poverty by extending our work with FareShare*

[93] *For example Food Connection Programme trial vs Piloting retail store surplus food redistribution and use in Wales*

[94] *A range of case studies can be found at Surplus food redistribution (WRAP), Who do we work with? (Fareshare) and Waste Prevention Case Studies (IGD)*

increase in the amounts being redistributed between 2012 and 2014. There are greater volumes of food surplus suitable for redistribution from manufacturing and 3PL, and encouraging this will be a priority under Courtauld 2025.

Whilst good progress has been made in the redistribution of food surplus that cannot be prevented, and the results of recent trials at back of retail stores look promising, it will be important to monitor progress over time, assess existing and potential new barriers and develop mechanisms to share learnings and overcome these barriers. From discussions with stakeholders involved in this research these barriers are likely to differ between large and small businesses, and retailers and manufacturers. There are however clear opportunities to further raise awareness of what foods are suitable for redistribution, and the benefits this can bring to businesses, staff and communities. WRAP will be developing its 'Your Workplace Without Waste' training and resources to incorporate topics around making best use of surplus food, and through Courtauld 2025 signatory meetings encouraging businesses to make use of these and other materials. This will complement on-going work by the redistribution sector with food businesses. Identifying suitable recipients for surplus food can also be a challenge, particularly if businesses want to use both national and local organisations. There are now a range of guidance materials and initiatives to facilitate this, and case studies to illustrate success.

There are opportunities to increase redistribution through reviewing redistribution sector policies to accepting food beyond their 'best before' date (where there is no food safety risk, and quality if still acceptable – for example whilst some recipients accept fresh fruit and vegetables or bread past the 'best before' date, others do not and most do not take other foods such as ambient goods beyond the date). There are also practical steps that can be taken to help increase the safe redistribution of chilled and frozen food.

The 2015 estimate of food surplus used in animal feed was dominated by two main sources: the bakery and fruit and vegetable sub-sectors which together account for 80% of the total. Additional potential to divert more to animal feed exists across all non-meat sectors, where surplus can be safely segregated at source thereby avoiding any risk of contamination from material containing animal by-products that are prohibited from use in animal feed. The estimates of future animal feed potential take into account the increases seen between 2011 and 2015 in amounts of food surplus being used for animal feed production, concluding that further potential exists for additional food surplus diverted to this route. For more complex manufacturing sites with multiple production lines with both 'ABP' and 'non-ABP' areas, this will require a better understanding of the flows of suitable material from production areas and the extent to which they can be safely segregated, in line with animal feed hygiene regulations.

Discussions with retailers and manufacturers highlighted the importance of both their staff and enforcement agency staff having clear and consistent guidance on how to store surplus food prior to sending this for animal feed, and identified this as a key barrier to increasing volumes sent via this route.

For diversion to animal feed, the study also noted considerable interaction with redistribution of surplus, as would be anticipated (as some sources of surplus will be suitable for both). However, whilst some food surplus that is currently being diverted to animal food is suitable for redistribution to people and should take this route, this analysis suggests that diversion of material that is currently being wasted (for example being sent to AD) to animal feed instead would lead to an overall increase in the amount of material available to animal feed producers.

The potential reduction in retail and manufacturing food waste identified in this report, of around 450,000 tonnes or 23% of total food waste, is broadly consistent with that modelled during the development of the Courtauld 2025 food waste prevention target. That target requires a 20% per capita reduction by 2025 across the food system, and takes in to account potential population and production growth. Achieving the target will be challenging for all sectors, but this research shows that the contribution from retail and manufacturing is stretching but realistic, and provides insights that will help deliver against it.

The potential scale of food waste reduction identified in this report, and the contributions from prevention, redistribution and diversion to animal feed are based on an overall assessment of what is realistic at a UK level. There will be significant differences between different businesses in what they may be able to achieve, and what interventions may work best for them, as a result of their product mix, size, location, policies towards mark-downs, progress made to date and so on. The estimates in this report are not therefore targets for individual businesses, but a guide to what the sectors as a whole could achieve – which WRAP will monitor through Courtauld 2025.

Recommendations

This research has applied a new approach to estimating both how much food surplus and waste comes from manufacture and retail, and how much of this might be suitable for a range of waste prevention interventions. It has pulled together data and insights from a wide range of sources, covering a diverse set of sectors and sub-sectors. It clearly identifies the potential for stopping food waste arising, redistributing more to people and diverting more surplus to produce animal feed. It should however be stressed that this forms the foundation upon which to build a more comprehensive understanding of this area, as methodologies evolve, interventions are evaluated and more targeted research undertaken.

The following represent opportunities to further improve data quality and relevance over time:

- Refine the estimates for how much food waste might be prevented from arising based on a) the evaluation of innovations in processing, equipment, packaging management etc., as these are implemented, b) from monitoring the levels of food surplus and waste arising over time and c) from feedback on the barriers to implementing relevant innovations.
- Refine the estimates for how much of the food surplus and waste might be suitable for redistribution based on learnings from both the providers and recipients of food surplus. Innovations in the types of material that could be turned in to products suitable for use by recipients could lead to an even higher percentage of future food surplus and food that might have been wasted being used to feed people.
- It should also be noted that whilst this research provides more granular estimates of food surplus and waste for the sectors, it does not reveal priorities for action within a sub-sector. Further and more focused 'mapping' will be required for the sub-sectors with the greatest potential to prevent food waste. As a first step WRAP is working with a major dairy business to map material flows from multiple sites and a wide range of products (including milk, soft and hard cheeses, butter, yoghurt etc.), with the objective of identifying the greatest opportunities for both prevention and maximising value from the non-preventable materials.
- Further research into the scale and types of food surpluses and wastes occurring within the third party logistics element of the UK grocery supply chain to understand the scale and type of waste arising and identify the most effective and efficient way of handling any food surplus or waste.

- For the retail sector there is a need to establish more clarity around damages occurring both at stores and within depots and this should be used to highlight waste prevention opportunities by product category.
- Further analysis of existing datasets to show where the food waste is being disposed to (disposal routes) by sub-sector, separating out material that may have already been subject to on-site treatment (and therefore less suitable for subsequent treatment by AD or other options) from untreated sludges (such as those that contain peelings from fruit and vegetables).

The following are also critical for the delivery of the waste prevention opportunities identified in this report:

Collaborative action targeting priority areas:

- This research has identified areas where the greatest potential impacts can be made, and also that collaboration between businesses across the supply chain will be needed to realise the greatest benefits (for example between brands and retailers in tackling some of the in-store food waste, and retailers and manufacturers in addressing some of the opportunities around forecasting). The outputs from this research will inform decision making on where resources should be allocated, for example through working groups under Courtauld 2025, and future 'whole chain resource efficiency' projects[95].
- WRAP will establish a Redistribution Working Group under Courtauld 2025 to understand more about the implications associated with realising some of the redistribution potential identified in this study. It will be particularly helpful to share insights from retailer back of store and manufacturing trials that have been undertaken in different parts of the UK during 2015 and early 2016.

Awareness raising/behavioural change:

- The study found that there was often a poor understanding across the sector about the sorts of surplus that were within scope for redistribution and how businesses with food surpluses can partner with redistribution organisations. This issue should be addressed through the improved guidance and partnership tools developed by the redistribution sector and WRAP, the use of awareness raising resources such as 'Your Workplace Without Waste' and through greater engagement on this issue with individual businesses and trade associations under Courtauld 2025[96].
- In order to enable greater amounts of food surplus to be diverted to animal feed production WRAP will be working with the FSA and representatives of national and local enforcement bodies to improve the consistency and clarity of both the guidance available to food businesses and the training of staff on the ground.

Maximising value from food waste that cannot be prevented:

- Around 1.5 million tonnes of food waste may not be suitable for prevention (120,000 tonnes from retail, equivalent to 0.3% of product sold in 2014; 1.4 million tonnes from manufacture, equivalent to 2.4% of product sold), at least not within the shorter term. This will need to be assessed for optimal treatment and use. This will need to look at the balance between on-site versus off-site treatment options, both in terms of commercial and environmental benefits.

[95] *See Whole chain resource efficiency*
[96] *For example see Surplus food redistribution, Your Workplace Without Waste, The FareShare Food Efficiency Framework*

Methodological improvements:

- A standard protocol for food surplus and waste measurement and more effective key performance indicators (KPIs) for monitoring would be beneficial, to overcome the wide variation in the standard of data on food surplus and waste, which varied from sites that only had basic waste returns provided by their site waste contractors, to those with systems in place delivering line-specific data against a balanced set of KPIs. This should also clarify areas of uncertainty such as the accounting for retail depot vs back of store redistribution and the relationship with third party logistics operators and suppliers. There may also be an opportunity to work with the relevant national regulatory bodies to improve the consistency and relevance (to food surplus and waste) of the data reported to them.
- Linked to the variation in data quality, there were marked differences in the resourcing and commitment to waste reduction from site to site. In some cases roles were split, with waste reduction shared with health and safety, whereas at others sites dedicated waste managers had clear lines of accountability to carry out a programme of work and report on progress. These were also the sites with a clearer picture of the wider costs to the business of avoidable food and drink waste and consequently in a better position to reduce waste more effectively.

Appendix A: Meat, poultry and fish

Meat, poultry and fish – assessment of food waste prevention, food surplus and food waste

Overview

The meat, poultry and fish manufacturing sector includes slaughter houses, de-boning and meat cutting plants as well as meat processing units. It does not include the parts of the agricultural sector that rear livestock, hatcheries or other facilities involved with the handling of livestock. However the boundaries are sometimes blurred, as some of the larger sites encompass some of the 'farm and livestock' wastes as facilities often integrate different stages at a single site.

The sector produces 5.3 million tonnes of product with a sales value in 2014 of £17 billion (PRODCOM, 2014).

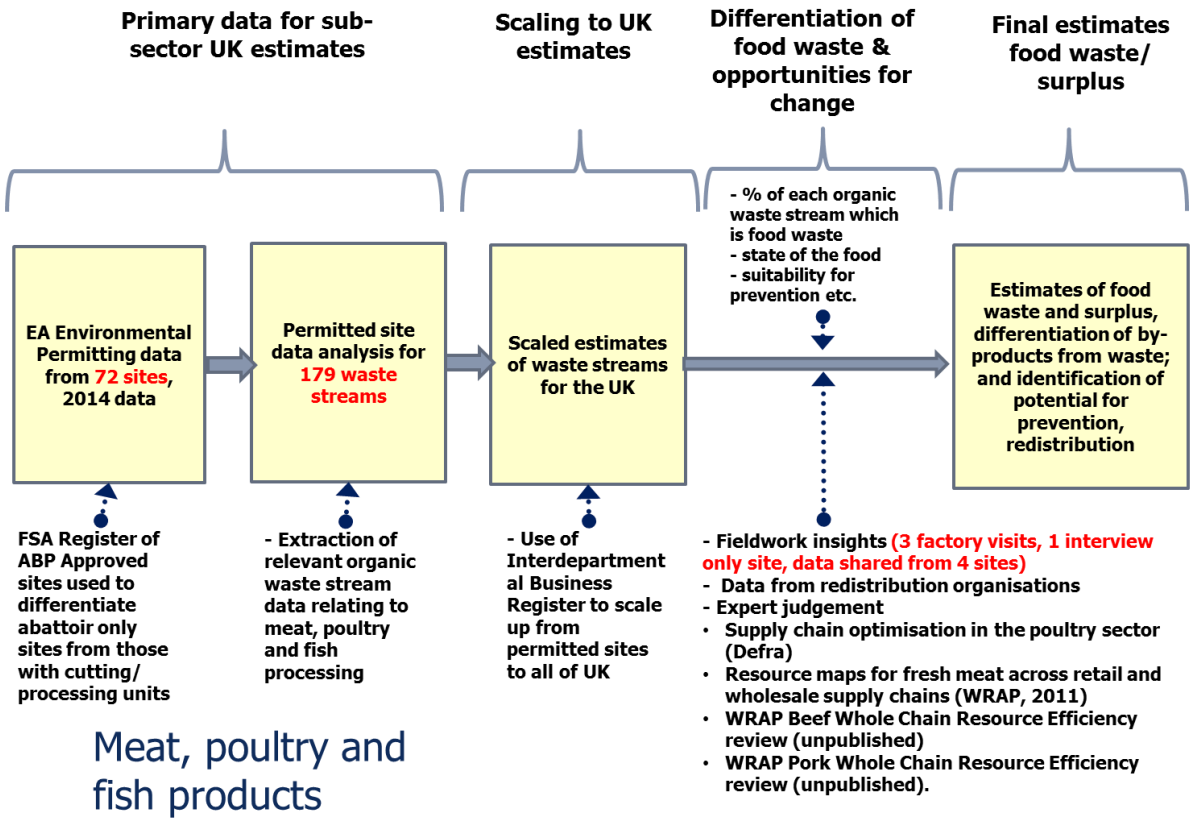
The key waste streams from the sector relate to residual material from abattoirs, once all meat intended for human consumption has been removed from carcasses. Before BSE in 1996, the residual material was harvested and significant quantities used in the human food supply chain and in pet food. Since the strict regulation of use of animal by-products was introduced (particularly post 1996 when the TSE Regulations were introduced), residual material has been sent to rendering and the overall carcass utilisation rate fell as a result. In recent years, overall carcass utilisation has improved, particularly as a result of new export markets in the Far East and elsewhere. Rendering is a by-product treatment process in which residual material is cooked at high temperatures to remove moisture, kill bacteria and separate out the fat and protein streams. Abattoirs either pay for this service, if it is Specified Risk Material (SRM) for example, or receive a fee for the best fats. The rendered material is used to produce a range of products including biodiesel and to a limited extent, dry pet food.

The assessment has focused on meat production waste, rather than issues linked to abattoirs and the extent to which more of residual animal tissue and other by-products could be utilised in higher value markets as alternatives to rendering (for instance red offal sold to export markets). For this reason, sites that were only slaughter houses, rather than cutting and processing units that carrying out meat processing, were excluded from the study as being outside the scope of the manufacturing sector. For cattle, these operations are more likely to occur at different sites; but for the poultry sector, slaughtering, processing and packing is a highly integrated operation.

Evidence gathering approach

The different data sources and types of evidence used to support estimates for the sub-sector are summarised in Figure A1.

Figure A1: Summary of evidence gathering approach– Meat, poultry and fish sub-sector



Information on the rendering sector was obtained from:

- Rendering: Foodchain and Biomass Renewables Association (FABRA) survey 2012, which was the source used in the WRAP 2013 study to estimate Category 3 animal by-products[97] collected from abattoirs cutting plants and sent to rendering, no more recent data source was found; and
- The Use of Animal By-products: The improving opportunities to add value to the beef and sheep slaughtering sectors, EBLEX, 2014[98], this source provided useful analysis of rendering trends in the UK.

Site visits were conducted at two meat processing sites and a fish processing factory. A poultry processing organisation was interviewed, although a site visit was not possible. Distinguishing between sites engaged with slaughtering and those cutting and processing meat was challenging as many sites combine both activities, especially within the poultry sector.

Within the EP data the study was able to differentiate sites involved with meat processing from those that were solely operating abattoirs or rearing units. This involved application of FSA listings of approved meat/ poultry sites to the EP data in order to exclude farms, rearing

[97] *Cat 3 are low risk ABPs and include carcasses and body parts passed fit for human consumption at a slaughterhouse, discarded meat products or foods of animal origin originally meant for human consumption, hides, skins etc,. from undiseased animals*

[98] *The use of animal by-products, EBLEX 2014*

units and abattoirs from the analysis. The FSA carries out inspections at slaughterhouses, meat cutting premises and minced meat and meat products premises. Theses premises are approved under requirements of Regulation (EC) 853/2004 and are listed on the FSA website[99]. The revised EP data still contained sites that were integrated meat processing and slaughtering operations. At such sites it was not possible within the EP data to distinguish between waste streams associated with meat processing from those from slaughter houses.

Findings summary

The site visits and stakeholder interviews highlighted the nature of arisings from EP returns, the points at which product surplus/waste typically occur and the main routes for product that does not meet product specifications. Table A1 provides examples of the main surpluses and waste arising from this sector.

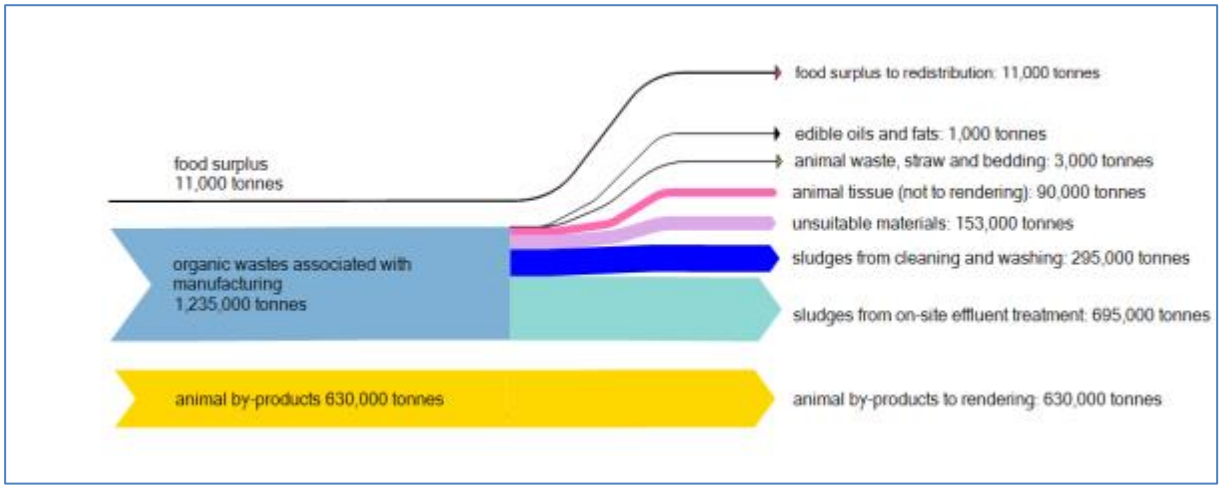
Table A1: Example surpluses / waste – Meat, poultry and fish

Materials	Source	Example Management Approach
Sludges	From regular wash-downs of processing halls; including product fragments/ off-cuts, oil and fat recovered from treatment plant residues	Land-spreading
Meat fragments and off-cuts from processing	Machine breakdowns, poor blade maintenance; Bill of Material (BOM) ends from slicing	Sent to secondary markets
	Over-trimming	Sent to secondary markets
Floor waste	Floor waste from cutting and slicing machines, machine breakdowns	Sent to rendering
Meat product	QA failure on slicing line; failed to meet retailer specification	To commercial redistribution and to secondary markets
Animal tissues wastes	De-boning, connective tissue, skin, depending on plant segregation efficiency, may contain edible co-products that could be sold	Rendering

Data was obtained from EP returns. The meat, poultry and fish processing sub-sector contained 72 processing sites; these sites produced 179 waste streams with organic content. An additional 270 sites were excluded from the EP data as they were either slaughter houses only or other sites that did not carry out meat processing (such as rearing units). Analysis of the data is presented in Figure A2. Within the IDBR data used for scaling estimates to UK level, 190 local business units are recorded within the comparable employment size bands to the EP sites (those employing 100 or more staff). The sub-sector contains 1,490 smaller local business units not represented within the EP data.

[99] FSA list of approved meat premises

Figure A2: Organic wastes and food surplus flows – Meat, poultry and fish; UK scaled estimates derived from 2014 EP data



Organic waste streams

The organic waste streams associated with meat, poultry and fish processing sites amount to 1.2 million tonnes per annum, mainly in the form of sludges (695,000 tonnes/year) arising from on-site treatment and from site washing and cleaning operations. 153,000 tonnes consists of meat/ fish product waste rejected as being unsuitable for use.

Additional insights are:

1. Materials unsuitable for production or consumption: from site visits these were found to consist of floor waste (from a variety of sources, such as: losses from processing line conveyors, cutting/ slicing machine breakdowns, off-cuts and trimmings accidentally dropped) and meat that could not be sold to alternative markets, with most other off-cuts and out of specification product being sent to alternative markets and therefore not included within the waste arisings data, 153,000 tonnes;
2. Sludges from on-site treatment activities: i.e. from site cleaning, interceptor sludges and from slaughter houses, 695,000 tonnes;
3. Sludges from washing and cleaning, 295,000 tonnes;
4. Animal tissue wastes not sent to rendering, 90,000 tonnes: this waste stream may over-lap with the first, but is more likely to contain bone and other material from cutting / butchery plant; and
5. Edible oils and fats, 1,000 tonnes.

Table A2: Treatment and disposal of organic waste streams containing food waste – Meat, poultry and fish, UK estimates derived from 2014 EP data

Disposal Route	Materials unsuitable for production or consumption	Sludges from on-site treatment of effluent (mostly consists of wet material from food prep areas)	Sludges from site washing, cleaning, (mostly contains food waste + water)	Animal tissue wastes not sent to rendering	Edible oils and fats
Landfill	0	0	3,000	0	0
Incineration / Energy recovery	78,000	8,000	1,000	90,000	0
Land-spreading	36,000	627,000	235,000	0	0
AD/ composting	40,000	60,000	28,000	0	1,000
Other recycling / biological treatment	0	0	28,000	0	0
Total	153,000	695,000	295,000	90,000	1,000

Findings suggest that some animal tissue waste included within EP returns is a by-product stream from abattoirs and from cutting units that overlaps with the rendering sector (see By-products section below), with material sent to energy recovery that might otherwise have gone to rendering plants, or to co-product markets. Where animal-tissue wastes are sent to energy recovery, these may be derived from a variety of sources, including slaughter houses (at integrated sites), de-boning and cutting units, as well as floor waste and any meat waste that cannot be sent to secondary markets.

In addition to the waste streams in Table A2, 3,000 tonnes of animal faeces, bedding and straw arises at some of the integrated sites within meat and poultry processing. According to the EP data, these wastes are mainly sent to energy recovery. The 2013 WRAP study included these materials within total food and drink waste estimate: these have been excluded in the current food and drink waste estimates, discussed in the next section.

Food waste

The food waste element within the 1.1 million tonnes is estimated to be 540,000 tonnes (44% of the organic waste streams associated with manufacturing). This takes account of the product contribution to the weight of sludges generated by on-site treatment and cleaning processes (about a third of the weight, consisting for example of body fluids, juices arising from cooking and other processing). It is assumed from observations made during site visits that the majority of the weight is accounted for by cleaning and process water as sludges transferred off-site are highly liquid, with suspended solids generally less than 10% and the waste sludges being tankered off-site.

Table A3 Food waste within organic waste streams – Meat, poultry and fish, UK estimates derived from 2014 EP data

Meat, poultry and fish	Organic waste streams containing food waste				Total (tonnes per annum)
	Materials unsuitable for production or consumption (tonnes per annum)	Sludges from on-site treatment of effluent (tonnes per annum)	Sludges from washing and cleaning (tonnes per annum)	Animal-tissue waste (to waste disposal options)	
Organic waste streams	153,000	695,000	295,000	90,000	1,233,000
Of which: Food waste	140,000	230,000	90,000	80,000	540,000
Of which: Avoidable food waste	60,000	50,000	20,000	30,000	160,000
Avoidable as % total food waste	43%	22%	22%	38%	30%
				Food surplus to redistribution	11,000
				Food surplus to animal feed	0

Approximately 30% of the food waste was thought to be avoidable in that if managed differently it could be kept within the human food supply chain.

Waste prevention potential

Meat, poultry, fish are high value foods and, as a result, a range of alternative markets for by-products and surpluses exist. Furthermore, much of the waste in this sector occurs earlier in the supply chain either associated with animal by-products generated from abattoirs, or rejected/ fallen stock. For example, over-sized or under-sized pigs rejected from processing into bacon or ham. As a result, the waste prevention potential at the meat processing stage is believed to be quite limited, at less than 4% of current food waste, or approximately 20,000 tonnes.

Table A4: Waste prevention measures – Meat, poultry and fish

Better data management to establish yield losses and pin-point lost value and root causes of down-grades Improvements to forecasting accuracy to reduce poor yielding 'top-up' production runs needed to fulfil customer orders (higher start-up and shut down losses per unit of production); also in examples linked to seasonal demands (e.g. barbecue cuts and meat products, Christmas in the poultry sector) Better visual inspection of in-take material to reduce 'off-spec.' production. The need to set up tracking systems to establish yield variability on processing lines Process improvements that reduce losses (in value and waste) through more extensive adoption of lean manufacturing principles, more value stream mapping to establish where value is lost in processing/ packing lines and establish links with variability of inputs Better grading of intake from abattoirs in relation to intended meat products and customers (e.g. in relation to bacon), reducing QA rejects later in production Investigate potential to revise specifications set by customers that can result in significant 'down-grades' e.g. chops needing to be equally sized, standard chicken portions Reductions in over-trimming of chicken breast fillets Improving measurement and monitoring of losses throughout processing stages, particularly to reduce rejected product due to earlier stages: poor condition of the meat/ failure to comply with specifications Better segregation of material in abattoirs and cutting plant to reduce the extent of edible co-products currently sent to rendering; likely to be a particular problem with smaller and medium-sized abattoirs

Table A5 Summary of waste prevention potential – Meat, poultry and fish, UK estimates

Meat, poultry and fish	Waste prevention potential (tonnes per annum)
Potential to prevent waste arising	20,000
Additional redistribution potential	
from current avoidable food waste	assumed to displace material from alternate markets/ down-grades
Total potential for waste prevention	20,000
as % avoidable food waste	13%

Food surplus to redistribution

The study estimated that 11,000 tonnes of product was redistributed in 2015. Evidence from the site visits and WRAP whole chain resource efficiency studies (listed in Figure A1) suggest that the main form of 'waste' is loss of value relative to the intended end markets, rather than physical waste sent to treatment and disposal options. Meat products made available for redistribution are likely to be in competition with lower grade markets elsewhere within

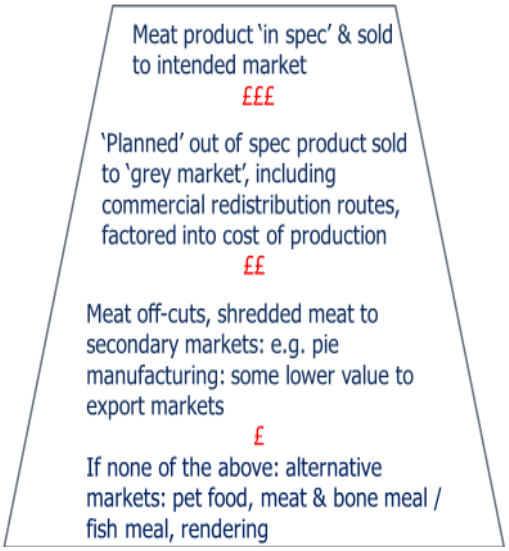
the food processing sector (e.g. pie manufacturing), for use in pet food or sold to discount retailers. Below the level of meat products, the sector produces edible co-products that can be sold (e.g. raw fatty tissues as a source of edible fats) and material that is fit for human consumption but is used elsewhere in the food sector.

At the sites visited, it was apparent that down-grading of product into lower value markets and uses is the main form of waste within the sector. For by-product and down-graded/ lower value cuts, product markets are located both within the human food supply chain and in other markets e.g. pet food. The hierarchy of uses for product waste in this sector reflects the high value of protein sources.

For product that is transferred to down-graded markets, this is often factored into production costs. Therefore a highly demanding product specification for a customer might generate a steady and predictable flow to supply commercial routes that include, amongst others, commercial redistribution. Floor waste in cutting and processing plant is classed as Category 3 ABP and is no longer fit to be consumed and is sent for rendering or incineration.

Figure A3 outlines the general pricing approach for the different product types.

Figure A3: General pricing approach for meat products in the UK



Food surplus to animal feed

No animal feed potential was identified for this sector due to the nature of the products and the restrictions that apply to the use of ABPs in animal feed.

By-products

Based on the scaled EP data, the UK meat, poultry and fish processing sector (excluding abattoir and other non-processing sites) sends 630,000 tonnes of animal by-products to rendering (Figure A2). This compares with the overall quantity of ABPs sent to rendering of 2.25 million tonnes per year, including fallen stock (Fabra survey[100], 2012). Much of this material is handled by licenced renderers to generate tallow and proteinaceous material which is ground into meat and bone meal. Furthermore, animal hides and skins are sold to the leather industry. The fish processing industry also generates large quantities of by-

[100] *Fabra Food Chain and Biomass Renewables Association*

products not destined for the table, which are used in fish meal and fish oil processing facilities. The assessment of the use of animal by-products conducted by EBLEX in 2014 identified a large discrepancy between product going to rendering according to abattoir estimates (0.75 million tonnes) against what renderers declare they receive (1.5 million tonnes). It is therefore uncertain what proportion of ABPs sent to rendering are from the meat processing sub-sector and it seems likely that the Fabra survey estimate of 2.25 million tonnes from all sources is an over-estimate.

Conclusions

- Meat, poultry, fish are high value foods, with well-established alternative markets for out of specification, off-cuts and other recovered materials, such as fats;
- The greatest resource inefficiencies in this sector occur earlier in the supply chain, where over/under weight livestock are rejected and inedible animal-tissues/ bone and other animal by-products are sent to rendering;
- The proportion of carcasses that are used by the human food supply chain is a key issue, given that before the advent of the Animal By-products Regulations there was far higher utilisation of red offal and edible co-products and a greater use of ABPs within the pet-food industry. Recently carcass utilisation has improved with the growth of export markets. EBLEX estimate that since 2008, an extra 10% of live weight of bovine animals is being consumed[101]. Since the BSE crisis, there has been a slow resurgence in export markets;
- Redistribution potential is limited by the fact that down-graded product markets are mature and long-established, reflecting the value of the products. Food surpluses currently going to waste are rare occurrences; and
- Waste prevention potential was identified through better tracking of current losses in value across production processes, better demand forecasting and more extensive use of 'lean' principles to reduce process losses.

[101] *The use of animal by-products, Eblex*

Appendix B: Dairy products

Dairy products – assessment of food waste prevention, food surplus and food waste

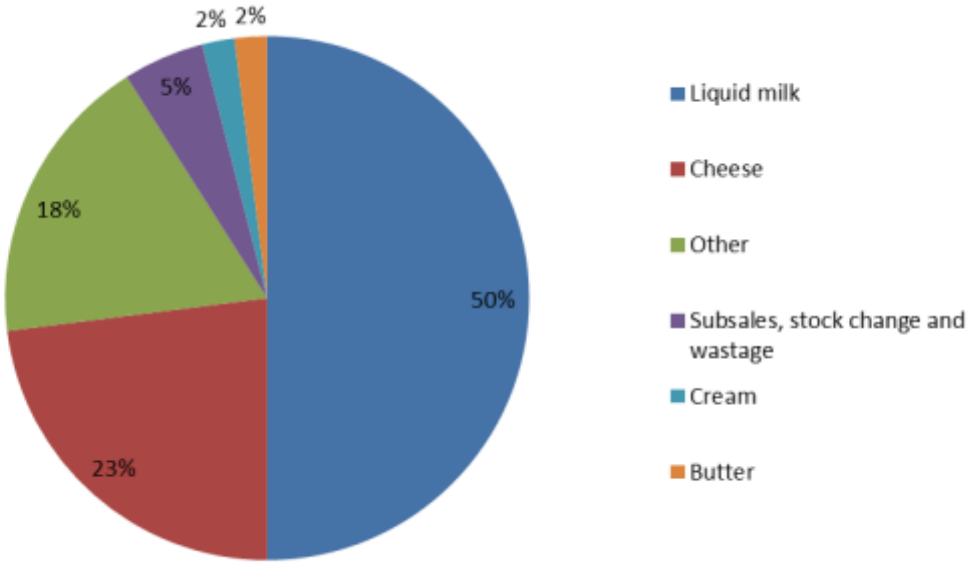
Overview

The dairy sector includes manufacturers of milk, cream, cheese, yoghurts, yoghurt drinks, butter, crème fraîche, ice cream, dried powders and other dairy products.

The UK dairy industry produces around 14 billion litres of milk each year, making it the third-largest producer of milk in the EU after Germany and France, and the tenth largest producer in the world. In 2014/15, 48% of raw milk produced in the UK went into the production of liquid milk, the remainder being used for dairy-based food and drink manufacturing[102]. The dairy products manufacturing sector had total sales of £7.75 billion in 2014, associated with 10.2 million tonnes of product (PRODCOM, 2014).

As shown in Figure B1, the latest statistical release of usage of milk by dairies in England & Wales from Defra[103] [104] (October 2015 figures) indicates around half of milk produced was sold as liquid milk, 23% was used for cheese production, 2% for cream and 2% used for butter production.

Figure B1: England and Wales milk usage statistics 2015

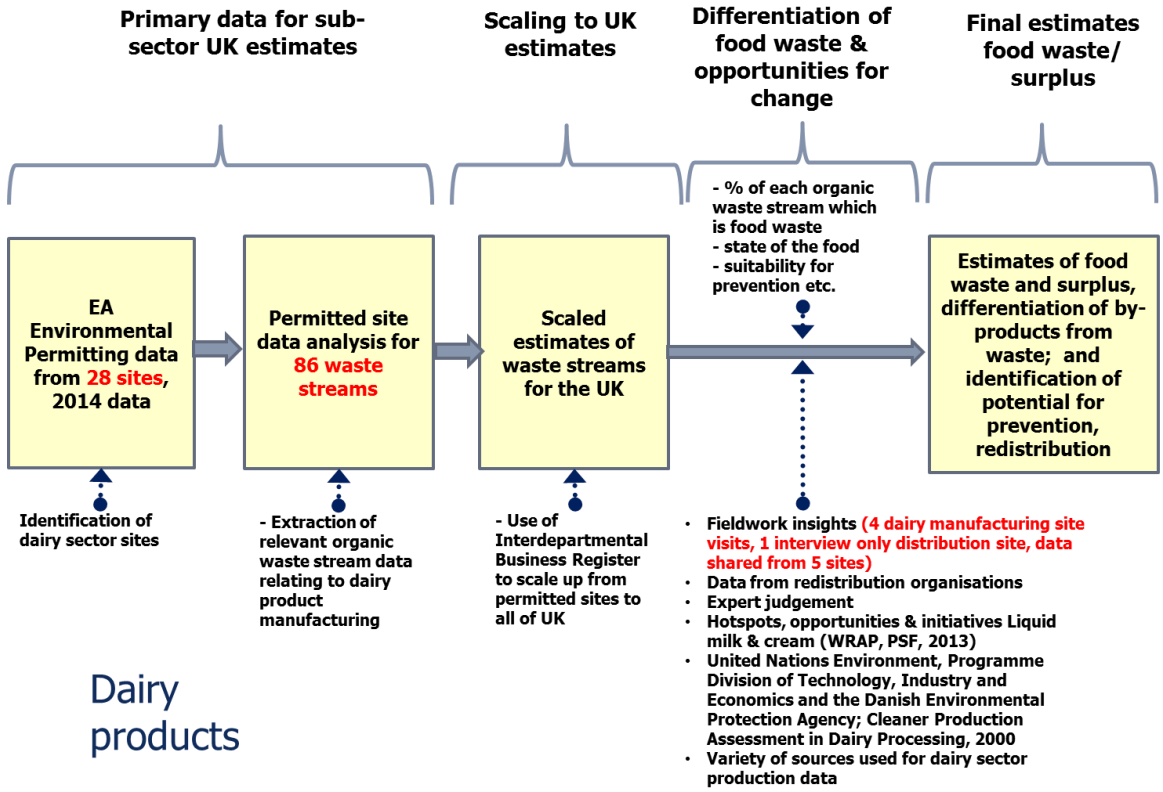


[102] House of Commons Library, Dairy industry in the UK: statistics, Standard Note: SN/SG/2721, last updated: 29 January 2015.
[103] Department for Environment Food & Rural Affairs, Usage of milk by dairies in England & Wales – October 2015, 10th December 2015.
[104] Similar surveys are run by the Rural & Environment Science and Analytical Service (RESAS) for Scotland and the Department of Agriculture and Rural Development (DARD) for Northern Ireland.

Evidence gathering approach

To inform this research, evidence was gathered from the sources indicated in Figure B2.

Figure B2: Summary of evidence gathering approach– Dairy sub-sector



Site-based data, observations and interviews were completed at two large dairies, a large independent cheese manufacturer, a small independent cheese manufacturer and an independent yoghurt and ice cream manufacturer. An additional interview (but with no site visit) was completed with a large milk distribution facility owned by one of the large dairies previously visited.

Supply chain mapping and inputs from other studies:

- House of Commons Library, Dairy industry in the UK: statistics, Standard Note: SN/SG/2721, updated: 29 January 2015;
- Agriculture and Horticulture Development Board (AHDB), Dairy statistics An insider's guide *2015;*
- Department for Environment Food & Rural Affairs, *Usage of milk by dairies in England & Wales – October 201*5, 10th December 2015;
- United Nations Environment, Programme Division of Technology, Industry and Economics and the Danish Environmental Protection Agency; *Cleaner Production Assessment in Dairy Processing*, 2000; and
- Whey and Whey Waste Management Strategy & Feasibility Study for the construction of a bi-communal Whey and Whey Waste Treatment Plant FINAL REPORT, 2007.

Findings summary

From the variation in site types, and the products manufactured, it can be deduced that the dairy sector is, as a whole, a highly complex industry. Manufacturing sites in the UK range from small-scale family run businesses which produce a limited range of products to large scale production facilities which have received multi-million pound investments in technology designed to produce a wide variety of milk-derived products.

Milk is transformed into hundreds of different products as:

- The intended primary product;
- Various lower grades of product, some of which are sold for further processing;
- By-products which are marketable in their own right;
- By-products which are sold for further processing; and
- By-products which are used for feeding animals.

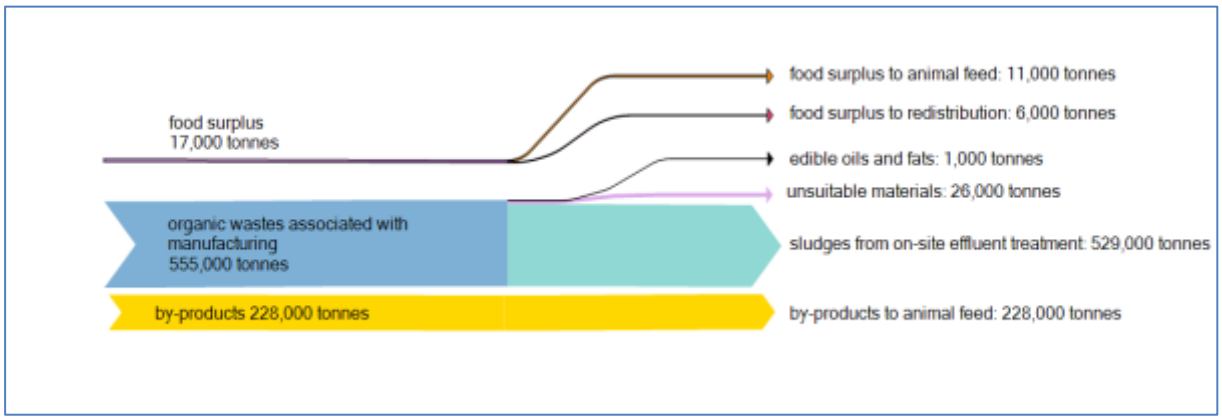
The main processes involved in milk product manufacture are:

- Heat treatment, e.g. pasteurization to sterilise the milk;
- Centrifugation to separate milk fats (cream) from the liquid part of the product;
- Homogenisation to blend fats back in after centrifugation;
- Coagulation to produce curds which form the basis of cheese; and
- Dewatering – various forms to make concentrates, e.g. condensed milk, and milk-based powders.

2014 Environmental Permitting data

Data was obtained from EP returns classified by industry sector for 28 sites (23 dairy, 4 cheese, 1 ice cream site), including 86 waste streams with organic content. The EP coverage compares with 70 sites across the UK employing 100 or more staff and 325 smaller business units (IDBR). Analysis of the data is presented in Figure B3.

Figure B3: Organic wastes, food surplus and by-product flows – Dairy; UK scaled estimates derived from 2014 EP data



Organic waste streams

Previous estimates of food waste associated with the sector did not differentiate between the different types of organic waste reported under the EP regulations and were not linked to site visits. Although liquid milk production produces relatively little waste, site management, cleaning and general workplace hygiene results in high levels of water use, resulting in sludges with high loading of biodegradable material and fatty residues.

In total the scaled-up EP data estimated 555,000 tonnes of waste from the dairy sector, with that tonnage consisting of sludges from on-site treatment processes and only 26,000 tonnes of materials rejects as unsuitable, including out of specification products. It is estimated that 343,000 tonnes relates to food waste, with liquid production waste a major contributor to the weight of sludges produced by treatment processes. It was assumed that wasted product or ingredient inputs to on-site treatment plant would be roughly equivalent to 60% of the total sludge weight. This assessment is based on observations from site visits, but does not include any product discharged direct to sewer.

Effluent
Depending on the nature of the operating procedures, the primary effluents at dairies are:

- Whey effluent: if not further processed on site before sale, it is commonly used as animal feed, fertiliser, or treated to lower its oxygen demand before entering the sewer;
- Rejected liquid product: milk that cannot be sold as intended or a downgraded product is used as animal feed, fertiliser or treated before being discharged to the sewer; and
- Cleaning effluent: typically wash water, cheese fines, milk and cleaning chemicals. Dairy effluent typically has a high biological oxygen demand and varies in pH and temperature, prompting many dairies to have their own wastewater treatment system. With careful management, process waters and fines not containing cleaning chemicals can be retained for re-working, downgraded product or by-products.

Out of specification product
Out of specification, milk, other ingredients, cream, yoghurts and ice cream are routinely used as animal feed, spread on land as a fertiliser, used as a feedstock for anaerobic digestion or disposed of via the sewer (with or without pre-treatment).

Treatment processes applied to dairy effluents include dissolved air-floatation plant (DAF), aerobic treatment processes, with the most significant sources of sludge likely to be derived from aerobic (activated sludge) treatment processes.

Table B1: Treatment and disposal of organic waste streams containing food waste – Dairy sector, UK estimates derived from 2014 EP data

Disposal Route	Materials unsuitable for production or consumption	Sludges from on-site treatment of effluent (mostly consists of wet material from food prep/ water)
Landfill	>500	>500
Incineration / Energy recovery	11,000	102,000
Land-spreading	3,000	393,000
AD/composting	10,000	32,000
Other recycling / biological treatment	1,000	1,000
***Total**	26,000	529,000

[*totals may not add due to rounding]

The analysis of EP data is in line with on-site observations, with the majority of waste originating from on-site effluent treatment in the form of sludges, of which most are spread onto the land. The second largest category is "materials unsuitable for consumption or processing", the majority of which are also disposed of to land - this is likely to represent operating locations which do not have an onsite wastewater treatment plant or AD plant and which are located conveniently close to suitable farmland, where it is more productive and cost effective to apply the material to the land.

Table B2: Food waste within organic waste streams – Dairy sub-sector, UK scaled estimates derived from 2014 EP data

Dairy	Organic waste streams containing food waste		Total (tonnes per annum)
	Materials unsuitable for production or consumption (tonnes per annum)	Sludges from on-site treatment of effluent (tonnes per annum)	
Total organic waste streams	26,000	529,000	555,000
Of which: Total food waste	26,000	317,000	343,000
Of which: Avoidable food waste	20,000	180,000	200,000
Avoidable as % total food waste	77%	57%	58%
		Food surplus to redistribution	6,000
		Food surplus to animal feed	12,000

Waste prevention potential

A significant issue for the dairy sector is how to minimise the extent to which recoverable materials are lost to wastewater systems during plant cleaning operations. With careful management and investment, the amount of recoverable materials (and volumes of water) going to wastewater treatment can be minimised. Table B3 provides a summary of measures that could be implemented or more widely adopted across the sub-sector. Taking into account the quantities of food waste and potential impacts of these measures (from site visits and sources listed in Figure B1), it is estimated that there is potential for a 7% reduction in food waste through reduction at source measures, equivalent to 40,000 tonnes per annum.

Table B3: Waste prevention measures – Dairy sub-sector

The development of specialised processes such as ultrafiltration (UF) and modern drying processes have increased the opportunity for the recovery of milk solids from whey, which were formerly discharged as waste to sewer or fed to animals.
In-process technologies to reduce waste: collection of solid wastes, such as curd particles, using a brush instead of directing them to the drain with a water spray.
Further investments in Clean In Place (CIP) technologies which are calibrated to automatically control the process to an optimally efficient level.
Reduction of waste caused by line cleaning, such as through the use of pigging systems to remove product residues from the internal surfaces of pipeline prior to cleaning.
Ensuring that tanks, pipes and hoses are as empty as possible before cleaning is commenced.
Reduction in waste associated with damaged final products: through packaging failure, poor handling and breakages.

Table B4: – Summary of waste prevention potential – Dairy sub-sector, UK estimates

Dairy	Waste prevention potential (tonnes per annum)
Potential to prevent waste arising	40,000
Additional redistribution potential	
from current avoidable food waste	5,000
from current surplus to animal feed	1,000
Additional animal feed potential	15,000
Total potential for waste prevention	61,000
as % avoidable food waste	31%

Food surplus to redistribution

Milk as a liquid product and cream
Dairies have contracts with supermarkets to process (pasteurisation, separation of cream, bottling and distribution) set volumes of milk. Volumes tend to be stable from week-to-week and month-to-month. Very low volumes are sold to small retailers on a 'sale-or-return' basis. It is common-practice in the dairy industry that stocks of butter (a more stable product) are built up in times of excess milk supply. On-farm surpluses that milk processors do not receive for processing were outside of the scope of this study, but animal by-products regulations provide various exemptions for on-farm use as an animal feed or fertiliser.

Solid and powdered milk-based products
Solid products, e.g. hard cheeses have a relatively long production process, including ripening (months) which, if kept at optimal temperatures, have a long shelf-life. This means that should orders be cancelled there is adequate time to find an alternative buyer, instead of the product going to waste or being significantly down-valued. In addition, the Intervention Butter Scheme supports butter producers and manufacturing creameries by buying excess butter and skimmed milk powder (SMP) when prices are low and selling them when they rise.

Semi-solid products
Semi-solid products such as soft cheeses and yoghurts have a longer shelf life than liquid milk, but relatively short in comparison to cheeses, butters and milk-based powders. Manufacturers need to forecast orders carefully in order to minimise surpluses that cannot be sold. Evidence from the sites visited indicated that surplus or damaged products were routinely collected by pig farms or, if they did not have enough capacity, the products would be sent to an anaerobic digestion facility. In the case of the yoghurt manufacturer visited, it was understood that stock held at the third party distribution warehouse was collected by a redistribution charity (the warehouse distribution company charges a handling fee to the manufacturer for that service).

It is estimated that the dairy sector currently redistributes 6,000 tonnes of products per annum (estimated from unpublished redistribution sector statistics). Based on sites currently redistributing, it is estimated that an additional 6,000 tonnes of packaged product would be suitable for redistribution. The types of surplus that arise include labelling errors, quality failures caused by batch change-overs (e.g. slightly discoloured yoghurts), slight variants in product consistency or missing ingredients (fruit pieces, product too runny), or over-production of short-life products.

Food surplus to animal feed

Rejected post-pasteurisation liquid dairy products, not diverted for use in the cheese industry, were mostly being sent to AD. It is estimated that 12,000 tonnes per annum is currently diverted to feed by the dairy sub-sector, mostly through direct to farm routes. There is potential for use of more rejected product in livestock feed, provided the de-packing equipment is available and that the product meets the requirements of Feed Hygiene Regulations and compliance with Animal By-product Control Regulations[105]. It is estimated that an additional 15,000 tonnes per annum could be sent down this route, preventing food surplus that is currently discarded as waste.

If not used or sold for further processing, whey (by-product) is routinely fed to pigs or cows. From observation of this practice during the site visits, it occurs only where the animals are kept on the same production site or an adjacent farm, because transporting unconcentrated whey soon negates its market value. The advantages of on-site feeding arrangement are that capital investment costs are very low and minimises effluent charges for the cheese and/or butter production process overall. Similar arrangements exist for product that cannot be sold, e.g. due to yoghurt nearing its expiry date where the operating location means that human food redistribution routes are not economically viable.

By-products

The chief by-product of the dairy industry is whey, estimated to be 228,000 per year (PRODCOM, 2014). The production of whey is an inherent part of the cheese-making and butter-making (known as buttermilk) process. The site observations indicated that dairies commonly produce whey butter from whey (the resulting whey from the whey butter making process is called 'whey buttermilk'). More advanced dairies will use technologies, such as evaporators and ultrafiltration to produce whey concentrates, that will be further processed into whey powders. Whey powders are utilised as bodybuilding supplements, bakery ingredients, processed foodstuffs and animal feeds.

Downgrade of milk

In milk pasteurisation and blending operations the research team observed that if milk originally intended for sale as a liquid could not meet the strict specifications required, it was routinely sent to cheese manufacturers, which can utilise milk with different specifications (if not previously rejected at the processor's gate).

Cheese recovery

Site observations were in line with the Food Standard Agency's (FSA) 'Cheese Recovery Guidelines'[106] which cover:

- Line recovery;
- Fines;
- Mis-shapes;
- Off-cuts;
- Downgrade and quality rejects;
- Returns; and
- Cheese contaminated with visible mould which is not present as part of the production process or integral to the final product.

The FSA is clear that the use of 'floor sweepings' in the food chain is unacceptable, regardless of any further sorting or processing to which the sweepings may be subjected.

[105] Further guidance on use of dairy products as feed
[106] Cheese recovery guidance

The FSA guidance sets out the detailed circumstances acceptable, but the range of options includes:

- Further processing, e.g. for sale as a grated cheese product;
- Sale to a specialised manufacturer of lower-grade cheeses, including processed cheese and cheese flavourings; and
- Disposal in accordance with animal by-products and other relevant waste and environmental legislation.

Conclusions

The assessment has characterised the main surplus, waste and by-product flows and provided UK estimates. The site visits and other information sources have been used to identify the potential for additional redistribution and diversion to animal feed as well as a number of waste prevention measures that can improve the resource efficiency of dairy production processes. Many of the later are being developed by the industry as current best practice:

- For dairy products that are stable, any surpluses can be sold via normal routes. Less stable products are manufactured to order, can in turn be used in the production more stable products (e.g. butter, cheese), or have a short shelf life and need to be kept chilled if they are to be redistributed;
- Rejected product that cannot be sold can also be redistributed, particularly in cases where products fail to meet customer specifications, but are otherwise safe to consume (packaging/ labelling errors, batch changeovers causing colour variation);
- There is potential to divert rejected product unsuitable for redistribution to animal feed, particularly where direct to farm routes are available and de-packing can be carried out safely and within feed hygiene standards;
- There are established routes for selling sub-premium products, recovered materials and by-products to sub-premium markets (including specialist processors) for production of additional foodstuffs for both animal (whey-derived feed) and human consumption;
- The raw ingredients, by-products and surplus generated by the dairy sector containing rich sources of protein, fats and carbohydrates that are highly nutritious. Any materials that are unsuitable for human consumption yet still fit for use in feed offer a valuable foodstuff for animals; and
- The assessment found that the choice of management route for wastes and by-products generated by the sector depends on a complex mix of circumstances related to the exact nature of the material, the business type, size and operating location. For example, unconcentrated whey does not have a high market value per litre which means storage and transportation costs can easily outweigh the benefits of on-farm use in its raw state. Investment in high-tech processing technology or on-site AD would depend on the circumstances, including economies of scale. It is therefore likely that sites requiring EPs are more likely to be operating AD and other higher tech treatment technologies than smaller sites.

Appendix C: Ambient products

Ambient products – assessment of food waste prevention, food surplus and food waste

Overview

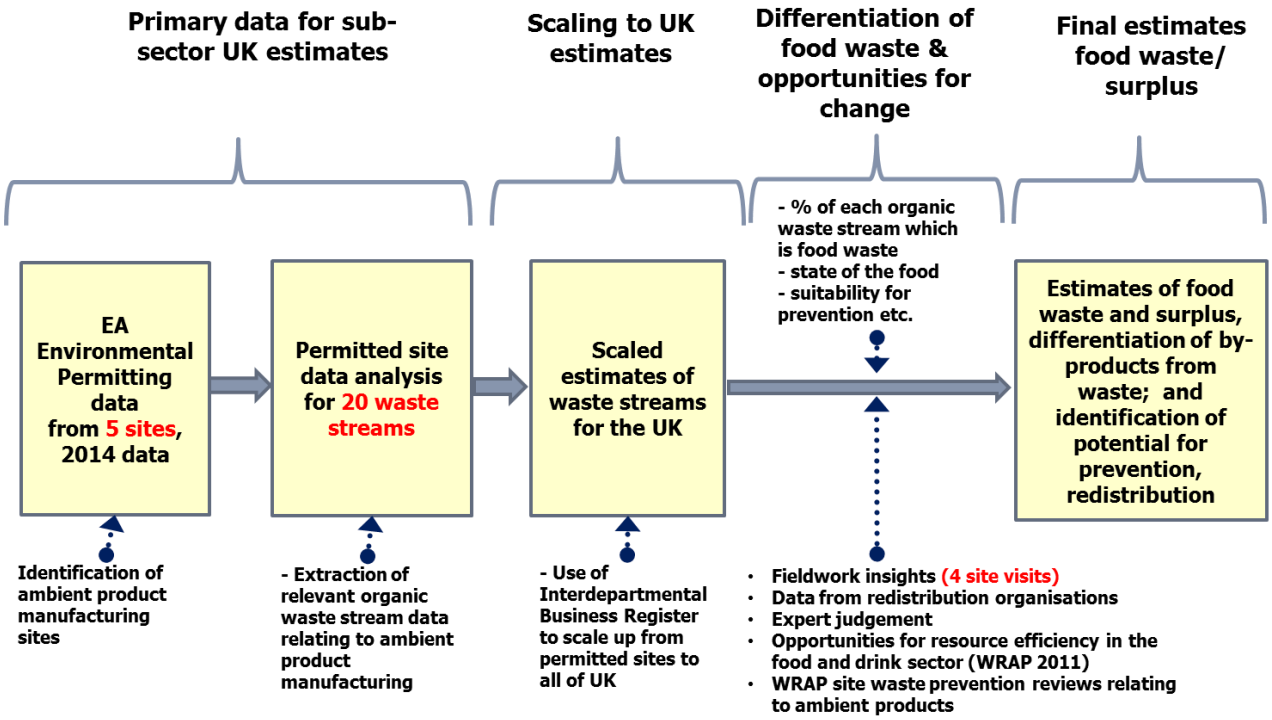
The ambient grocery market covers a wide range of different products that are processed or packaged to allow them to be stored at room or ambient temperatures for a longer shelf life. For the purposes of this analysis, this sub-sector includes the following manufacturing categories: canned specialities; canned fruits, vegetables, preserves, jams and jellies; dried and dehydrated fruits, vegetables and soup mixes; pickled fruits and vegetables, vegetable sauces and seasonings, and salad dressings.

In 2014, the UK ambient grocery sector produced 1.6 million tonnes of product and sales of £2.9 billion.

Evidence gathering approach

The evidence was gathered from the sources summarised in Figure C1. The sector was poorly represented within the EP data, containing returns from only 7 sites covering 20 waste streams. Site-based data and observations from 4 site visits were complemented by interviews with key stakeholders

Figure C1: Summary of evidence gathering approach– Ambient product sub-sector



Ambient products

Findings summary

This sector covers a wide range of different products and manufacturing operations vary considerably in terms of scale and sophistication, ranging from multi-national producers of branded and non-branded goods to small artisan manufacturers with limited product ranges.

Table C1 summarises the main types of waste/ by-products that occur in the ambient sector.

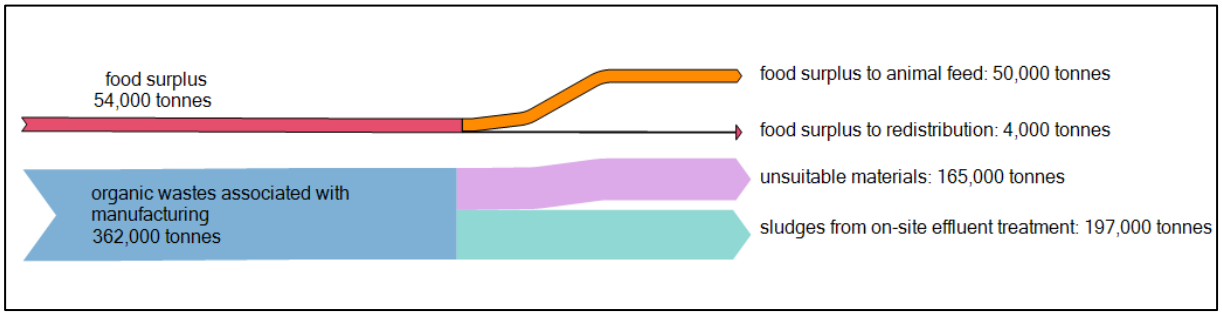
Table C1: Example surpluses, wastes and by-products – Ambient products sub-sector

Materials	Source	Example Management Approach
Ingredients	QA/ shelf life/ handling issues/ contamination	Animal feed AD e.g. ABP and other materials not suitable for animal feed
Work in progress	QA/ technical issues/ handling issues/ changeovers/ cleaning & maintenance	Rework (limited extent) Animal feed AD e.g. ABP and other materials not suitable for animal feed Discharge to sewer
By-products	Production processes, rejected pasta/ noodles	Animal feed
Finished Products	R&D/ QA/ shelf life/ handling issues/ packaging failure/ customer returns	Rework AD e.g. ABP and other materials not suitable for animal feed Animal feed Redistribution Staff shop sales (not included in food surplus estimates)

2014 Environmental Permitting data

Data was obtained from EP returns classified by industry sector for 7 sites, including 20 waste streams with organic content. These data were used to scale to a UK population of 60 local business units employing 100 or more staff. The coverage was therefore relatively poor in relation to the total number of sites across the UK. Analysis of the data is presented in Figure C2.

Figure C2: Organic wastes, food surplus and by-product flows – Ambient products sub-sector, UK scaled estimates derived from 2014 EP data



Organic waste streams

The 2014 EP data suggests that the ambient sector generates two main types of waste:

- Materials described in the EP data as 'unsuitable for production or consumption': from site visits these were found to contain unusable ingredients floor sweepings, scrapings from equipment clean down, QA rejects etc. that could not be sold to alternative markets; and
- Sludges from on-site treatment of effluent: mainly wet material from food preparation and site cleaning with a high water content.

A small amount of waste in the form of edible fats and oils is also generated (only 10 tonnes per annum).

Table C2: Treatment and disposal of organic waste streams containing food waste – Ambient products sub-sector, UK scaled estimates derived from 2014 EP data

Disposal Route	Materials unsuitable for production or consumption (tonnes per annum)	Sludges from on-site treatment of effluent (tonnes per annum)
Landfill	0	0
Incineration / Energy recovery	24,000	0
Land-spreading	33,000	129,000
AD/composting	0	23,000
Other recycling / biological treatment	108,000	45,000
Total	**165,000**	**197,000**

Table C2 shows that the great majority of materials unsuitable for production or consumption from this sector are sent for biological treatment/ other recycling. Waste in the form of sludge generated by the ambient sector is highly liquid and sent mainly for land-spreading. Edible fats, oil and grease (FOGs) are generally skimmed from DAF units and recovered for sale.

Food waste

It is estimated that 185,000 tonnes of the organic waste stream associated with ambient product manufacturing consists of food waste. 89% of this is associated with material rejects from manufacturing processes and 11% from on-site treatment sludges. For the latter, as the products are generally solid the ingredient and product water element of the sludge is minimal.

Table C3: Food waste within organic waste streams – Ambient products sub-sector, UK scaled estimates derived from 2014 EP data

Ambient	Organic waste streams containing food waste		Total (tonnes per annum)
	Materials unsuitable for production or consumption (tonnes per annum)	Sludges from on-site treatment of effluent (tonnes per annum)	
Total organic waste streams	165,000	197,000	362,000
Of which: Total food waste	165,000	20,000	185,000
Of which: Avoidable food waste	125,000	5,000	130,000
Avoidable as % total food waste	76%	25%	70%
		Food surplus to redistribution	4,000
		Food surplus to animal feed	50,000

Waste prevention potential

A number of sites visited collected data on overall waste quantities, but were not able to account in any detail for processes and production stages that had contributed to these quantities. Many of the sites had multiple production lines and varied ingredients, adding to the complexity of waste monitoring. Overall, the sub-sector had a wastage rate equivalent to 10% of the total UK production tonnage, a higher proportion than any other food and drink sub-sector. However, the analysis was based on a very limited number of sites and the scaling factors are therefore relatively large.

The potential for food waste prevention was estimated to be 25,000 tonnes per annum, a reduction of 13% on current levels. This was based on observations from site audits, particularly in relation to the likely benefits of closer waste monitoring of individual production lines to challenge current waste levels.

Table C4: Potential waste prevention measures– Ambient products sub-sector

Use waste monitoring data to plan corrective action and prevent waste: better prioritisation (rather than simply collect and record).
Complex sites with multiple lines: focus more on waste monitoring (rather than simply hours worked / production rates) and challenge current waste levels.
Value stream mapping to prioritise waste prevention.
Review practice of having a 'waste allowance' within 'Bill of Materials' BOMs (whereby assumptions about quantities lost in production are built into the system).
In-take/storage of ingredients: improve stock rotation, 'first-in-first-out', to reduce losses.
Better 'line balancing' to reduce downtime and wastage.
Procurement review: minimum order quantities (MOQ) for bulk purchases, not used in time.

Table C5 – Summary of waste prevention potential – Ambient products sub-sector, UK estimates

Ambient products	Waste prevention potential (tonnes per annum)
Potential to prevent waste arising	30,000
Additional redistribution potential	
from current avoidable food waste	5,000
from current surplus to animal feed	400
Additional animal feed potential	10,000
Total potential for waste prevention	45,000
as % avoidable food waste	35%

Food surplus to redistribution

A small proportion of material from the ambient products sector is sent for redistribution (approximately 4,000 tonnes per annum in 2014) either via national redistributors or to local charities.

Due to the nature of the product and production processes, redistribution potential relates mainly to finished products rather than to work in progress, as significant additional handling activity would be required to convert work in progress materials into something that would be considered appropriate for human consumption and which can be easily handled through the current redistribution channels.

During a number of the site visit and stakeholder interviews, considerable concern was raised about the risk that redistribution poses to the integrity of branded products, and this was cited as a barrier in terms of the increasing the quantity of ambient product that is redistributed. It was also evident that site staff generally had a lack of understanding of the sorts of food surplus within scope of redistribution schemes.

Based on current performance of sites redistributing food and from observations made during site visits, it is estimated that there is potential to redistribute an additional 5,400 tonnes of food surplus from within the sub-sector.

Food surplus to animal feed

50,000 tonnes of food surplus product was sent to animal feed in 2015, and this sector provides 8% of the total volume of surplus food sent to animal feed in the UK. Where surplus materials are not suitable for animal feed, e.g. due to ABP or high salt or spice content, these materials are mainly sent to AD.

It is estimated that there is potential to expand diversion to animal feed by an additional 10,000 tonnes per annum.

Conclusions

- Ambient product manufacturing contains a miscellaneous grouping of different product types, and the limited data suggests higher than average wastage rates in relation to finished product;
- Instances of food surplus that are likely to become waste are a rare occurrence; However, the majority of surplus is currently sent to animal feed (50,000 per annum), with potential to expand to 60,000 tonnes per annum;
- There is currently little opportunity to redistribute work in progress due to the nature and form of these materials. Redistribution potential therefore exists mainly around packaged products, with the potential to expand from 4,000 tonnes to nearly 10,000 tonnes per annum; and
- Brand implications of redistribution activities need to be understood and any actual or perceived barriers addressed before the redistribution potential within this sector can be realised.

Appendix D: Alcoholic drinks

Alcoholic drinks – assessment of food waste prevention, food surplus and food waste

Overview

The alcoholics drink sub-sector includes the distilling, rectifying and blending of spirits, manufacture of wine from grapes, cider and other fruit wines, beer and malt manufacturing.

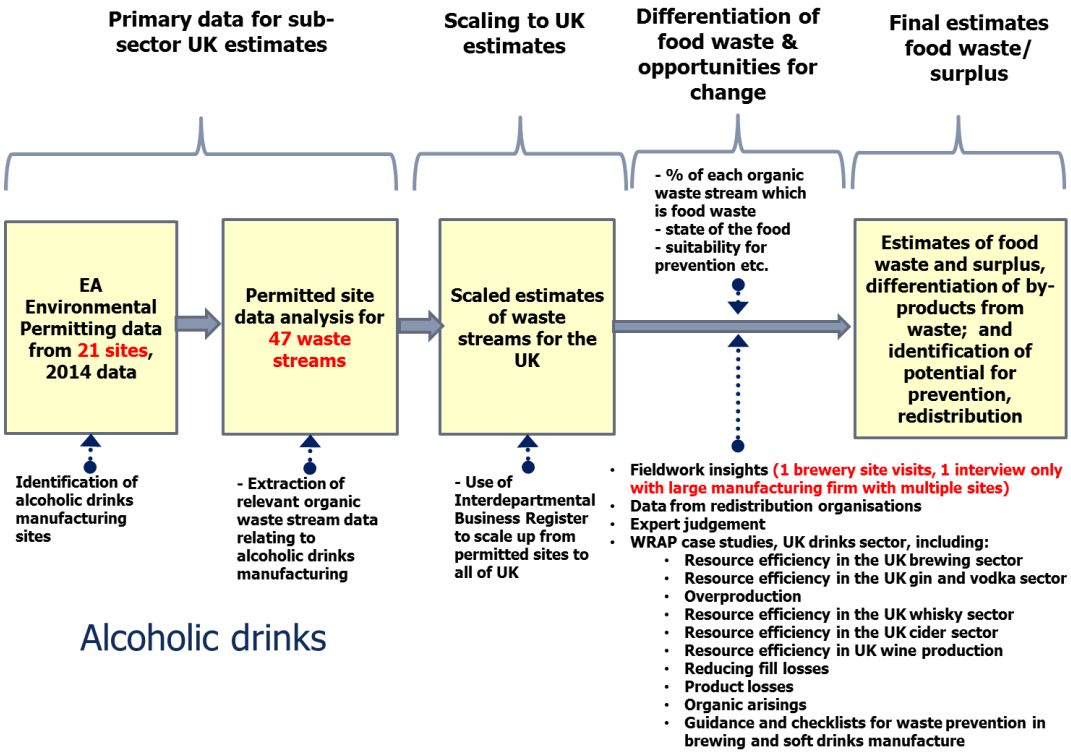
The value of sales from UK manufactured alcoholic drinks is £8.1 billion from 8 million tonnes of product in 2014 (PRODCOM, 2014).

Evidence gathering approach

The evidence was gathered from the sources outlined in Figure D1.

- Site-based data and observations from one site visit (brewery), interviews with key stakeholders at that site and analysis of site specific data; and data shared by one firm manufacturing spirits
- WRAP case studies relating to the manufacturing of alcoholic drinks[107]
- Analysis of relevant 2014 EP data.

Figure D1: Summary of evidence gathering approach– Alcoholic drinks sub-sector



[107] WRAP resource maps for drinks

Findings summary

Alcoholic drinks tend to have greater raw material and processing wastes than the soft drink sub-sector. Although there are significant quantities of 'waste', such as spent malt and grains in the brewing sector, most of these materials are classified as by-products as they are of nutritional value and are sold for use in animal feeds.

As with the soft drinks sector, water use is high, with large quantities used to wash storage tanks and process equipment.

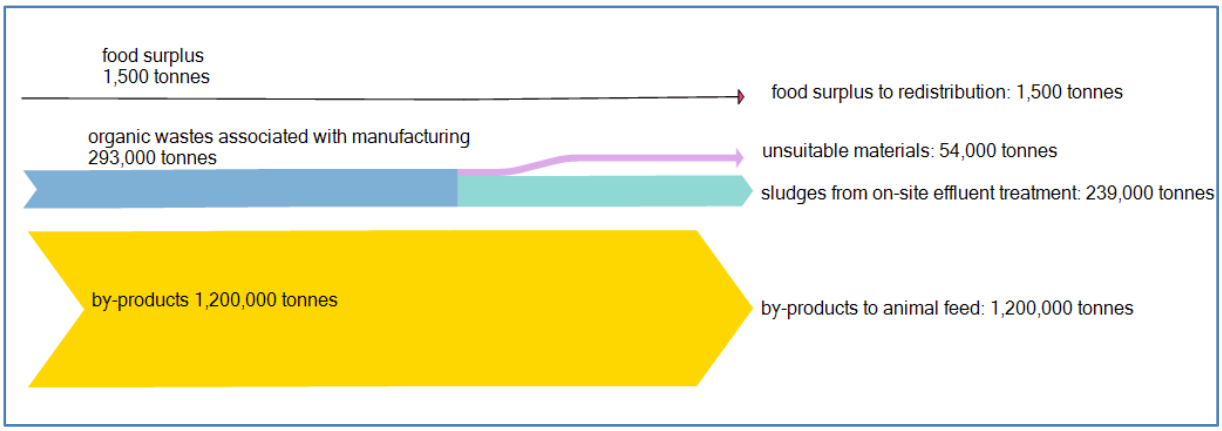
Table D1 Example surpluses, wastes and by-products – Alcoholic drinks sub-sector

Materials	Source	Example Management Approach
Finished products	Short-dated stock + end of promotion stock	Cleared through discounter and therefore not included in food surplus estimates
Effluent to treatment plant	Soluble sugars, starches, alcohol and protein from waste wort, beer and yeast; Yeast sediment – filtration slurry	Treated on site, sludges applied to land
	Digestate from on-site AD treatment & sludges from other on-site effluent treatment processes	AD digestate applied to land, smaller breweries less likely to have on-site AD, send for off-site AD treatment
Work in progress	Under-fills and over-fills in cans/ bottle individual filling lines, sealed before check-weighing	Not possible to rework, redistribution a possibility
Work in progress	Labelling faults, bottle seal faults	To redistribution or to AD
By-product	Spent malt and grain: excess wort and ullage	To animal feed (spent hops are generally unpalatable to livestock and are not used in feed, to AD)
Batch on bottling line rejected	QA issue with ingredients	Sent to AD or to animal feed

2014 Environmental Permitting data

Data was obtained from EP returns for 11 sites, including 31 waste streams with organic content. Analysis of the data is presented in Figure D2.

Figure D2: Organic wastes, food surplus and by-product flows – Alcoholic drinks sub-sector, UK estimates derived from 2014 EP data



Organic waste streams

Total waste flows are dominated by the outputs from on-site effluent treatment facilities (239,000 tonnes per annum) and a smaller waste stream containing materials rejected from production processes (54,000 tonnes per annum). Of these totals, 150,000 tonnes was equated with drink waste, rather than water from washing and cleaning operations. For this calculation, it was assumed that 40% of the sludge weight could be attributed to discarded drinks and ingredient water and 60% water from non-ingredient sources. This takes into account the approximate proportions of product and non-product water used within production processes [108] that would contribute to the weight of on-site treatment sludges. This approach is likely to under-estimate the quantities of product lost, due to the range of different on-site treatment processes found across the sector. In addition, losses through direct discharge to sewer are not reported with the EP waste data.

The main treatment routes for the organic-containing waste streams reported within the 2014 EP data relate to the land-spreading or land-injection of sludges and liquids from on-site treatment and other wastes labelling as containing 'unsuitable' materials.

The bulk of organic materials from brewing and distilling processes are by-product flows, representing 1.2 million tonnes per annum[109], twice as large as the waste flows estimated from the EP data. These materials are predominantly spent brewers' grains, yeast, ullage and malt from brewing and distilling processes. Other materials include brewers' hops, pomace from cider making, 'marc' from grape pressing and spent botanicals from gin production.

[108] *Resource maps for drinks*
[109] *Ibid.*

Table D2: Treatment and disposal of organic waste streams containing food waste – Alcoholic drinks sub-sector, UK estimates derived from 2014 EP data 2014

Disposal Route	Materials unsuitable for production or consumption (tonnes per annum)	Sludges from on-site treatment of effluent (tonnes per annum)
Landfill	0	0
Incineration / Energy recovery	1,000	0
Land-spreading	51,000	174,000
AD/ composting	2,000	1,000
Other recycling / biological treatment	0	64,000
Total	**54,000**	**239,000**

Food waste

It is estimated that 150,000 tonnes of the organic waste stream associated with alcoholic drink manufacture consists of food waste. 36% of this is associated with material rejects from manufacturing processes and 64% from on-site treatment sludges.

Table D3: Food waste within organic waste streams – Alcoholic drinks sub-sector, UK scaled estimates derived from 2014 EP data

Alcoholic drinks	Organic waste streams containing food waste		Total (tonnes per annum)
	Materials unsuitable for production or consumption (tonnes per annum)	Sludges from on-site treatment of effluent (tonnes per annum)	
Total organic waste streams	54,000	239,000	293,000
Of which: Total food waste	54,000	96,000	150,000
Of which: Avoidable food waste	30,000	30,000	60,000
Avoidable as % total food waste	56%	31%	40%
		Food surplus to redistribution	1,500
		Food surplus to animal feed	0

Waste prevention potential

The brewery site visit did not identify instances where waste prevention actions were needed. In line with sector guidance produced by WRAP[110], an assessment of potential for waste prevention at source estimated 8,000 tonnes per annum through measures to reduce product loss on filling lines.

[110] *Guidance and checklists for waste prevention in brewing and soft drinks manufacture*

Table D4: Waste prevention measures – Alcoholic drinks sub-sector

More effective calibration of filling heads to reduce over- and under-fill: reduction in filling inefficiencies, regular test calibrations of weight accuracy. Reduction in ingredient and product waste through addressing misalignment on filling lines and product falling off lines. Elimination of damaged cans before filling lines. Reduction in filtration losses in wine making. For shorter shelf-life ales, demand prediction and innovations to extend shelf-life. Potential to find alternate uses for ullage/ beer keg residues/ spoilt beer. (as a waste reduction measure)

Table D5 – Summary of waste prevention potential – Alcoholic drinks sub-sector, UK estimates

Alcoholic drinks	Waste prevention potential (tonnes per annum)
Potential to prevent waste arising	8,000
Additional redistribution potential	
from current avoidable food waste	More likely to displace alternative markets than be waste reduction
from current surplus to animal feed	Not known
Additional animal feed potential	Not known
Total potential for waste prevention	8,000
as % avoidable food waste	13.3%

Food surplus to redistribution

Current redistribution is estimated to be 1,500 tonnes and is limited to the commercial redistribution route and any off-specification product is generally sold through alternate markets. No assessment of the potential to expand redistribution was carried out due to limited information available. In addition it is uncertain whether or not current redistribution activity reduces waste or overlaps with stock clearance and other alternative lower value markets.

Food surplus to animal feed / by-products to animal feed

The main flows of material to animal feed are the by-product streams that include the diversion of brewers' grains and other materials that are suitable for use in animal feed. No assessment was carried out to expand current diversion to animal feed using other sources. There may be scope for ullage from brewing to be used in this way, but it would need to be diluted with materials from other sources.

Conclusions

- Current flows of surplus, waste and by-product from alcoholic drinks manufacture are dominated by spent materials from brewing and distilling sent to animal feed, a long-established route with not much scope to expand further diversion;
- Product losses are mainly associated with filling line inefficiencies;
- Extensive use is made of land injection and land-spreading for on-site treatment sludges;
- The assessment had insufficient information to identify waste prevention potential from site visit observations so instead drew on other WRAP work; and
- Redistribution potential is limited due to off-specification product being sold to alternative markets and therefore not within scope of the food surplus estimates within this analysis.

Appendix E: Fresh fruit and vegetable processing

Fresh fruit and vegetable processing – assessment of food waste prevention, food surplus and food waste

Overview

The UK fruit and vegetable processing sector consists of companies grading and packing fresh produce for supply to end markets, as well as those that process fruit and vegetables within the manufacturing sector, including for frozen products. The scope of this assessment includes the grading and packing of potatoes, fruit and vegetables, the processing and preserving of potatoes, but does not include field losses.

The total sales value of fruit and vegetables processed by the UK fruit and vegetable processing sub-sector was £1.1 billion in 2014 (PRODCOM, 2014). Table E1 shows the total UK production value of fruit and vegetable crops grown in the UK was £2.5 billion, with the total weight of product of 9 million tonnes per annum (Agriculture in the UK, 2014).

Table E1: Fresh fruit and vegetable production volumes and values, 2013

Product	Total UK production	UK total supply	UK production as % of supply	Value of UK production
Potatoes	5,921 kt	7,224 kt	82%	£684m
Fresh vegetables	2,796 kt	4,857 kt	55%	£1,234m
Fresh fruit	427 kt	3,951 kt	10%	£622m

Source: Agriculture in the UK 2014, 2013 provisional estimates, May 2015

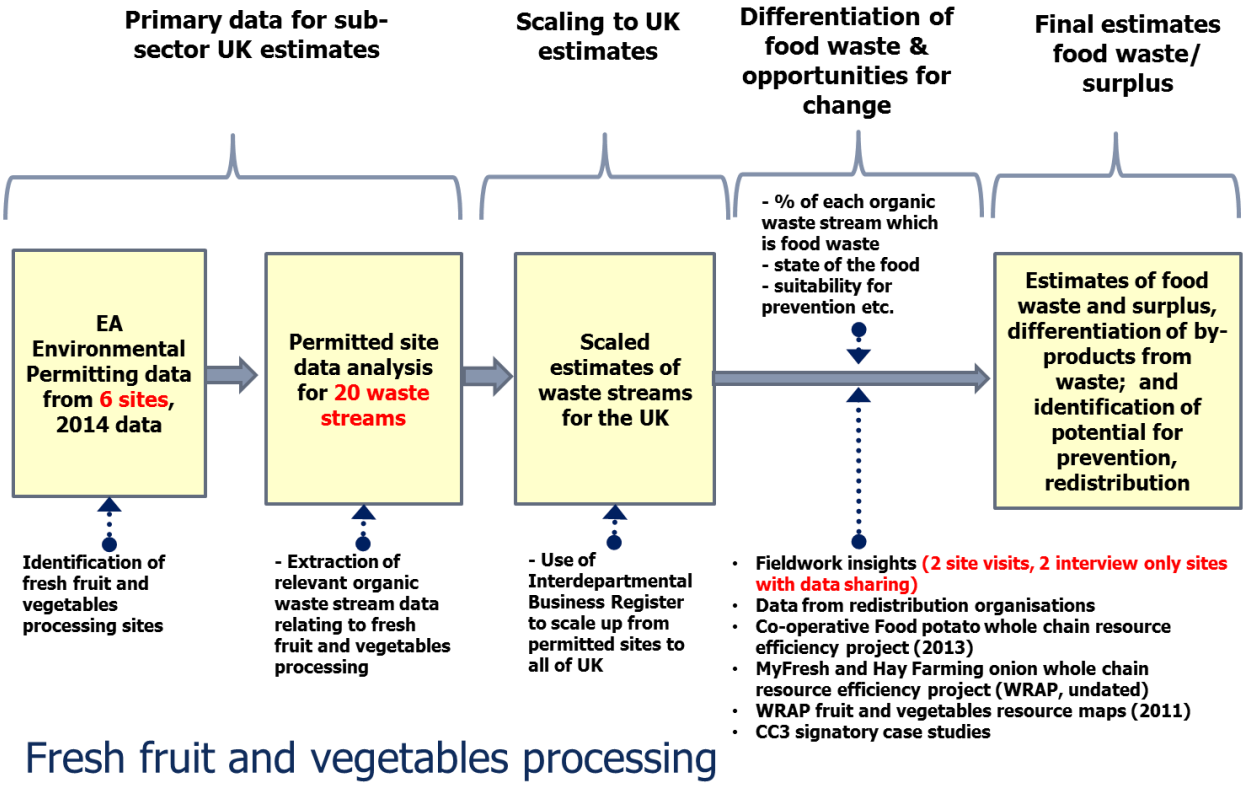
Evidence gathering approach

The sources and approach to evidence gathering is summarised in Figure E1.

- High level supply chain mapping was available from the Co-operative Food potato whole chain resource efficiency project (2013)[111], WRAP fruit and vegetables resource maps (2011)[112] and Myfresh and Hay Farming whole supply chain resource efficiency projects (WRAP, undated)[113].

[111] *Co-operative food potato whole chain resource efficiency project 2013*
[112] *Fruit and vegetable resource maps 2011*
[113] *Myfresh and Hay Farming whole supply chain resource efficiency project*

Figure E1: Summary of evidence gathering approach – Fruit and vegetables processing sub-sector



Findings summary

This sector is highly varied in terms of produce types, product characteristics, the influence of seasonality and reasons for loss. For example, some produce is inherently fragile, with higher natural rates of respiration and shorter shelf-life, whereas other types of fruit and vegetables can be stored longer term. Towards the end of the growing season or as a result of adverse growing conditions, quality may deteriorate and losses and out-grades increase. Table E2 provides an overview of the example wastes and surpluses that occur in this sector.

Table E2: Example surpluses and wastes – Fresh fruit and vegetable processing sub-sector

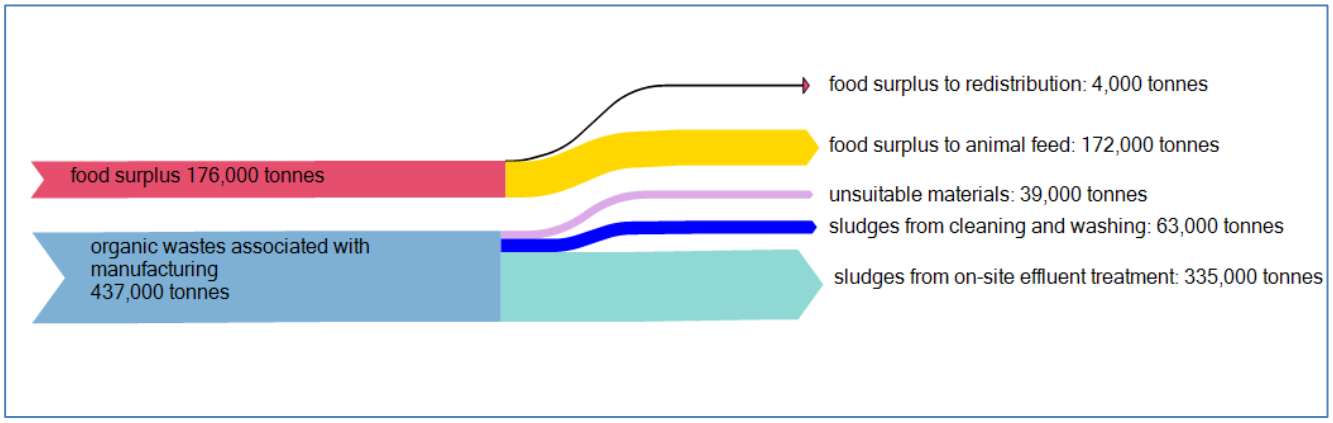
Materials	Source	Example Management Approach
Down-graded produce	Inbound product at pack house does not meet Class I or Class II specification; may be due to over-sized/ under-sized produce or to wider variety of reasons: poor handling/ bruising, moulds, pests/ disease (e.g. carrot fly, cavity spot in carrots), physiological changes (e.g. greening of potatoes, silvering of carrots, wilting in salads), poor temperature management.	To lower value markets (cut, sliced, batons as a by-product), animal feed or AD
Grading errors	During grading processes, good quality produce may be mis-identified and down-graded as a result. Where such losses have been quantified, the scale of this loss was estimated at between 3-4% for a highly mechanised grading process.	To animal feed or AD
Rejected whole loads	Inbound product; if the quality is too low, it is not worth sorting/ grading; there is considerable interaction between pre-farm gate losses and rejects at pack houses	Returned to farm (not recorded in site waste data)
Soil and stones	Washed from incoming produce before grading	Contributes to sludges from washing/ cleaning; stones caught within screens prior to on-site treatment; some sites operate settling ponds; soil may be sent back to farm
Surplus to redistribution	Class II produce being sent to redistribution (not down-grade) e.g. carrot batons where the produce was not sufficiently orange for the intended market specification	Sent to redistribution
Bunched produce, organic carrots	Undersize items within bunch or yellowing of carrot leaves	Animal feed
Packaged vegetable selections	Missing items in mixed fresh vegetable selections sold as ingredients for specific dishes	Re-work
Rejected packaged product, leaf crops	Seal failure/ leaf salad with leaves trapped within seal	To AD
Inedible material rejected from fruit/ vegetable processing	Inedible food material from peeling, stoning, stalking	To AD
Sludges	From routine washing, testing and plant de-sludging operations	To on-site lagoon system, sludge to land-spreading

2014 Environmental Permitting Data

Data was obtained from 2014 EP returns that included six sites, producing 20 waste streams with organic content. The limited number of sites is a reflection of the higher threshold set for need a Permit for sites processing vegetable materials compared with those processing materials that contain meat or dairy.

At the UK level there are 80 sites employing more than 100 employees, therefore the estimates shown in Figure E2 are subject to higher uncertainty than other sub-sectors.

Figure E2: Waste and by-product flows – Fresh fruit and vegetable processing sub-sector, UK estimates derived from 2014 EP data



Organic waste streams

Significant losses of fruit and vegetables occur on farm from unharvested product, over-planting, weather events, pests, disease, rejected loads returned to farm and cancelled orders. These losses are not within scope of the current study. At processing sites, grading losses vary widely by type of crop and variety.

The 2014 EP data records three main types of waste streams from sites (Table E3):

1. Materials unsuitable for production or consumption. This represents a small quantity of materials relative to other waste streams and relates mainly to out-graded produce that is not suitable for alternative markets. Such materials are mostly sent to AD or land-spreading (approximately 39,000 tonnes/year);
2. Sludges from on-site treatment activities. This waste stream consists mainly of wet sludges from treatment of wastes from fruit and vegetable preparation (approximately 335,000 tonnes/year); and
3. Sludges from washing/ cleaning and peeling of fruit and vegetables this waste stream (62,000 tonnes/year) includes peelings and off-cuts at sites that process fresh fruit and vegetables into pre-prepared products, such as carrot batons, mixed cut salads and cut fruit salads. It differs from stream 2 in that the wastes have not been processed through an on-site treatment plant and therefore includes raw fruit and vegetable materials.

Table E3: Treatment and disposal of organic waste streams containing food waste – Fresh fruit and vegetable processing sub-sector, UK estimates derived from 2014 EP data

Disposal Route	Materials unsuitable for production or consumption	Sludges from on-site treatment of effluent (mostly consists of wet material from food prep/ water, soil)	Sludges from washing, cleaning, peeling (food prep waste + water)
Landfill	0	0	0
Incineration / Energy recovery	4,000	0	0
Land-spreading	12,000	335,000	56,000
AD/ composting	24,000	0	7,000
Total	**39,000**	**335,000**	**63,000**

*Totals may not add up due to rounding

Wastes in the form of sludges generated by the fresh fruit and vegetable processing sub-sector are highly liquid and are mainly tankered off-site and applied to land as slurries. The more solid wastes, in the form of rejected produce and peelings, are sent to AD or composting. The latter are more likely to contain material suitable for redistribution than the streams that contain washings and peelings.

Food waste

The food waste element within the 437,000 tonnes/year is estimated to be 144,000 tonnes (33%). This takes account of the extent to which the treatment sludges of both types are likely to contain non-food elements such as soil, wash water, weeds and grit. The fraction of food-related material is assumed to be higher for streams that contain peelings and other rejected materials.

Avoidable food waste is a high proportion of total food waste and is mainly associated with out-graded produce that is still good to eat, over-peeling and poor grading.

Table E4: Food waste within organic waste streams – Fresh fruit and vegetable processing sub-sector, UK scaled estimates derived from 2014 EP data

Fresh fruit & vegetables	Organic waste streams containing food waste			Total (tonnes per annum)
	Materials unsuitable for production or consumption (tonnes per annum)	Sludges from on-site treatment of effluent (tonnes per annum)	Sludges from washing, cleaning, peeling (tonnes per annum)	
Organic waste streams	39,000	335,000	63,000	437,000
Of which: Food waste	39,000	65,000	40,000	144,000
Of which: Avoidable food waste	35,000	35,000	30,000	100,000
Avoidable as % total food waste	90%	54%	75%	69%
			Food surplus to redistribution	4,000
			Food surplus to animal feed	172,000

Waste prevention potential

There is potential to reduce the quantities of fresh fruit and vegetables wasted at processing sites through the implementation of measures that prevent waste at source. Of the total food waste element of waste arisings, at least 12% of current wastage could be eliminated, based on observations during sites visits and acting on the measures set out in Table E5. This equates to 17,000 tonnes/year, with the most significant contributions likely to be made by greater diversification of out-grade markets and whole supply chain initiatives to reduce surpluses.

Table E5: Waste prevention measures – Fresh fruit and vegetable processing sub-sector

Yield losses through process inefficiencies: excessive peeling, physical damage to the produce (poor conditioning) or premature spoiling.
Reduction in grading errors where good produce ends up in out-grades.
Reducing the scale of out-graded materials wasted or sent to animal feed through new markets for greater range of produce (e.g. smaller potatoes that are 'microwaveable' and sold as a premium product).
Whole supply chain improved sharing of knowledge and demand forecasting to improve crop utilisation and moderate supply and demand.
Earlier discussion of tolerances in product specification, between retail buyers and producers, in seasons when yields are lower than expected or there are other problems with produce meeting quality standards.
Better monitoring of out-grades and losses on different packaging lines.

Table E6: – Summary of waste prevention – Fresh fruit and vegetable processing sub-sector, UK estimates

Fresh fruit & vegetables	Waste prevention potential (tonnes per annum)
Potential to prevent waste arising	17,000
Additional redistribution potential	
from current avoidable food waste	30,000
from current surplus to animal feed	13,000
Additional animal feed potential	25,000
Total potential for waste prevention	72,000
as % avoidable food waste	72%

Food surplus to redistribution

Only 4,000 tonnes of produce is estimated to be currently redistributed for human consumption by the fresh fruit and vegetable processing sub-sector. This low quantity reflects the perception that the haulage and handling costs of making the surplus available would be prohibitive, with some producers finding it cheaper to donate packaged product rather than finding ways of making out-graded produce available.

Leaving to one side the commercial factors and based solely on the assessment of what would be fit for human consumption, Table E7 provides minimum and maximum estimates of redistribution potential. From observations made during site visits, it is assumed that 15-20% of out-grades are suitable for redistribution i.e. 'easily redistributable' and that a further 10-15% would require further processing (i.e. inclusion in soups, slicing, use at redistribution outlets providing meals). The quantities of produce that could be collected through gleaning from farms would add to the tonnages shown in Table E7, but pre-farm gate sources are outside the project scope.

Table E7: Range of estimates for redistribution potential from fresh fruit and vegetable processing (tonnes)

	Minimum estimate	Maximum estimate
Category 1 Produce readily redistributable	15,000	24,000
Category 2 Produce requires further work	10,000	18,000
Total, including current redistribution (4,000 tonnes)	**24,000**	**41,500**
Potential additional redistribution	**20,000**	**37,500**
Source of additional redistribution tonnages	66% from what is currently food waste / 33% diversion from what is currently sent to animal feed	

Food surplus to animal feed

It is estimated that 172,000 tonnes per annum of rejected product is sent to animal feed. Much of the material currently sent to animal feed is likely to be Class III produce from sites engaged in grading and packing operations. However the site visits found instances of higher grade produce on lines packing exclusively for a specific retailer being sent to lower grade

markets or to animal feed. Much depends on whether or not sites that are processing fresh fruit and vegetables have a range of alternative markets for down-graded produce and the extent to which there is a local demand as stock feed. This will vary by geography and by season, with periods of glut making alternative markets less viable. Where those markets do not exist, the quantities of fruit and vegetables ending up in the waste stream will be greater.

It is likely that some of the 'unsuitable' material that is rejected and some of the peelings that are currently sent to AD would be suitable for animal feed. An additional 20,000 tonnes of material could be diverted to animal feed, giving a maximum potential of 195,000 tonnes.

Conclusions

- Sludges from cleaning and preparing produce and from on-site waste water treatment are the dominant waste streams in this sector. These flows are wet waste streams and contain significant quantities of non-food materials, such as soil from washing;
- Material rejected from product or by-product streams represents the main 'food waste' element. However, these materials are likely to be lower grade, but also contain higher grades that have been mis-sorted;
- The site visits and supporting stakeholder interviews found instances of redistribution using Class II product, as well as material that would otherwise have been destined for alternative markets; and
- There is significant potential to redistribute more product within this sector however the costs of this may be prohibitive compared with allowing local farmers access to material for use in animal feed.

Appendix F: Bakery, cake and cereals

Bakery, cake and cereals – assessment of food waste prevention, food surplus and food waste

Overview

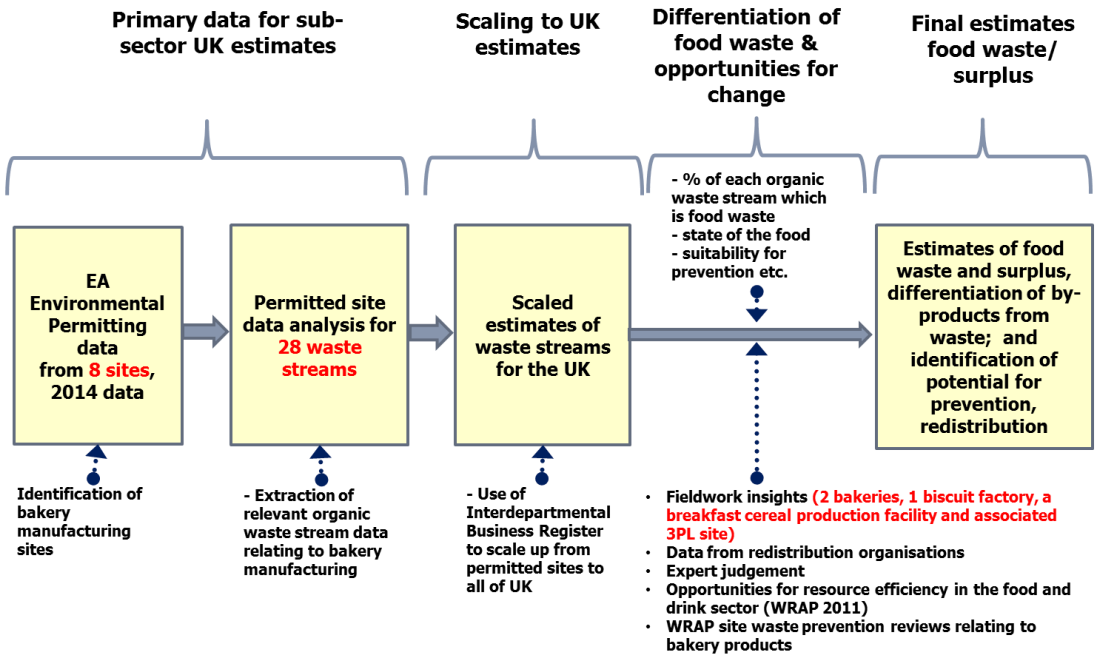
For the purposes of this analysis, this sector included bakery, cakes, biscuits and breakfast cereals[114] and covered a range of different products including fresh bread and other bakery products, cookies and crackers, frozen bakery products and cereal breakfast foods.

In 2014, the UK bakery sector produced 5.6 million tonnes of products with a sales value of £9.8 billion (PRODCOM, 2014).

Evidence gathering approach

Evidence was gathered from the sources indicated in Figure F1. The site-based data and observations included two bakeries, a biscuit factory and a breakfast cereal production facility and associated 3rd party distribution operation

Figure F1: Summary of evidence gathering approach– Bakery, cakes, biscuits and breakfast cereals sub-sector



Bakery, cake and cereals

Findings summary

This sub-sector covers a wide range of products and production operations vary significantly from large scale, industrial bakeries to small craft bakeries. Table F1 provides an overview of the main types of waste/ by-products that occur in the bakery sector.

[114] Breakfast cereals included here, rather than milling sector as food surplus/ waste profile more similar to the bakery sector

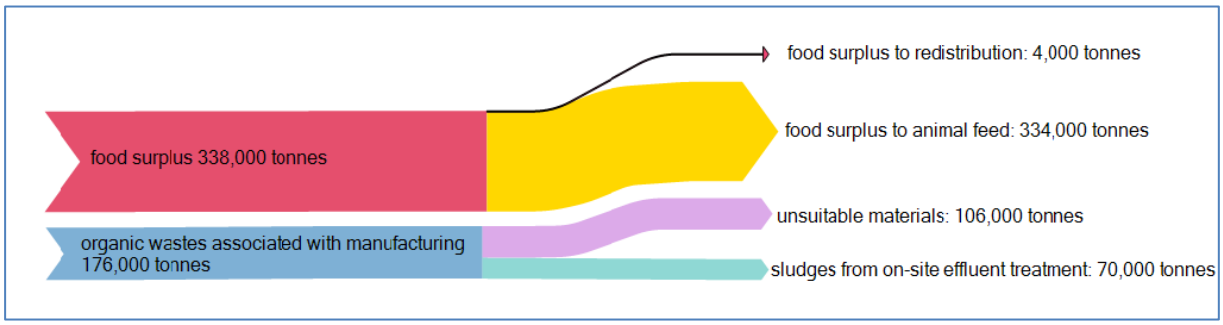
Table F1: Example surpluses, wastes and by-products – Bakery, cakes, biscuits and breakfast cereals sub-sector

Materials	Source	Example Management Approach
Ingredients	QA/ shelf life/ handling issues/ contamination	Animal feed Hazardous waste (e.g. in the case of pest infestation/ certain ingredients e.g. spices etc.) – disposal Anaerobic digestion
Work in progress	QA/ technical issues/ handling issues/ changeovers/ cleaning & maintenance	Re-work Animal feed Anaerobic digestion
By-products e.g. bread crumbs	Production processes	Sold as a separate product
Finished products	R&D/ QA/ shelf life/ handling issues/ packaging failure/ customer returns	Rework Animal feed Redistribution Staff shop sales, not included within food surplus totals

2014 Environmental Permitting Data

Data were obtained from EP returns and contained eight sites, producing 28 waste streams with organic content. Across the UK there are 195 local business units employing 100 or more staff, with a large number of smaller sites (2,745). Analysis of the data is presented in Figure F2 below.

Figure F2: Organic wastes food surplus and by-product flows – Bakery, cakes, biscuits and breakfast cereals sub-sector; UK estimates derived from 2014 EP data



Organic waste streams

The 2014 EP data suggests that the bakery sector generates two main types of organic waste (see Table F2):

- Materials unsuitable for production or consumption: from site visits these were found to contain unusable ingredients, waste dough, floor sweepings, scrapings from equipment clean down, QA rejects etc. that could not be sold to alternative markets; and
- Sludges from on-site treatment of effluent: mainly wet material with a high water content from food preparation and site cleaning activities.

As Table F2 shows, the majority of materials unsuitable for production or consumption from this sector are sent to AD/ composting

Table F2: Treatment and disposal of organic waste streams containing food waste – Bakery, cakes, biscuits and breakfast cereals, UK estimates derived from 2014 EP data

Disposal Route	Materials unsuitable for production or consumption (tonnes per annum)	Sludges from on-site treatment of effluent (tonnes per annum)
Landfill	0	0
Incineration / Energy recovery	3,000	0
Land-spreading	0	68,000
AD/ composting	103,000	2,000
Total	106,000	70,000

Food waste

The estimate for the total amount of food waste within the 176,000 tonnes is 114,000 tonnes (64%). This total includes all material rejects as these will be rejected bakery products and ingredients. It is assumed that the sludges mainly result from site cleaning and consist of non-product and ingredient water with minimal solids (11%) derived from wasted product or ingredient.

Table F3 Food waste within organic waste streams – Bakery, cakes, biscuits and breakfast cereals sub-sector, UK scaled estimates derived from 2014 EP data

Bakery, cakes, biscuits and breakfast cereals	Organic waste streams containing food waste		Total (tonnes per annum)
	Materials unsuitable for production or consumption (tonnes per annum)	Sludges from on-site treatment of effluent (tonnes per annum)	
Total organic waste streams	106,000	70,000	176,000
Of which: Total food waste	106,000	8,000	114,000
Of which: Avoidable food waste	87,000	3,000	90,000
Avoidable as % total food waste	82%	38%	79%
		Food surplus to redistribution	4,000
		Food surplus to animal feed	334,000

During the site visits it was observed that a number of products that did not meet final quality requirements were sold into a range of secondary markets (depending on the nature and value of the product and the production operation), e.g.

- Damaged products being downgraded and sold as 'mis-shapes' via lower value distribution channels, and therefore not available as a food surplus for redistribution;
- Damaged products being downgraded and sold as ingredients to other manufacturers, e.g. to confectioners, fish bait manufacturers, direct to farmers for animal feed; and
- Short life products being sold via the discount retail sector.

Evidence of rework was noted on a number of the site visits especially at the primary and secondary packaging stages. WIP is harder to rework due to the nature of the product, e.g. dough mixes. The scale of rework undertaken is determined by a number of factors, e.g. volumes of product requiring rework, the time available (especially in the case of waste occurring during the initial production stages e.g. dough waste), production schedules and the availability of resources to complete this rework. Where materials cannot be reworked, they are generally sent to animal feed (dough is baked first) or anaerobic digestion.

Waste Prevention Potential

Across the sites that participated in the study, scope for waste prevention was identified in the context of process improvements and better house-keeping in relation to current losses. As an indication of overall potential, particularly through better monitoring systems to review over-baked and off-specification production, review of ingredients procurement and greater prioritisation of waste prevention, it was estimated that 10,000 tonnes of reduction potential would be possible, equivalent to 9% of current food waste.

Table F4: Waste prevention measures within the bakery, cakes, biscuits and breakfast cereals sub-sector

Collection of data relating to losses to be given greater priority tracking/ reducing waste and looking at the operational aspects rather than just the commercial aspects.
Need for closer monitoring of waste levels caused by over-baked/ off-spec production.
Closer monitoring of surplus to animal feed and the need for inclusion within waste KPIs.
Review of ingredients purchasing policies: bulk purchase of ingredients can cause issues with shelf life especially where minimum order quantities (MOQs) are high.
Address barriers to redistribution: perceived risks to the integrity of branded products

Table F5 – Summary of waste prevention – Bakery, cakes, biscuits and breakfast cereals sub-sector, UK estimates

Bakery, cakes, biscuits and breakfast cereals	Waste prevention potential (tonnes per annum)
Potential to prevent waste arising	10,000
Additional redistribution potential	
from current avoidable food waste	5,000
from current surplus to animal feed	1,000
Additional animal feed potential	60,000
Total potential for waste prevention	75,000
as % avoidable food waste	83%

Food surplus to redistribution

A small proportion of products are sent for redistribution (approximately 4,000 tonnes per annum in 2015), either via national redistributors or to local charities. However, this is limited due to the relatively short shelf life of a lot of bakery products and also concerns around the potential impact of redistribution on brand integrity. A number of the sites visited also made local donations of products e.g. to local events/charities.

This research identified some evidence of redistribution, especially in the case of longer life products. However quantities are very low compared to the volume of materials sent to animal feed. Due to the nature of the product and production processes, redistribution potential relates mainly to finished products rather than to work in progress (e.g. dough). Significant additional handling activity would be required to convert work in progress materials into a product that would be considered appropriate for human consumption and which can be easily handled through the redistribution channels.

During a number of the site visit and stakeholder interviews, considerable concern was raised about the risk that redistribution poses to the integrity of branded products, and this was cited as a barrier in terms of the increasing the quantities of bakery products that are redistributed.

The requirements of the redistribution charities may also impact the redistribution potential, e.g. some redistributors are not prepared to accept 'snack' products and others are not prepared to accept products where the primary packaging is damaged, even though the product itself is undamaged.

The overall assessment of potential to redistribute additional food surplus from the sub-sector concluded that an additional 6,000 tonnes per annum could be redistributed, with 20% of this product displacing current animal feed diversion and 80% from sources currently sent for disposal. This assessment was based on site observations and an analysis of mean quantities currently redistributed by participation sites.

Food surplus to animal feed

The majority of surplus bakery product is sent to animal feed (334,000 tonnes per annum) and this sector provides over 52% of the total volume of surplus food sent to animal feed in the UK. This is a long-established route for bread waste and other suitable material from this from this sub-sector.

At some sites staff regarded the revenue stream associated with this route as an impediment to addressing the root causes of surplus and waste. As the material sold to the former foodstuff processing sector is accounted for as revenue, it is not regarded as a waste stream, even though the revenue losses compared with the intended market are significant.

The potential for additional material to be sent to animal feed is estimated to be 60,000 tonnes, an additional 18% above current levels. This estimate factors in the food surpluses generated by the sector that are likely to contain ABPs that are prohibited from use within animal feed i.e. ruminant gelatines may be found in certain bakery products. It was not possible to collect sufficiently detailed data to provide a split between ABP and non-ABP waste streams.

Conclusions

- The scale of food losses varies considerably across the sub-sector, but the results suggest that current diversion of food surplus to animal feed is three times larger than estimated food waste. This reflects the suitability of bread and cereal surpluses for use in animal feed and the long-established relationship between the sub-sector and the animal feed industry;
- There is currently little opportunity to redistribute work in progress due to the nature and form of these materials. Redistribution potential therefore exists mainly around packaged products and is estimated to be about 6,000 tonnes, 20% of which is estimated to be surplus suitable for redistribution currently diverted to animal feed; and

- Brand implications of redistribution activities need to be understood and any actual/ perceived barriers addressed before the redistribution potential within this sector can be realised.

Appendix G: Pre-prepared meals

Pre-prepared meals – assessment of food waste prevention, food surplus and food waste

Overview

Pre-prepared foods are, in general, complex products assembled from a high number of ingredients. These products typically have a short shelf life if chilled or can be frozen. This sector of the UK grocery market is very diverse and includes a wide range of products, e.g. meat or poultry dishes; fish dishes (including fish and chips); vegetable dishes; frozen or otherwise preserved pizza; fresh (i.e. uncooked) pizza; and sandwiches.

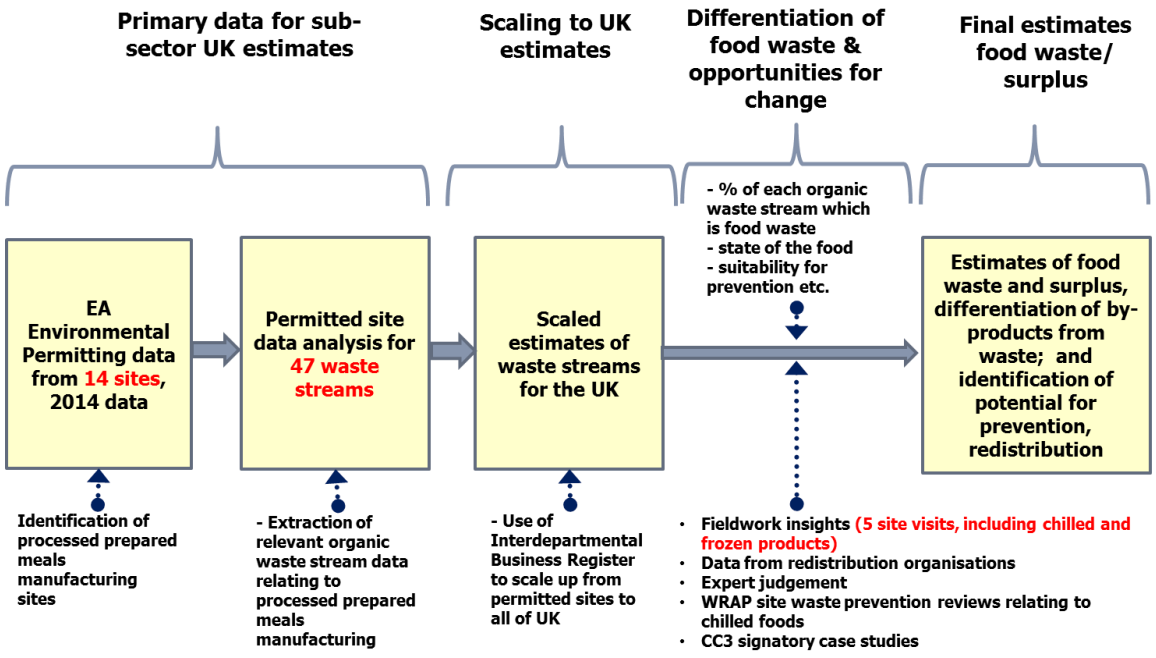
In 2014 the UK pre-prepared meal sector manufactured 1.3 million tonnes of products, with sales of £5.2 billion (PRODCOM, 2014). This sector consists of 45 larger business units employing 100 or more staff and a large number of smaller businesses.

Evidence gathering approach

To inform this research, evidence was gathered from the sources outlined in Figure G1.

- Site-based data and observations from 5 site visits (both chilled and frozen operations), interviews with key stakeholders at that sites and analysis of site specific data; and
- WRAP site waste prevention reviews relating to chilled foods

Figure G1: Summary of evidence gathering approach – Pre-prepared meals sub-sector



Pre-prepared meals

Findings summary

The complexity and variety of pre-prepared products can give rise to waste at many different points in the supply chain. For example, one of the sites visited handled approximately 2,500 different ingredients. There were wide variations in wastage rates across the sites visited, reflecting the differences in product types and end-market specifications. For a study of this type it is not possible to know whether or not the sites that agreed to participate were typical of such a diverse sector. It should also be noted that the site visits only provide a snapshot of operations and waste levels on the day of the visit. As there are no published benchmarks for food waste (e.g. by product type), it is not possible to make on assessment of this point. The data analysed as part of this research suggests that overall wastage in this sector in relation to weight of output product was around 6%[115]. This reflects the nature of more complex products where the potential for rework may be more limited (e.g. in sandwich making) and product formulation and shaping may be more susceptible to errors. Table G1 summarises the main types of waste or by-products that occur in the pre-prepared meals sector.

Table G1: Example surpluses, waste and by-products – Pre-prepared meals

Materials	Source	Example Management Approach
Ingredients	Bread crusts in sandwich making; also crushed or misshaped bread (sandwich maker)	Sent to animal feed
Ingredients	Unused ingredients supplied in minimum quantities, often not used in time (sandwich maker)	As food waste to AD
Ingredients	Natural variation in ingredients, impacts on product (ready meal manufacturer)	Improve consistency in procurement, minimise losses through rework
Work in progress	Out of specification pizza bases QA/ production processes Under/ over baked Trimmings (e.g., tomato ends, vegetable peel) Floor waste, cutting/preparation waste in sandwich making Rejects from cooking process (e.g. pasta meals) Residues in cooking vessels (pizza manufacturer)	To AD
Work in progress	'Mis-shapen' product, represents the majority of waste, 'underweights'/ 'short dated' (ready meal manufacturer)	What cannot be reworked is sent to AD Some sent to redistribution, but limited by lack of cold storage at redistribution depot
Work in progress	BOM ends from beef used as sliced meat in sandwich making (sandwich maker)	Packaged within high care area and sold as by-product
Work in progress	'Wrongly mixed product' (ready meal manufacturer)	Redistribution, instances where ingredients may be missing

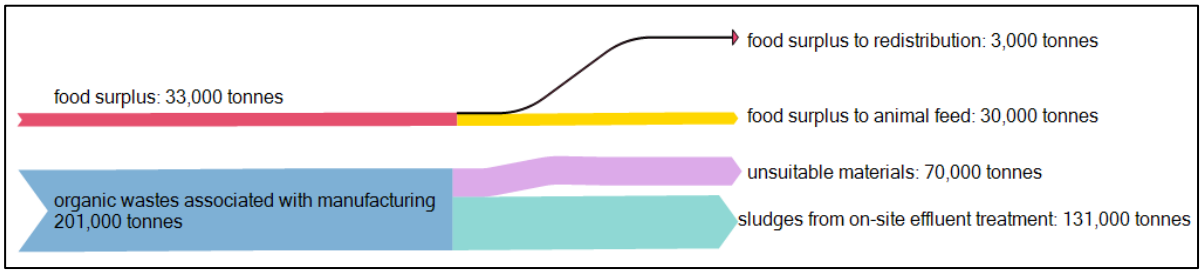
[115] *Confidential discussions with the Chilled Food Association suggests that this estimate (which covers both chilled and frozen pre-prepared foods), is consistent with findings from a survey of their members (which found an average of 7-8% food waste (compared to production volumes)*

Materials	Source	Example Management Approach
Site washing/ cleaning	Wash water containing food particles, oils and fats, floor washings & equipment changeovers (sandwich maker)	Treated via dissolved air flotation (DAF) plant
Finished Products	QA, production processes, customer returns, packaged sandwiches with smeared windows. (pizza maker), handling issues (e.g. cold chain disruption), impact of storage conditions on product appearance	To AD, cannot go from low care to high care for rework
Finished Products	Returns from retailer, QA rejects, handling issues (e.g. cold chain disruption), impact of storage conditions on product appearance	Volumes too small for redistribution and brand integrity issues prevent this, given to staff (pizza manufacturer). Retailer returns dealt with by 3PLs

2014 Environmental Permitting data

Data was obtained from 2014 EP returns for 14 sites, including 47 waste streams with organic content. The sub-sector has 45 larger sites employing 100 or more staff and 75 smaller local business units. Analysis of the data is presented in Figure G.2.

Figure G2: Organic wastes, food surplus and by-product flows – Pre-prepared meals, UK estimates derived from 2014 EP data



Organic waste streams

The 2014 EP data suggests that the pre-prepared meals sector generates two main types of waste stream:

- 'Materials unsuitable for production or consumption' (70,000 tonnes per annum) varied across the sector, reflecting the diversity of products: QA rejects not suitable for rework, over-baked/ under-baked; and
- Sludges from on-site treatment of effluent, (131,000 tonnes per annum) from site cleaning and shut-downs.

Small quantities of waste edible oils also arise; these are partly derived from the skimmings taken from waste water treatment plant.

Table G2: Treatment and disposal of organic waste streams containing food waste – Pre-prepared meals, UK estimates derived from 2014 EP data

Disposal route	Materials unsuitable for production or consumption (tonnes per annum)	Sludges from on-site treatment of effluent (tonnes per annum)
Landfill	0	0
Incineration / Energy recovery	41,000	0
Land-spreading	0	127,000
AD/ composting	29,000	3,000
Other recycling / biological treatment	0	0
Total	**70,000**	**131,000**

Food waste

It is estimated that of the total 201,000 tonnes of organic wastes arising from the sub-sector, 83,000 tonnes is food waste. This is mostly solid material rejected or wasted during manufacturing that is hauled off-site for disposal. Observations during site audits concluded that sludges were highly liquid with a minor component of solids derived from site washing and cleaning processes. These sludges are mainly applied to agricultural land in the form of slurries. Production rejects are either sent to energy from waste or AD/ composting facilities.

Table G3: Food waste within organic waste – Pre-prepared meals sub-sector, UK scaled estimates derived from 2014 EP data

Pre-prepared meals	Organic waste streams containing food waste		Total (tonnes per annum)
	Materials unsuitable for production or consumption (tonnes per annum)	Sludges from on-site treatment of effluent (tonnes per annum)	
Total organic waste streams	70,000	131,000	201,000
Of which: Total food waste	70,000	13,000	83,000
Of which: Avoidable food waste	60,000	5,000	60,000
Avoidable as % total food waste	86%	38%	72%
		Food surplus to redistribution	2,500
		Food surplus to animal feed	30,000

Waste prevention potential

The site visits and data analysis conducted suggest that a range of waste prevention opportunities exist within this sector however further analysis would be required to identify these in detail. In the first instance, the focus on waste monitoring should be increased and current waste levels should be challenged. Although data relating to all major waste streams are typically being captured, few sites were carrying out a regular, in-depth analysis of this data for the purposes of identifying and addressing the root cause of food waste within their operations. This increased focus on current waste levels should be accompanied by clearly

defined responsibilities for waste management (rather than the typical split of job function between health & safety and environment) and should be underpinned by a comprehensive set of KPIs which are designed to drive improvements in waste prevention.

On the basis of site visits and the findings of WRAP waste mapping studies within the sub-sector (unpublished) the waste prevention potential is estimated to be 13,000 per annum, equivalent to 15% of current food waste arisings.

Table G4: Waste prevention measures – Pre-prepared meals sub-sector

More effective line balancing in ready-meal and sandwich making: ensuring that batch-sizes for different ingredients match up with product recipe.
Improved depositor design in sandwich and pizza making: better changeover and fewer residues.
Dedicated waste capture on individual production lines.
Skills audit: manual processes on wraps production line.
MOQ: challenge company procurement policies on grounds of waste caused by bulk ordered ingredients that are not used in time.
Reduction in ingredient losses through improved stock control and ordering systems.
Reduced trimming of salad, tomato, find uses for cucumber cores.
Avoidance of short batch-runs in ready meal production, as wastage from start-up and shut-down times greater as proportion of finished product.
Address barriers to redistribution: perceived risks to the integrity of branded products

Table G5 – Summary of waste prevention – Pre-prepared meals sub-sector, UK estimates

Pre-prepared meals	Waste prevention potential (tonnes per annum)
Potential to prevent waste arising	15,000
Additional redistribution potential	
from current avoidable food waste	5,000
from current surplus to animal feed	400
Additional animal feed potential	4,000
Total potential for waste prevention	24,000
as % avoidable food waste	37%

Food surplus to redistribution

Small quantities of food are currently diverted to redistribution (approximately 2,500 tonnes per annum). There is significant redistribution potential in this sector; however brand issues and a widely held perception that 'quantities are not significant enough' restricts the volumes of food that are currently sent for redistribution. The annual redistribution potential for pre-

prepared meals is estimated at 7,000 tonnes, based on data from sites currently engaged in redistribution and observations from site visits.

Food surplus to animal feed

For sites where safe segregation of non-ABP contaminated food surplus is in place, diversion to animal feed is estimated to account for 4,000 tonnes per annum.

Within this sector, products that contain ABPs that are prohibited from use in animal feed have to be strictly segregated from other food surplus that is suitable for use in feed. Only one of the sites visited used animal feed as a route for food surplus, with others unable to send materials to animal feed due to segregation risks between ineligible ABPs and other materials. Safe segregation could overcome the compliance issues where the non-ABP material can be segregated at source (e.g. rerouting pasta that is currently sent to AD to animal feed). Such processes would allow the amount of food sent to animal feed to be increased from 30,000 tonnes per annum to approximately 34,000 tonnes per annum. However it should be noted that this potential increase is still limited due to the scale of contamination risks associated with ABPs within the sub-sector and the challenge of establishing such levels of segregation. It also requires site assessment of ABP and non-ABP arisings, which in turn requires better tracking of food waste and surplus in relation to production lines.

Conclusions

- This sector represents a greater challenge in terms of food redistribution due to the need to ensure that products are constantly held at an appropriate temperature within the chill chain to avoid spoilage;
- Short shelf life, coupled with the need to hold products within the chill chain, appear to be the main causes of waste in the case of chilled prepared meals (ingredients, work in progress and finished products). Both of these factors make these products more challenging to redistribute;
- The nature of frozen products means that these products typically have longer shelf lives and lower waste levels; however storage requirements for these products makes redistribution more complex;
- The majority of food surplus is currently sent to animal feed, with potential to divert more if greater efforts are made towards mapping of ABP and non-ABP zones within sites and across surpluses;
- There is currently little opportunity to redistribute work in progress due to the nature and form of these materials. Redistribution potential therefore exists mainly around packaged products and is estimated to be an additional 5,400 tonnes per annum; and
- Brand implications of redistribution activities need to be understood and any actual or perceived barriers addressed before the redistribution potential within this sector can be realised.

Appendix H: Soft drinks and fruit juices

Soft drinks and fruit juices – assessment of food waste prevention, food surplus and food waste

Overview

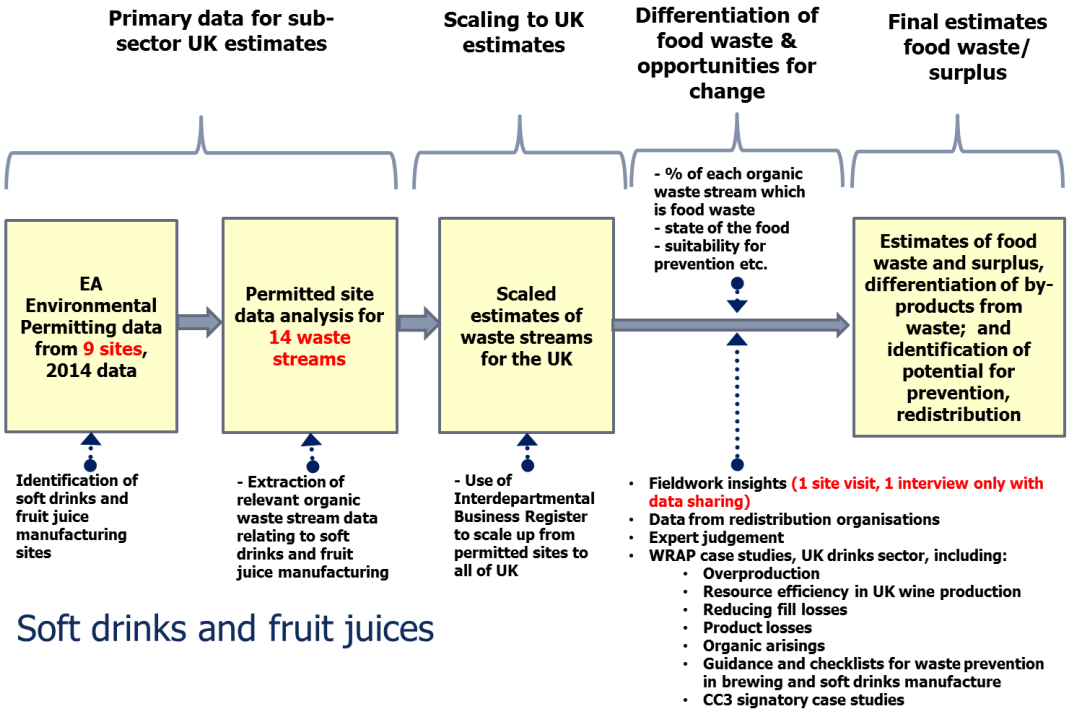
This sub-sector includes fruit juices, manufacture of fruit and vegetable juice, soft drinks (carbonates and dilutable drinks - quashes, cordials) and the production of mineral waters and other bottled waters. Carbonated drinks represent the largest category, with 48% of market (BSDA Annual Report 2015). The sub-sector manufactures 15 million tonnes of product in the UK, with a total sales value of £5.4 billion (PRODCOM 2014). In the UK production is dominated by two key companies: Britvic and Coca-Cola Enterprises.

Evidence gathering approach

To inform this research, evidence was gathered from the sources shown in Figure H1 which included:

- Two sites participating soft drink manufacturers, one with a site visit and the another data sharing only; and
- High level supply chain mapping[116] [117] and material flow analysis, based on WRAP resource efficiency reviews.

Figure H1: Summary of evidence gathering approach – Soft drinks and fruit juices sub-sector



Findings summary

The soft drinks sector has low wastage rates relative to production volumes and very low levels of surplus. Most of the opportunities to reduce waste further relate to produce entrained in cleaning operations and reduction in losses caused by over-fills and under-fills.

[116] *Resource efficiency in the UK soft drinks sector*
[117] *Reducing fill losses, resource review UK drinks sector*

Table H1 provides examples of the main waste types encountered.

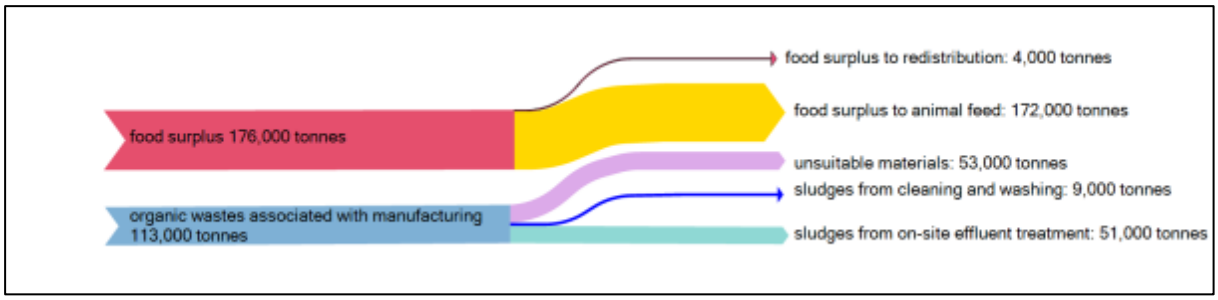
Table H1: Example surpluses and waste – Soft drinks and fruit juices

Material	Source	Example Management Approach
Finished products	Short-dated stock + end of promotion stock	Cleared through discounter (food surplus)
Effluent to treatment plant	Wash water, some dilute product, CIP systems	Review of liquid product lost through push waters, review of sensitivity of in-line BRIX meters to detect changes in sugar content
Work in progress	Under-fills and over-fills in bottling line, where product is not sealed before check-weighing, rework is possible	Reworked
Work in progress	Labelling faults, bottle top defect in forming of plastic	To redistribution or to AD
Work in progress	QA rejects on bottle seals	Not suitable for redistribution, crushed and sent to AD via liquid tanker, formerly sent to animal feed
Surplus product	Part pallets surplus to order requirements, end of promotion surpluses	Redistribution and staff shop, not included in food surplus estimates
Batch on bottling line rejected	QA issue with ingredients	Sent to AD or to animal feed

2014 Environmental Permitting data

Data was obtained from EP returns for nine sites, including 14 waste streams with organic content. According to IDBR estimates, the sub-sector contains 25 larger local business units employing more than 100 staff and 240 small sites. Analysis of the data is presented in Figure H2 below.

Figure H2: Organic wastes, food surplus and by-product flows – Soft drinks and fruit juices sub-sector; UK estimates derived from 2014 EP data



Organic waste streams

Total organic waste quantities are low relative to production tonnages, estimated to be 113,000 tonnes per annum, or 0.75%, based on the scaled-up EP data. However, this includes water bottling, which distorts the overall numbers as these bottling plants have no organic waste streams. The soft drinks industry uses large quantities of water in products and in production processes.

The participating sites did not include fruit juice manufacturers and were limited to the carbonated and 'dilutables' sections of the soft drink market.

The main waste streams arising from the sub-sector were evenly split between rejected product and inputs to production waste, estimated to be 53,000 tonnes per annum ('materials unsuitable for production or consumption') and sludges generated from on-site treatment processes, at 51,000 tonnes per annum.

The treatment and disposal options applied to sites reporting under the EP regulations are shown in Table H2. The use of land-spreading of more liquid waste streams from washing and effluent treatment plant is the predominant route. AD and incineration are also management routes for rejected products and ingredients.

Table H2: Treatment and disposal of organic waste streams containing food waste – Soft drinks and fruit juices, UK estimates derived from 2014 EP data

Disposal Route	Materials unsuitable for production or consumption	Sludges from on-site treatment of effluent (mostly consists of wet material from food prep/ water)	Sludges from washing, cleaning, peeling (mostly contains food prep waste + water)
Landfill	0	0	0
Incineration / Energy recovery	11,000	0	0
Land-spreading	39,000	0	9,000
AD/ composting	2,000	0	0
Other recycling / biological treatment	0	51,000	0
Total	53,000	51,000	9,000

Food waste

In terms of total drink waste (i.e. wasted product/ food waste), it is estimated that 77,000 tonnes per annum arises within the 113,000 tonnes total (Table H3), which is equivalent to 0.5% of total UK production tonnage. This is based on the assumption that all of the materials rejected as unsuitable are food waste and that approximately 40% of the sludge weight within the EP data can be equated to liquid product and ingredient water, (with 60% of the weight consisting of non-product water).

It is difficult to reconcile 'dry wastes' in the form of ingredients (e.g. fruit concentrates, sugars, syrups and flavourings) with product weights which are predominantly accounted for by added water, indeed more so than any other industry sub-sector. The estimate is for final product weight within the EP reported waste streams, rather than dry weight of input ingredients.

Table H3: Food waste within organic waste flows – Soft drinks and fruit juices sub-sector, UK scaled estimates derived from 2014 EP data

Soft drinks and fruit juices	Organic waste streams containing food waste			Total (tonnes per annum)
	Materials unsuitable for production or consumption (tonnes per annum)	Sludges from on-site treatment of effluent (tonnes per annum)	Sludges from washing, cleaning, peeling (tonnes per annum)	
Total organic waste streams	53,000	51,000	9,000	113,000
Of which: Total food waste	53,000	21,000	3,000	77,000
Of which: Avoidable food waste	17,000	7,000	1,000	25,000
Avoidable as % total food waste	32%	33%	33%	32%
			Food surplus to redistribution	2,000
			Food surplus to animal feed	12,000

Waste prevention potential

The soft drinks sector has low wastage rates but areas for improvement have been identified, particularly in relation to filling rates, surpluses relating to end of promotion stock, and juice extraction efficiencies in fruit juice production.

The overall potential for measures, such as those in Table H4, to reduce drink waste at source is estimated to be 5,000 tonnes per annum. The estimate is derived from the site visit and discussions with site operators, as well as on WRAP soft drink sector resource efficiency reviews.

Table H4 Waste prevention measures – Soft drinks and fruit juices

More efficient wash-down procedures, less syrup/ ingredient lost to waste water.
Minimisation of set-up losses and run-down losses through larger batches.
Reduction in losses associated with 'push water' used to move product through production process.
Over-production of soft drinks: improvements to demand prediction, review of promotional offers and surpluses generated.
Improvements in juice extraction efficiencies within fruit juice manufacture.
Continuous improvement approach to reduction in rejects, caused by under-fill and over-fill in packaging formats - maintain optimal setting on filling machines.
Review line run rates and economics of higher wastage rates relative to value of sales and customer order fulfilment.
Overcoming barriers to switching from AD to animal feed due to perceived difficulties of compliance with the regulatory requirements

Table H5 – Summary of waste prevention – Soft drinks and fruit juices sub-sector, UK estimates

Soft drinks and fruit juices	Waste prevention potential (tonnes per annum)
Potential to prevent waste arising	5,000
Additional redistribution potential	
from current avoidable food waste	2,000
from current surplus to animal feed	200
Additional animal feed potential	8,000
Total potential for waste prevention	15,000
as % avoidable food waste	60%

Food surplus to redistribution

The current level of redistribution of surplus soft drinks is low, at 2,000 tonnes per annum. The potential to expand this is limited by the low quantities of surplus available and the current use of clearance houses for any shorter-dated stock and the use of staff shops at production sites as a further route. There is potential to expand to 4,200 tonnes per annum, if current levels of redistribution at participating sites were extended across the sector.

Food surplus to animal feed

Some drink surplus is diverted to animal feed and is estimated to be 12,000 tonnes per annum. This is tankered product waste that is removed from site by specialist contractors for use on farm as feed. This could be increased by an additional 8,000 tonnes, with more sites switching from AD and becoming registered as feed producers, based on one large soft drinks manufacturer's recent experience. The carbohydrate content of soft drinks makes the surplus suitable for animal feed. Interviews with site operators found that there was resistance to switching from AD to animal feed because of the perceived difficulties of compliance with the regulatory requirements around feed hygiene, and the need to keep the surplus secure and covered on-site.

Conclusions

- The soft drinks industry operates with low wastage rates, using highly automated systems and highly developed monitoring systems;
- Low levels of surplus drink arise from the industry, particularly in relation to longer shelf-life products where surplus and stock can be cleared through alternative markets;
- Current redistribution of surplus soft drinks is low in relation to total soft drinks production and the estimated maximum potential is 4,200 tonnes per annum;
- There is also potential to divert surpluses away from AD and incineration to animal feed, estimated to have a maximum potential of 20,000 per annum;
- Potential to reduce waste levels further relate to the issue of filling efficiency and rejects related to over-fill and under-fill; and
- Further areas of prevention potential relate to water use and the reduction of ingredient losses (e.g. syrups) in washings and water used to 'push' product through process stages.

Appendix I: Confectionery

Confectionery – assessment of food waste prevention, food surplus and food waste

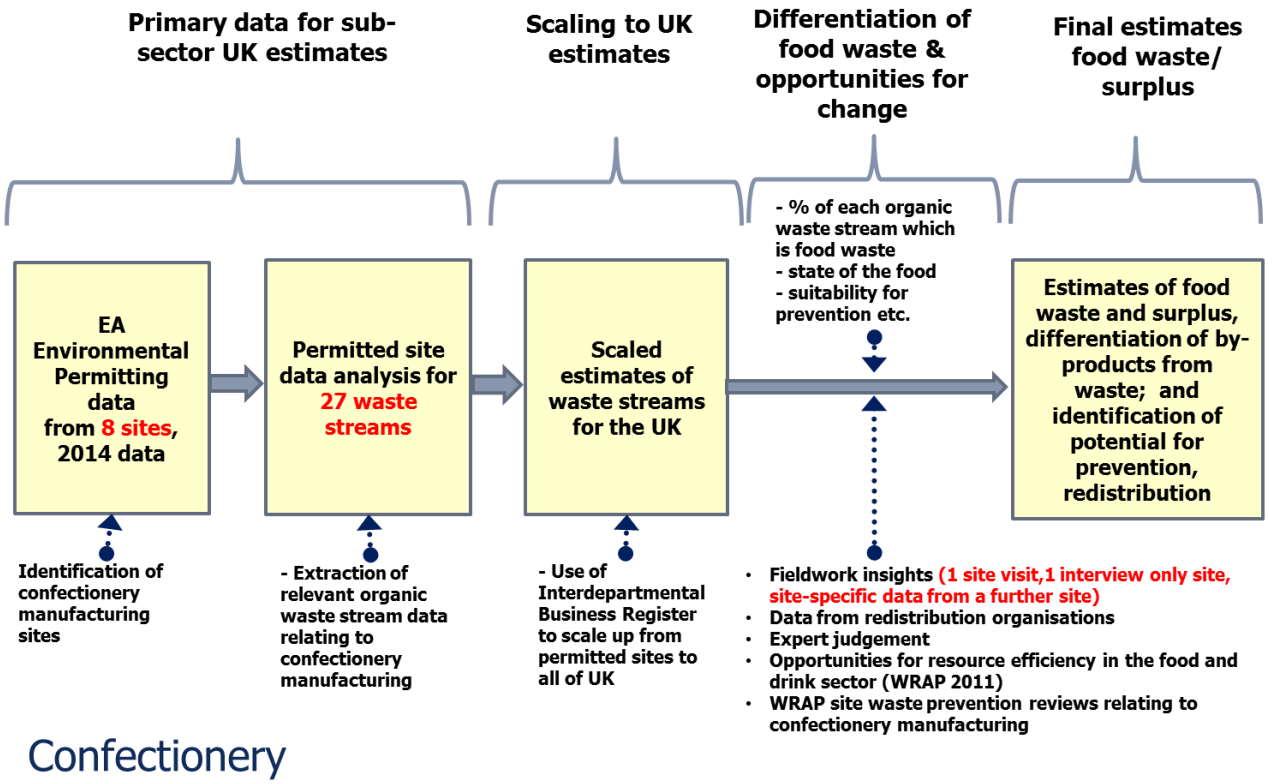
Overview

For the purposes of this analysis, this sector includes confectionery products that include chocolate and cocoa products, sugar confectionery and chewing gum. In 2014 the UK confectionery sector produced 0.7 million tonnes of products, with a sales value of £2.6 billion (PRODCOM, 2014). Overall UK demand for confectionery declined in 2014, although the value of sales rose by approximately 2%. In the UK the chocolate confectionery sector accounts for the majority of total confectionery value. This sector is also the fastest growing area of the market, with sustained growth since the start of the decade, a trend which is expect to continue over the next few years[118].

Evidence gathering approach

A summary of the evidence gathering approach is given in Figure I1 and included site-based data and observations were obtained from one site visit, interviews with key stakeholders and analysis of site specific data from two sites.

Figure I1 Summary of evidence gathering approach– Confectionery sub-sector



[118] www.food.manufacture.co.uk (Nicholas Robinson), 24/7/2015

Summary of findings

There is a considerable focus on resource efficiency across the confectionery sector, and a number of the international confectionery manufacturers have introduced sophisticated waste prevention programmes often centred on 'lean' production principles. For example, in 2015, Nestlé announced that it was converting confectionery waste into renewable energy that was then used to power one of its UK production operations thereby, helping the company to achieve its zero waste to landfill targets and save money.

At the site visited, waste targets are set and performance against these managed carefully, with food waste and rework measured in detail by shift. Any significant issues are logged and handed over to the operational/ engineering teams for investigation. Table I1 summarises the main types of waste/ by-products that occur in the confectionery sector.

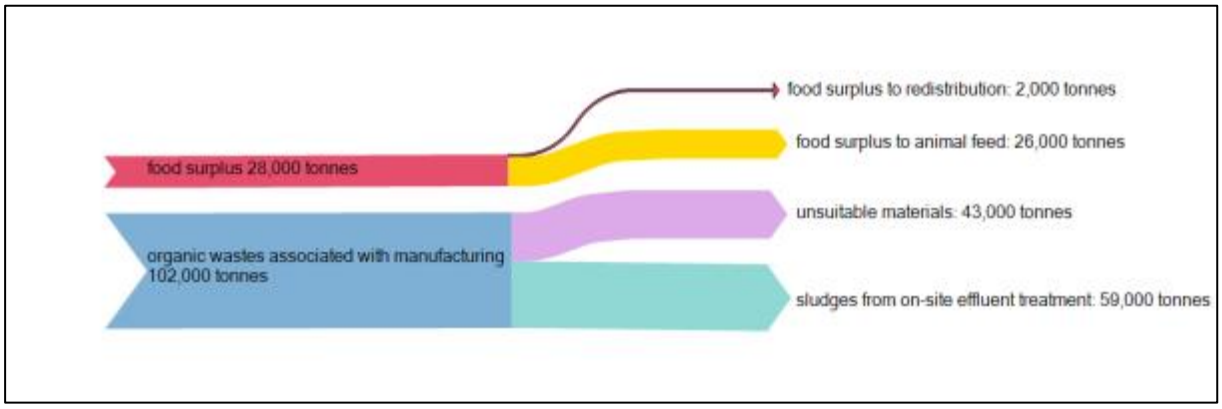
Table I1: Example surpluses, wastes and by-products – Confectionery

Materials	Source	Example Management Approach
Ingredients	QA/ shelf life/ handling issues/ contamination	Animal feed Anaerobic digestion
WIP/ By-Products	QA/ technical issues/ handling issues/ changeovers/ cleaning & maintenance	Rework Animal feed Anaerobic digestion
Sludges	Clean In Place waste sludge associated with milk evaporator	To AD
Finished Products	R&D/ QA/ shelf life/ handling issues/ packaging failure/ customer returns	Rework Animal feed Redistribution Staff shop sales

2014 Environmental Permitting data

Data was obtained from EP returns classified by industry sector for eight sites, including 8 sites and 27 waste streams with organic content. The sub-sector operates 35 sites employing more than 100 staff and 315 smaller manufacturing sites. Analysis of the data is presented in Figure I2 below.

Figure I2: Organic wastes, food surplus and by-product flows – Confectionery sub-sector, UK estimates derived from 2014 EP data



Organic waste streams

The confectionery industry produced 102,000 tonnes of waste in 2014, equivalent to 14% of total finished product tonnes.

There are a range of reasons for food waste, including technical/ manufacturing issues (e.g. underfill, overfill, overcooking), shelf life, packaging defects, handling issues, poor forecasting and customer returns. The use of natural products can introduce a further degree of variability into the product mix and can result in additional waste. Seasonal effects can also drive additional waste. The use of food allergens, e.g. nuts in confectionery production, necessitates additional clean down requirements on certain production lines and this again can also result in increased waste arisings.

At the site visited, the majority of the waste observed appeared to be work in progress and primary packaged products. Many input materials and partially manufactured materials can be held for a number of days before being reworked and reintroduced into the production process. Some quality rejects, e.g. underweight chocolate bars, can also be de-packaged and reworked. The amount of product that is reworked, as opposed to being sent for disposal, is heavily dependent on the volumes of materials, production schedules and resource availability.

As Table I2 illustrates, the 2014 EP data suggests that the confectionery sector generates two main types of waste:

- Materials unsuitable for production or consumption: from site visits these were found to contain unusable ingredients, waste WIP, floor sweepings, scrapings from equipment clean down, QA rejects etc. that could not be sold to alternative markets; and
- Sludges from on-site treatment of effluent: mainly wet material from food preparation and site cleaning with a high water content. Typically about 15% solids, but depends on technology and extent of de-watering.

A small amount of waste in the form of edible fats and oils is also generated and sold as a by-product.

Table I2: Treatment and disposal of organic waste streams containing food waste – Confectionery, UK estimates derived from 2014 EP data

Disposal Route	Materials unsuitable for production or consumption (tonnes per annum)	Sludges from on-site treatment of effluent (tonnes per annum)
Landfill	0	0
Incineration / Energy recovery	0	8,000
Land-spreading	0	50,000
AD/composting	43,000	0
Total	**43,000**	**59,000**

*totals may not add up due to rounding

The vast majority of materials unsuitable for production or consumption from this sector are sent to AD/ composting. In some instances these materials are used to generate renewable energy for use in the production facilities themselves.

Waste in the form of sludge generated by the confectionery sector is highly liquid and sent mainly for land-spreading.

Food waste

Of total organic wastes associated with confectionery manufacturing, about 49,000 tonnes is estimated to be food waste (Table I3), mainly in the form of rejected product. Only 10% of sludge weight was assumed to be food waste, the rest comprising the water content of waste sludges from cleaning processes.

Table I3: Food waste within organic waste streams – Confectionery sub-sector, UK scaled estimates derived from 2014 EP data

Confectionery	Organic waste streams containing food waste		Total (tonnes per annum)
	Materials unsuitable for production or consumption (tonnes per annum)	Sludges from on-site treatment of effluent (tonnes per annum)	
Total organic waste streams	43,000	59,000	102,000
Of which: Total food waste	43,000	6,000	49,000
Of which: Avoidable food waste	28,000	2,000	30,000
Avoidable as % total food waste	65%	33%	61%
		Food surplus to redistribution	2,000
		Food surplus to animal feed	30,000

Waste prevention potential

Systems are highly automated at large production sites and many of the major firms are already applying 'lean' production principles to their processes. Using data from the site visited and information obtained from a number of unpublished secondary data sources, an estimate of 2,000 tonnes / year of additional waste prevention potential was made.

Table I4: Waste prevention measures within the confectionery sub-sector

Improvements to re-work to reduce surplus to animal feed.
Provide better buffering capacity to ingredient feeds on line, when shut-downs occur.
Waste reduction potential from CIP cleaning sludges, evaporation unit.
Reduction in floor waste through better belt alignment and more regular monitoring.
Address barriers to redistribution: perceived risks to the integrity of branded products

Table I5 – Summary of waste prevention – Confectionery sub-sector, UK estimates

Confectionery	Waste prevention potential (tonnes per annum)
Potential to prevent waste arising	4,500
Additional redistribution potential	
from current avoidable food waste	3,000
from current surplus to animal feed	1,000
Additional animal feed potential	7,000
Total potential for waste prevention	14,500
as % avoidable food waste	48%

Food surplus to redistribution

This research estimated that about 2,000 tonnes per annum is currently redistributed by the confectionery industry; a low amount compared to the volume of materials sent to animal feed. These quantities are limited due to concerns around the potential impact of redistribution on brand integrity, and also perception that redistribution should prioritise the sourcing of other food categories over the need for confectionery products.

Due to the nature of the product and production processes, redistribution potential relates mainly to finished products, rather than to work in progress. Significant additional handling activity would be required to convert work in progress materials into something that would be considered appropriate for human consumption and which can be easily handled through the redistribution channels.

During a number of the site visit and stakeholder interviews, considerable concern was raised about the risk that redistribution poses to the integrity of branded products, and this was cited as a barrier in terms of the increasing the quantities of confectionery that is redistributed.

The requirements of the redistribution charities may also impact the redistribution potential, e.g. some redistributors are not prepared to accept 'snack' products, and others are not prepared to accept products where the primary packaging is damaged even though the product itself is undamaged.

However there is potential to redistribute more from the confectionery sector, based purely on the material available rather than commercial decisions that firms might take. An additional 4,000 tonnes of confectionery products could be sourced across the sector, based on an assessment of quantities diverted from sites already redistributing.

Food surplus to animal feed

The materials used in confectionery production are of high quality and are a good source of fats, sugar and carbohydrates. As a result these materials have a very high nutritional value and are highly suitable for the production of animal feed. The majority of surplus confectionery product is currently sent to animal feed and this sector provides 4% of the total volume of surplus food sent to animal feed in the UK. There is potential to divert materials currently sent to AD to animal feed (estimated at an additional 7,000 tonnes).

During the site visit, a considerable volume of WIP rework was observed and the incorporation of reworked materials is a standard part of the production process for a range of different products. There was also some evidence of rework at the primary and secondary

packaging stages. Where materials cannot be reworked, they are generally sent to animal feed or to AD.

Conclusions

- The scale of food losses varies considerably across the sector, with an overall wastage rate of 7% of total UK production tonnage;
- Instances of food surplus that are likely to become waste are a rare occurrence; however the majority of surplus is currently sent to animal feed or AD;
- There is currently little opportunity to redistribute work in progress due to the nature and form of these materials;
- Brand implications of redistribution activities need to be understood and any actual or perceived barriers addressed, before the 4,000 tonnes per annum additional redistribution potential within this sector can be fully realised; and
- The majority of waste materials that are unsuitable for production are sent to AD, whereas the more liquid materials from cleaning operations are predominantly spread on land.

Appendix J: Milling

Milling – assessment of food waste prevention, food surplus and food waste

Overview

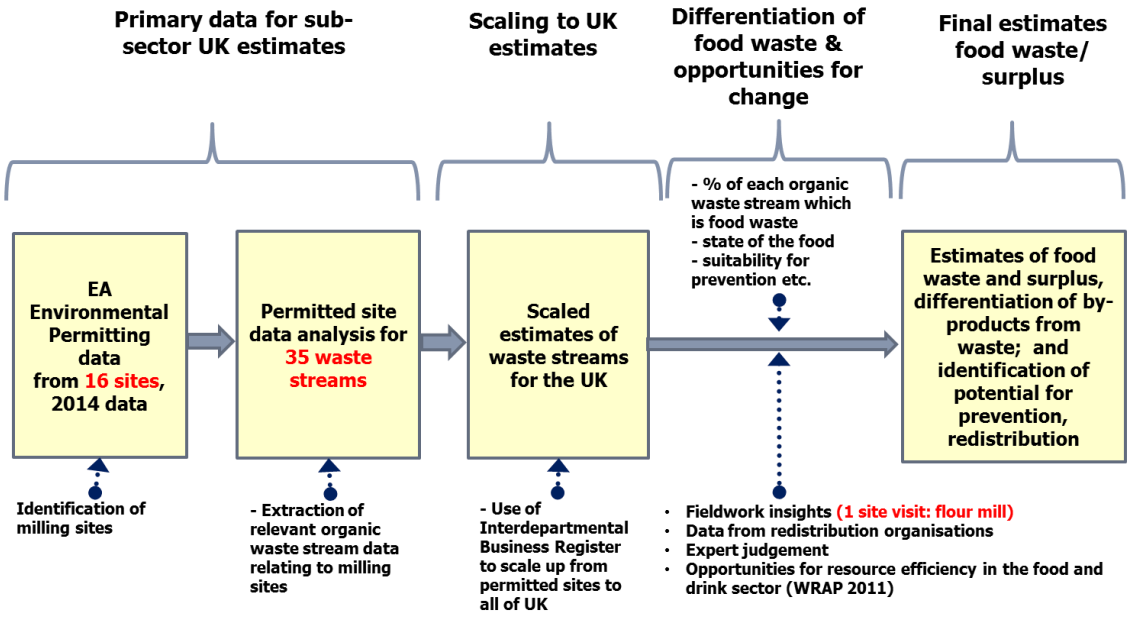
For the purposes of this analysis, this sub sector covers the manufacture of grain mill products and the manufacture of starches. In 2014, sales in this sector were worth £3.9 billion based on 6.1 million tonnes of UK production (PRODCOM, 2014). The UK flour milling industry consists of 30 companies, operating a total of 50 milling sites. Wheat is the industry's main raw material, with approximately 5 million tonnes milled annually to produce 4 million tonnes of flour. The four largest companies account for approximately 65% of UK flour production with a further ten companies producing significant quantities of flour. Many of the smaller millers have developed niches ranging from pre-packed flours and mixes to those for specific uses such as flours for speciality or ethnic breads[119].

The UK starch manufacturers produce 800,000 tonnes of starches (mainly sweeteners) from processing 1.45 million tonnes of cereals. Products are used as ingredients and functional supplements in a range of food, non-food, and feed applications.

Evidence gathering approach

Figure J1 provides a summary of the approach to evidence gathering in relation to the confectionery sub-sector. The fieldwork included collection of site-based data and observations from one flour mill.

Figure J1: Summary of evidence gathering approach– Milling sub-sector



Milling

[119] Nabim statistics, 2014

Findings summary

Due to the nature of the site visit and data gathering activities, the primary research element of this project focused mainly on flour milling.

Milling is a relatively simple process which transforms input materials, usually wheat, into a range of different products. There is a considerable focus on resource efficiency in the milling industry and raw agricultural input materials are transformed into a range of food, feed and non-food products. Work in progress and finished products can also be reworked in a number of different circumstances. As a result, food losses are relatively low within this sector, at less than 1% of output product by weight. Table J1 below summarises the main types of waste/ by-products that occur in the flour milling sector.

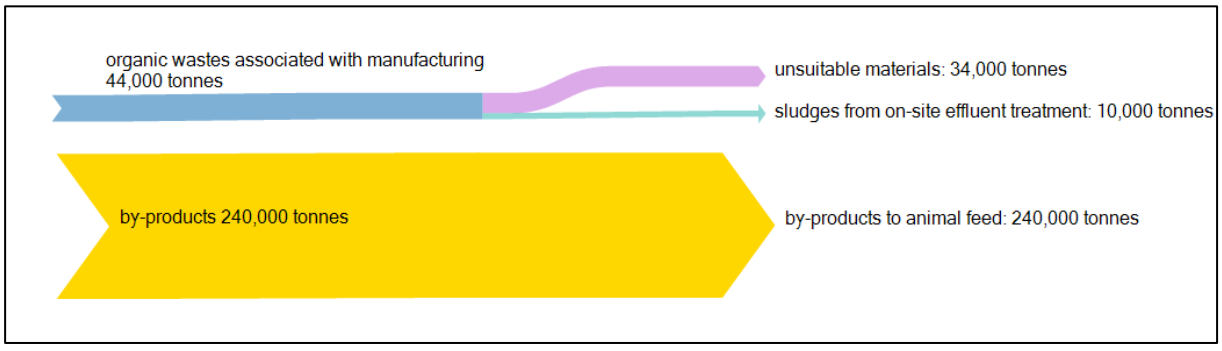
Table J1: Example surpluses, wastes and by-products – Milling sub-sector

Materials	Source	Example Management Approach
Straw/ chaff	Inbound product	Composting
Stones	Inbound product	Residual Waste/ pothole filling (on site)
Metal	Inbound product	Recycling
Ingredients i.e. wheat	QA/ production processes	Animal feed/ hazardous waste (e.g. in the case of pest contamination)
WIP i.e. flour	QA/ production processes	Rework/ animal feed (minimal)
By-products e.g. bran/ wheat germ	Production processes	Alternative products/ animal feed
Finished Products	QA/ production processes/ customer returns	Rework/ animal feed

2014 Environmental Permitting Data

EP data was obtained from the Environment Agency for 2014. This covered 16 sites in England within the grain milling sector, including 35 waste streams with organic content. This compares with the UK total of 25 larger sites employing more than 100 staff, and 160 smaller milling sites. Analysis of this data is presented in Figure J2 below, including estimates of by-products to animal feed, mostly consisting of non-bread wheat quality grain.

Figure J2: Organic wastes, food surplus and by-product flows – Milling sub-sector, UK estimates derived from 2014 EP data



Organic waste streams

Food losses during the milling process are typically very low. The majority of milling waste arises from materials that are separated from the agricultural input materials, e.g. straw, chaff associated with the grain and material picked-up during harvest such as stones, metal fragments and bolts from machinery. Wet processes associated with the manufacture of starches also produce sludge wastes for on-site treatment processes. Growing conditions can

strongly influence the amount of waste and by-product generated during the milling process, e.g. a poor harvest can alter the ratio of wheat flour kernel to bran and result in the need to divert significantly higher quantities of material as by-product or waste.

The 2014 EP data found that the milling sector generates two main types of waste (see Table J2):

- Materials unsuitable for production or consumption: from the site visits these were found to consist of straw, chaff, floor waste, stones and small pieces of metal that arrive in the wheat deliveries and that cannot be sold to alternative markets; and
- Sludges from on-site treatment of effluent, mainly wet material from food preparation and site cleaning, with a high water content. This relates mainly to milling activities other than flour milling which involve wet processes, e.g. production of starches.

Table J2 indicates that the vast majority of materials rejected from the milling sector as being unsuitable for production or consumption are sent to AD/ composting. Wastes in the form of sludges are highly liquid and sent mainly to land-spreading.

Table J2: Treatment and disposal of organic waste streams containing food waste – Milling sub-sector, UK estimates derived from 2014 EP data

Disposal Route	Materials unsuitable for production or consumption (tonnes per annum)	Sludges from on-site treatment of effluent (tonnes per annum)
Landfill	0	
Incineration / Energy recovery	6,000	0
land-spreading	0	10,000
AD/ composting	28,000	0
Other recycling / biological treatment	0	0
Total	**34,000**	**10,000**

Food waste

It is estimated that 35,000 tonnes of the organic waste stream associated with milling consists of food waste. 94% of this is associated with material rejects from manufacturing processes and 6% from on-site treatment sludges.

Table J3 Food waste within organic waste streams – Milling sub-sector, UK scaled estimates derived from 2014 EP data

Milling	Organic waste streams containing food waste		Total (tonnes per annum)
	Materials unsuitable for production or consumption (tonnes per annum)	Sludges from on-site treatment of effluent (tonnes per annum)	
Organic waste streams	34,000	10,000	44,000
Food waste	33,000	2,000	35,000
Avoidable food waste	9,500	500	10,000
Avoidable as % total food waste	29%	25%	29%
	Food surplus to redistribution		0
	Food surplus to animal feed		1,000

Food waste prevention potential

Flour milling is a relatively straightforward and predictable process, with a limited number of ingredients and end products. Reworking of work in progress and finished products is a standard operating procedure. These factors, together with a considerable focus on resource efficiency and significant investment in production technologies across the sector, mean that waste levels are relatively low, at less than 1% of total production volumes, and avoidable waste is generally well controlled.

The site visits and data analysis did not identify any particular food waste hotspots or any instances of significant food surpluses that are likely to become waste.

Table J4: Summary of waste prevention – Milling sub-sector, UK estimates

Milling	Waste prevention potential (tonnes per annum)
Potential to prevent waste arising	500
Additional redistribution potential	
from current avoidable food waste	0
from current surplus to animal feed	0
Additional animal feed potential	1,000
Total potential for waste prevention	1,500
as % avoidable food waste	15%

Food surplus to redistribution or animal feed

This research identified that no milling products are currently sent for redistribution from the sector. There are a number of reasons for this, including the nature of the product and the limited volume of materials available for redistribution. Products that do not meet the required quality standard are currently either reworked or sent to animal feed; however volumes are very low (240 tonnes/year).

By-products

The majority of material rejected from the flour milling process as unsuitable for the intended final products are converted into by-products, e.g. bran and wheat germ, and sent

to animal feed. Bran removed during the milling process is also added to other products, e.g. breakfast cereals, and widely used in animal feeds. Likewise, wheat germ can be used in other products (e.g. food supplements) and is also used in animal feeds.

Conclusions

- Product waste is a minor stream compared to inedible waste arising from input materials, e.g. chaff, straw, stones and metal;
- A focus on resource efficiency and significant investment in processing equipment means that food losses are very low across the milling sector and instances of food surpluses that are likely to become waste are a rare occurrence; and
- The site visit and supporting stakeholder interviews did not find clear instances of redistribution activity within this sector and the redistribution potential for milling products is believed to be very low.

Appendix K: Value of food and drink wasted within the retail and manufacturing sectors

The value of food wasted within the retail and manufacturing sectors was estimated from a combination of food waste arisings data and data on the sales value of products (PRODCOM data, 2014 for the value of food at manufacture, and data provided by three of the major retailers on the sales value of food wasted in their operations):

- In the UK retail sector food with a potential sales value of around £650 million ends up as waste, equivalent to 0.6% of 2014 household expenditure on food and drink[120];
- In the UK manufacturing sector, food with a potential sales value of around £1.25 billion ends up as waste, or about 2% of total sales value of UK food and drink manufacturing, based on PRODCOM 2014 estimates;
- This approach differed from the previous evaluation of the value of food waste (WRAP 2013[121]) which used a standard value for food waste within the manufacturing sector of £950/tonne, derived from 26 WRAP site waste prevention reviews;
- The value of retail lost sales associated with food waste is based on sales data applied to detailed product category level food waste data, whereas the previous study's value was derived from the manufacturing value with an additional 20% retail margin applied; and
- The previous study applied standard lost sales values to the estimates of total food waste (3.9 Mt from manufacturing, 0.43 Mt from retail) whereas the current study derives estimates from the revised estimates for total avoidable food waste.

The following steps were undertaken in order to produce the estimates in Table K1:

- Identification of the proportion of avoidable food waste within each industry sub-sector (as detailed in Appendices A to J);
- For the manufacturing sector, assessment of the extent to which avoidable food waste is finished product, part-finished or product ingredients (assumed to be 75% finished product, with 25% work in progress[122]);
- Integration of total sales value[123] of UK production associated with each industry sub-sector (PRODCOM data, 2014) and avoidable food waste; and
- Allocation of value of food waste in relation to proportion of avoidable food waste and proportion of total product value.

Calculation of the lost value associated with food surplus or waste within the retail sector is relatively straightforward. All material is associated with finished product that has been damaged, does not meet quality criteria or has not been sold in time. If this food had been managed in a different manner, it would have been fit for human consumption as a saleable product. However not all of this product would have been sold at its full retail price, and so the overall value of the food wasted at retail has been discounted to reflect the likely

[120] *Food statistics pocketbook 2014*
[121] *See Estimates of waste in the food and drink supply chain*
[122] *Based on the site visits undertaken as part of this research and discussions with those working in the sector. It is acknowledged that this is an estimate, and the exact figure is likely to vary by sub-sector. Further work as outlined in the report recommendations will help refine this in the future*
[123] *This is the value that manufacturers receive from sales to their retail, wholesale, hospitality and other customers, not the final retail value of the products*

proportion sold on promotion[124]. This discounts the full retail sales value of £3,381 to £3,099 per tonne.

This method is similar to the one adopted for estimating the value per tonne of food waste at a household level, i.e. based on the actual types of food waste[125], and unsurprisingly the value per tonne of food wasted in the household (which is based on the price paid by consumers of the food thrown away) is similar to the value calculated here for retail. The average value of food sold at retail in the UK is around £3,000 a tonne, based on consumer spending on food in 2014 (£113 billion[126]) and the overall amounts purchased (37.7 million tonnes[127]).

The situation is more complex for the manufacturing sector, as food and drink waste occurs at different stages within production processes and not all of the food waste is unavoidable (e.g. discarded inedible fractions not intended for human consumption). The assessment of avoidability was based on the findings for each sub-sector and overall it was assumed that 50% of food waste was avoidable. However, there was much variation across sub-sectors, with 80% avoidability attributed to bakery sub-sector food wastes; and only 40% in both the 'milling' and 'soft drinks and fruit juices' sub-sectors (as described in Appendices A to J).

The benefits of this new approach to estimating the value of food wasted at manufacturing are that it applies financial data more tailored to different food sub-sectors and allows the estimates of the value of food wasted to take account of the variation in the amount of avoidable food waste across food types. As this method makes use of national statistics the estimates are updateable when new PRODCOM data are released.

The financial estimates generated here represent the potential sales value of the food wasted, and not the potential net savings, which would vary between sub-sectors and businesses. This would depend on the amount of investment (time, capital etc.) required to prevent this food being wasted, any revenue from selling food surplus (albeit likely to be far below the full sales value) and the costs of waste management.

The average value per tonne of food waste at manufacture is £1,189. The difference between the retail and manufacturing values per tonne will reflect the composition of product wasted in retail versus the composition of final product wasted in manufacture, retail overheads and profit margins and the fact that the food wasted at retail will consist both of food produced in the UK and food imported.

[124] Around 33% of food and drink is bought on promotion, and the average discount is around 25%. It has therefore been assumed that a third of the food that ended up as waste may have been purchased at a 25% discount. See Supermarket Promotions and Food Prices and Promotions Analysis on Ambient Grocery Category for source material.
[125] See http://www.wrap.org.uk/content/household-food-and-drink-waste-uk-2012
[126] From Food Statistics Pocketbook 2015
[127] WRAP analysis of UK food purchase data, from Family Food 2014, as described in Household Food & Drink Waste – A Product Focus

Table K1: Total value of food and drink wasted in UK manufacturing and retail sectors

Sector	Total food waste (ktonnes per annum)	Avoidable food waste (ktonnes per annum)	Average value £ / tonne finished product	Assumed % final product equivalent	Total lost sales value (£ million)
Manufacturing	**1,722**	**867**	**£1,189***	**75%**	**£1,255**
Of which:					
Meat, poultry & fish	542	162	£3,360	75%	£408
Pre-prepared meals	83	58	£4,039	75%	£176
Ambient products	185	130	£1,977	75%	£193
Dairy products	343	206	£757	75%	£117
Confectionery	49	29	£3,598	75%	£78
Alcoholic drinks	150	60	£999	75%	£45
Bakery etc.,	113	90	£1,934	75%	£131
Fruit & vegetables	144	86	£1,433	75%	£92
Soft drinks & fruit juices	77	31	£359	75%	£8
Milling	35	14	£644	75%	£7
Sugar	2	1	£560	75%	<£1
Retail	**210**	**210**	**£3,099**	**100%**	**£651**
Total waste / value**	**1,932**	**1,077**	-	-	**£1,906**

* This represents an average weighted by volume of products

** Totals may not add due to rounding

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