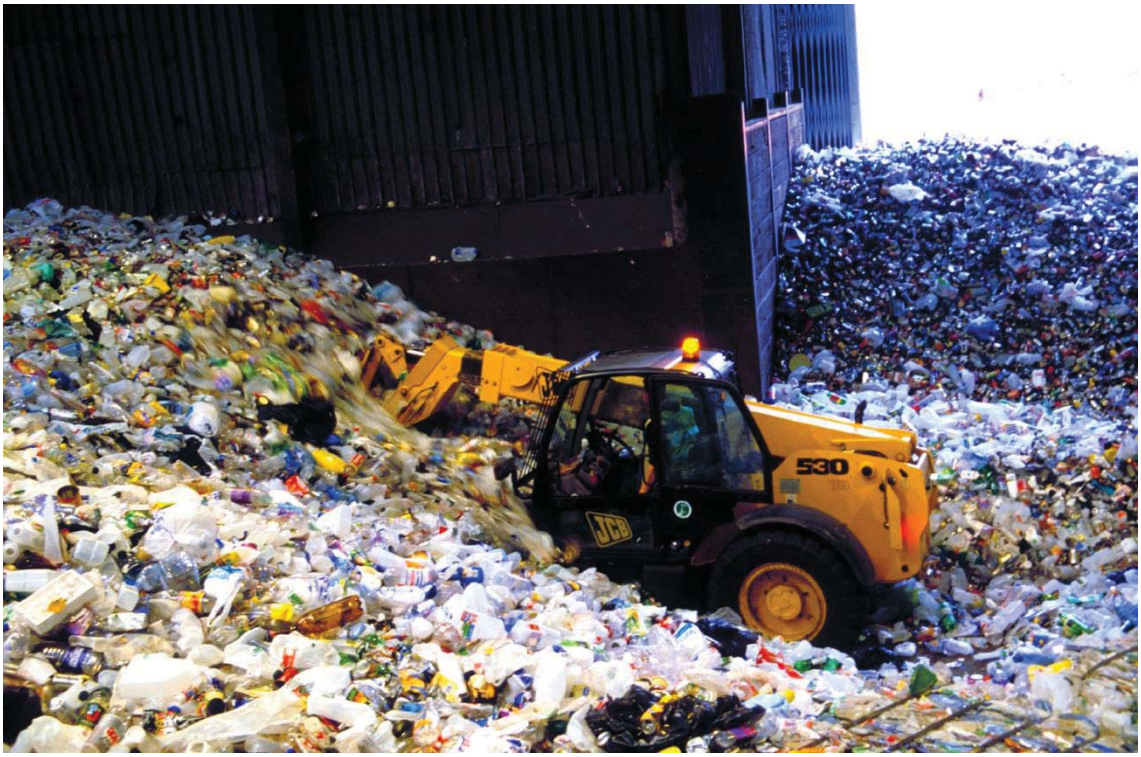
Final Report

Plastics Spatial Flow



An assessment of the quantity of un-recycled plastic in the UK

Project code: PMP006-001
Research date: Dec 2015 – Mar 2016 **Date:** June 2016

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PMP006-001, Plastics Spatial Flow, 2016

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Front cover photography: Plastics sorting

Executive summary

ES 1 Introduction

This report has been produced through joint work between Valpak and WRAP. It presents the results of the quantification of plastic in the UK from the point of it arising, through to its end destination of recycling, energy from waste (EfW), mechanical biological treatment (MBT) or landfill.

The results represent a snapshot of what the flow of plastic arising (both packaging and non-packaging) looked like in 2013. It should be noted that this will change with variations in factors such as waste arisings, recycling targets, technologies and end markets. The WRAP Plastics Market Situation Report (Spring 2016)[1] is recommended as a supporting document to this report as it provides in-depth information regarding plastic recycling, end markets and recycling infrastructure.

As part of the project, and also presented in this report, is an assessment of the quantity of plastic arising. The proportion that is not currently being recycled and then further breaks this figure down into material either subject to a long term PFI/PPP contract or not. It should be noted that plastic, not currently being recycled but subject to Private Finance Initiative (PFI)/Public Private Partnership (PPP) contract can be targeted for capture should it suit the contractors'/ local authority's situation[2], in which case additional plastic material could be available for other end uses such as mechanical recycling or Advanced Conversion Technology/ Advanced Thermal technology (ACT/ATT), of which polymer cracking is one example[3]. In all circumstances where plastics are not currently targeted or segregated from residual waste the current 'owners' of that material (public or private sector) would need to be clear about the business case for doing so.[4]

[1] http://www.wrap.org.uk/sites/files/wrap/Plastics_Market_Situation_Report.pdf

[2] *For example freeing up space in current EfW facilities or reducing the calorific value (CV) of material feeding EfW facilities.*

[3] *There is the potential for polymer cracking to be classed as 'recycling' rather than 'recovery' should the process outputs be polymers rather than liquid or gas; this would enable PRNs to be claimed on the packaging element of waste plastics should it be approved by Defra.*

[4] PPP / PFI contracts are principally or entirely related to household waste.

The project was undertaken using a variety of secondary research methods, namely reviewing existing published reports and unpublished data held by Valpak and WRAP, and internet searches.

The target audience for this report is therefore any individual or organisation interested in understanding the quantities of plastic arising that is not recycled. The data within the report could for example enable new investment in UK plastic reprocessing capacity or alternative routes such as polymer cracking to be optimally located to maximise the available feedstock while minimising transport costs. In addition, it should provide LAs with a clearer idea of the potential feedstock that is currently going to residual that could be made available to an end market user.

What is the size of the prize? An estimated 815kt of residual waste plastic was sent to landfill in 2013. Assuming a landfill cost of £100 per tonne (including landfill tax and gate fee) then the potential savings from diverting material from landfill to recycling or polymer cracking could amount to £82 million.

ES 2 Main Conclusions

A summary of UK plastic flows is illustrated in Figure ES1 and shows that around 3.3Mt[5] of plastic arose in the UK in 2013. Of this, approximately one-third was collected for re-use, recycling or recovery and the remaining two-thirds became residual waste. Over 60% of plastic arose from households, with the remainder from the commercial sector. Almost 70% of total plastic arising is thought to be packaging, with the rest mainly being found in carpets, construction and demolition (C&D) and waste electrical and electronic equipment (WEEE).

Of the plastics collected, almost 60% was exported for recycling in 2013. The majority of collected plastic remaining in the UK was recycled (67%). Plastic residual waste was treated in one of three ways; landfill (~37%), EfW (56%), or MBT (7%).

An estimated 2,343kt of plastic was not recycled in 2013. Of that figure 1,872kt of plastic was not subject to a long term PFI/PPP contract (see Figure ES3 for the geographical breakdown of where this material is potentially available in the UK). Of this an estimated 1067kt (57%) was thought to be most suitable for ACT/ATT (the polymers PE, PP/OPP and PS/HIPS). Meanwhile, an estimated 471kt of plastic was

[5] *The accumulated error margin calculated on the 3.2Mt of total plastic waste arisings is +/- 16%, indicating that arisings could fall between 2.8Mt and 3.8Mt (please see Appendix I for details on how error margins were calculated).*

not recycled but is under PFI/PPP contract (see Figure ES4 for the geographical breakdown) with 268kt thought to be suitable for ACT/ATT.

Looking to the future, overall household waste plastic arising's may grow during the period to 2030 as UK household numbers increase and consumption of plastic increases. At the same time waste plastic arising's from the commercial sector are also likely to grow as demand for construction, agriculture, electrical, automotive and other products rises. However, macroeconomic, policy, commodity price and other factors can have an impact on product design, which may, as has been the case with plastic packaging in recent years result in additional unit sales being negated by packaging light-weighting.

The future growth in the availability of plastic for end markets will depend upon the amount of plastic that local authorities and commercial collectors can divert from residual treatment or landfill. In turn this will depend upon an appreciation of the cost/benefit of extracting plastic out of existing, but under-utilised waste streams such as agriculture or diverting plastic away from current un-contracted and contracted treatment routes such as EfW/MBT and towards other end markets. The cost of collecting and sorting 'more difficult to recycle plastic from sources such as doing so is likely to change over time as new processes develop while the cost of diverting material away from residual treatment is likely to vary on a region by region basis depending on current contract conditions where material is under contract, and factors such as the cost of transporting plastic to end market facilities.

This report seeks to provide recovered plastics end markets with the confidence to know that additional plastic is potentially available, and where it may be able to be accessed. In turn the potential growth in plastic end markets through mechanical plastic recycling, but also alternative markets such as ACT/ATT could provide an incentive to invest in improving plastic collection systems.

ES 3 Key Data

Total Plastic Arisings 2013

- Total plastic arisings: 3,299kt
- Total household plastic arisings: 1,994kt
- Total commercial plastic arisings: 1,305kt
- The majority (70%) of plastic arisings is packaging: 2,260kt

Plastic Collected for Re-use, Recycling or Recovery 2013

- Total plastic collected for re-use, recycling or recovery: 1,104kt
- Total household plastic collected for re-use, recycling or recovery: 550kt

- Total commercial plastic collected for re-use, recycling or recovery: 554kt
- The majority (65%) of plastic collected is packaging: 714kt
- Total plastics recycled/re-used in the UK: 307kt
- Total plastics exported: 649kt

Total Plastics in Residual Waste 2013

- Total plastics in residual waste: 2195kt
- Total plastics in household residual waste: 1,444kt
- Total plastics in commercial residual waste: 751kt
- Total residual waste plastic subject to long term PFI/PPP contract: 471kt
- Total residual waste plastic sent to landfill: 815kt
- Total residual waste plastics to EfW: 1,230kt

Total Plastic Un-recycled & not subject to PFI/PPP Contract 2013

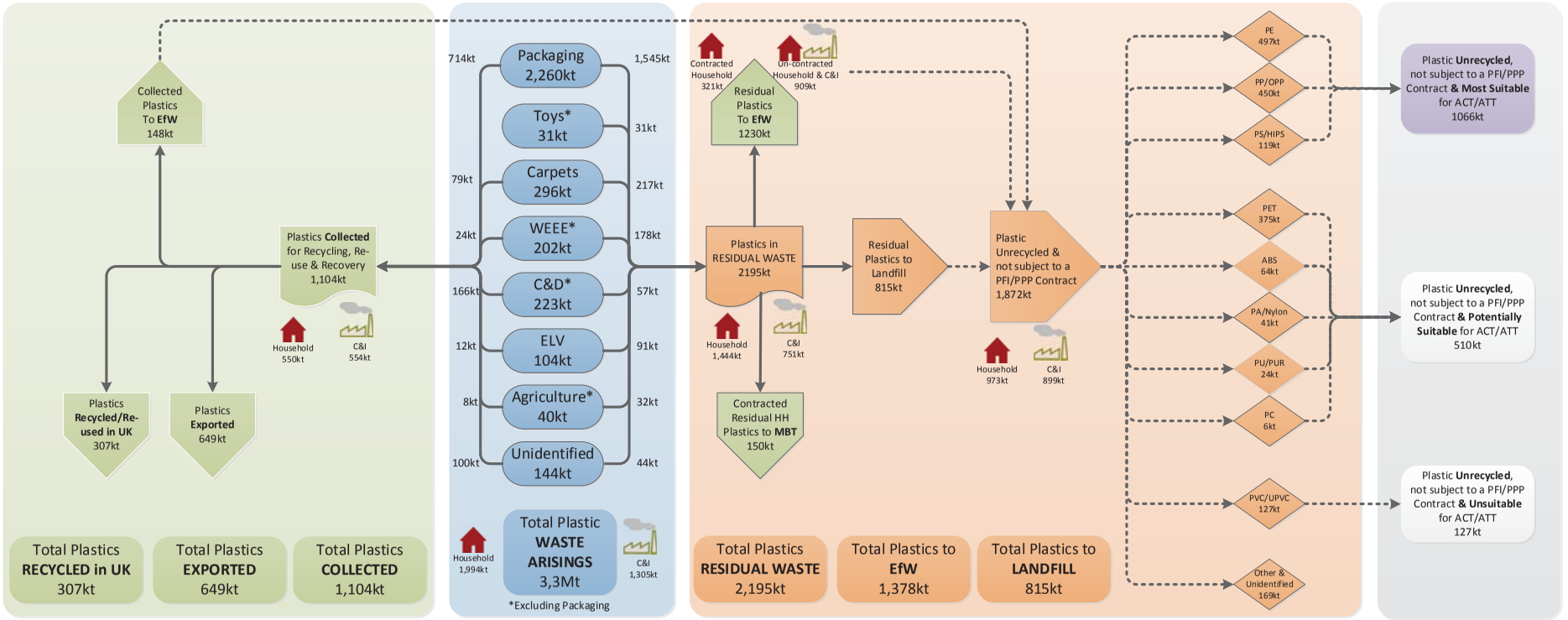
- Plastic un-recycled & without PFI/PPP contract 2013: 1,872kt
- Household plastic un-recycled and without PFI/PPP contract: 973kt
- Commercial plastic un-recycled and without PFI/PPP contract: 899kt

Plastic un-recycled, not subject to PFI/PPP Contract & Most Suitable for ACT/ATT 2013:

- Plastic un-recycled, without PFI/PPP contract and suitable for ACT/ATT in 2013: 1,066kt
- Plastics Un-recycled, subject to a PFI/PPP contract and suitable for ACT/ATT in 2013: 268kt

Note that all estimates presented in this report are subject to uncertainty. See Appendix I for more details on the robustness of the datasets used and the calculation of the error margins.

Figure ES1 UK Plastic Flow 2013[6]



[6] *See Appendix 1 for discussion of uncertainty.*

Figure ES2 Map of Total Plastic Arisings

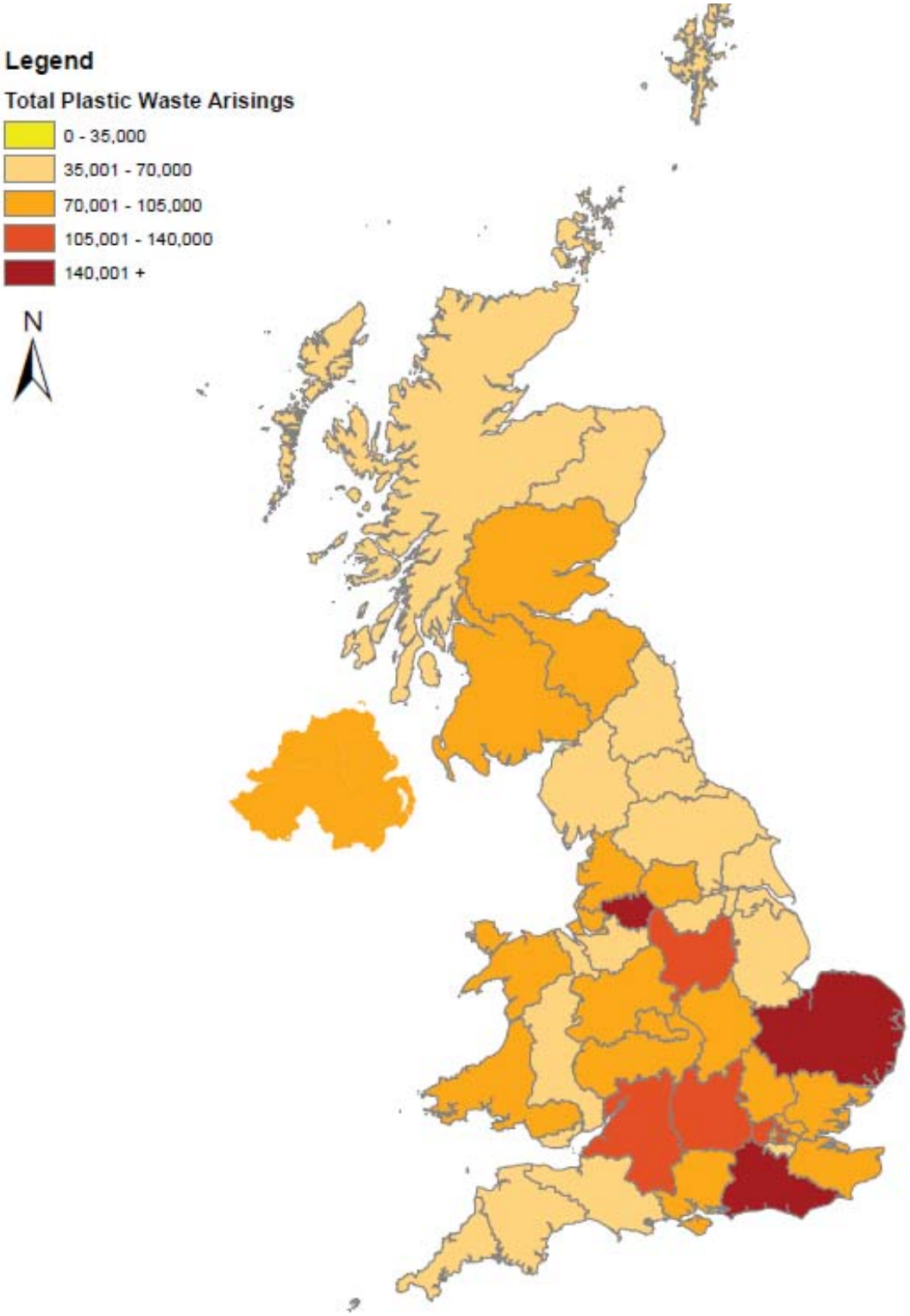


Figure ES3 Total Plastic Un-recycled and not Subject to a PFI/PPP Contract

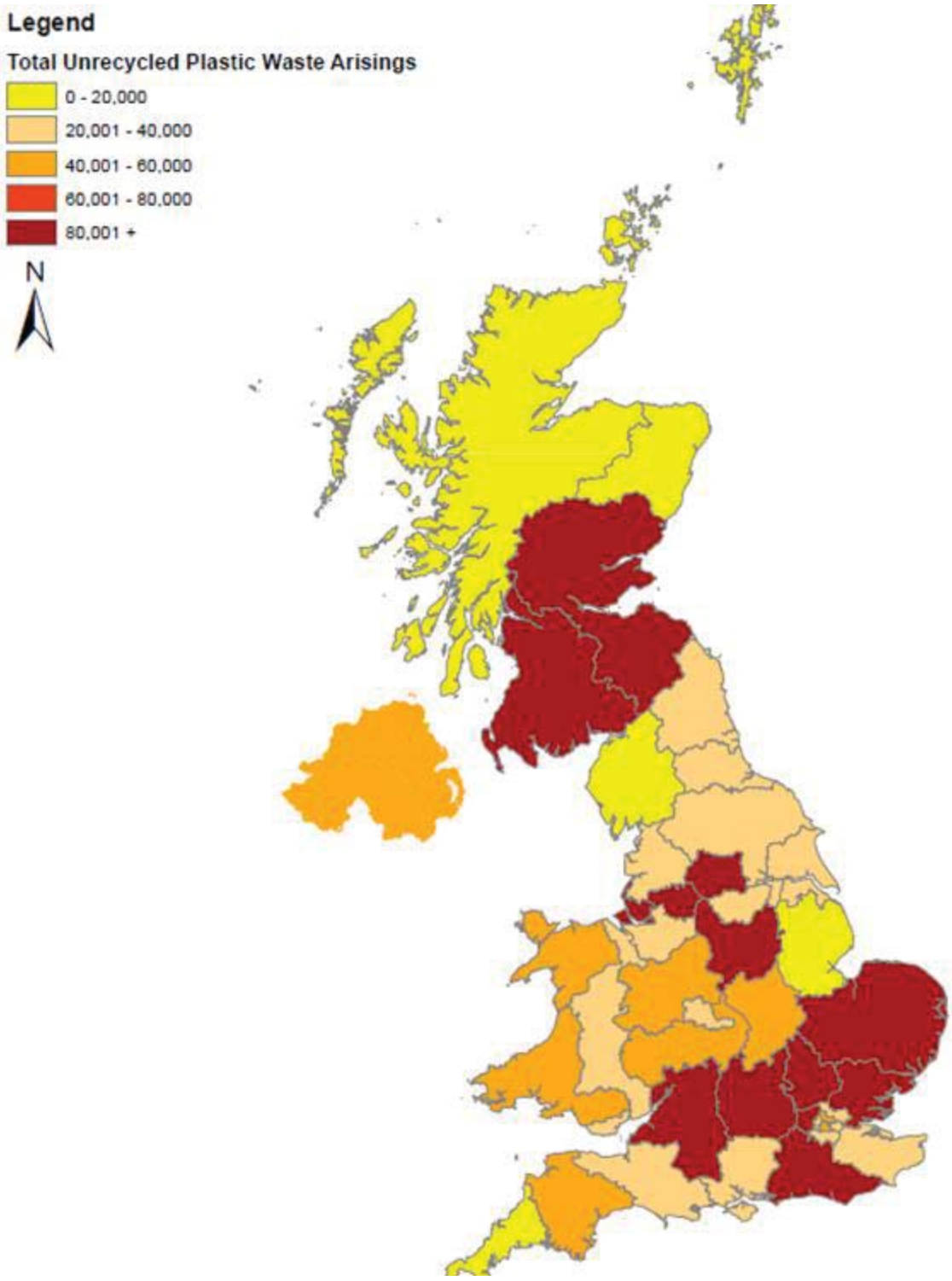
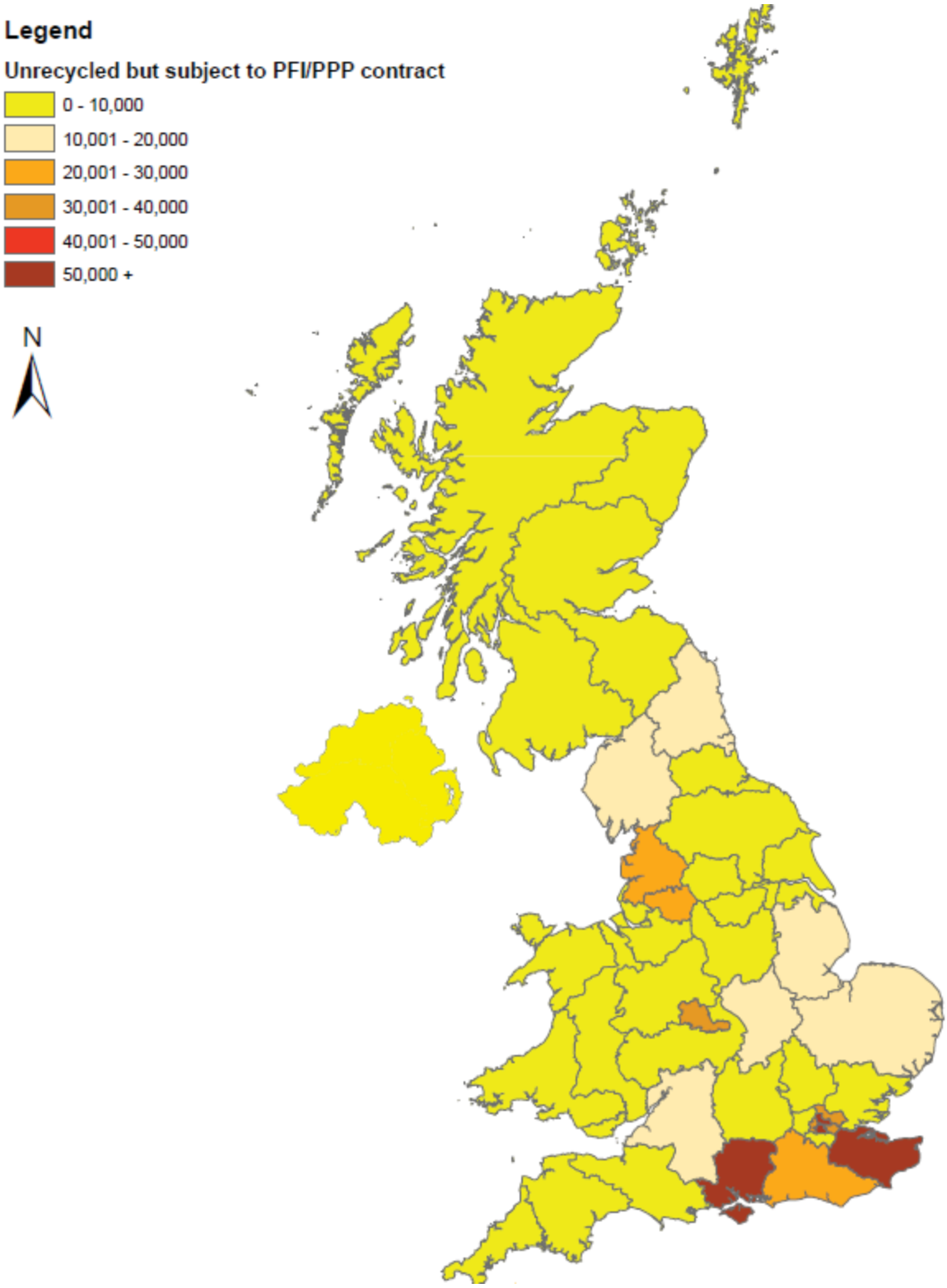


Figure ES4 Total Plastic Un-recycled and Subject to a PFI/PPP Contract



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Figures

Glossary

ABS – Acrylonitrile Butadiene Styrene
ACT/ATT– Advanced Conversion Technology/ Advanced Thermal technology
AWP – Agricultural Waste Plastic
ASR – Automotive Shredder Residue
BMBT– Biodrying Mechanical Biologic Treatment
C&D – Construction & Demolition
COMMERCIAL Waste Plastic –Waste plastic arisings from businesses/organisations (includes industrial, C&D and Agricultural plastic in this report)
Household Waste Plastic – Waste plastic arising from households
Defra – Government Department for Environment, Food & Rural Affairs
EA – Environment Agency
EfW - Energy from Waste
ELV – End of Life Vehicles
EPS – Expanded Polystyrene
EU – European Union
Gasification – Thermal decomposition of material at high temperature in limited oxygen
GVA(I) – Gross Value Added (Income Approach)
HDPE – High-density Polyethylene
HIPS – High Impact Polystyrene
kt – Thousand tonnes
LA – Local Authority
LFMBT – Landfill Mechanical Biological Treatment
LDPE – Low-density Polyethylene
LLDPE – Linear Low-density Polyethylene
MBT– Mechanical Biological Treatment
MRF – Mixed Recycling Facility
Mt – Million tonnes
NPWD – National Packaging Waste Database
NUTS - Nomenclature of territorial units for statistics (a hierarchical system for dividing up the economic territory of the EU)
ONS – Office for National Statistics
OPP – Oriented Polypropylene
PA - Polyamides
PC – Polycarbonate
PE – Polyethylene
PERN – Packaging Export Recovery Note
PET – Polyethylene Terephthalate
PFI/PPP– Private Finance Initiative/Public Private Partnership
POM – Placed on the Market
PP – Polypropylene
PRN – Packaging Recovery Note
PS – Polystyrene
PTT – Pots, Tubs and Trays
PU/PUR – Polyurethane

PVC/UPVC – Polyvinyl Chloride
Pyrolysis - thermal decomposition of material at high temperature in the absence of oxygen
Syngas – A synthesis gas produced during gasification
WDF – Waste Data Flow
WEEE – Waste Electrical and Electronic Equipment

Introduction

This report has been produced through joint work between Valpak and WRAP. It presents the results of the quantification of plastic in the UK from the point of it arising, through to its end destination of recycling, energy from waste (EfW), mechanical biological treatment (MBT) or landfill.

The results represent a snapshot of what the flow of plastic (both packaging and non-packaging) looked like in 2013, but it should be noted that this will change with variations in factors such as waste arisings, recycling targets, technologies and end markets. The WRAP Plastics Market Situation Report (Spring 2016)[7] is recommended as a supporting document to this report as it provides in depth information regarding plastic recycling, end markets and recycling infrastructure.

As part of the project, and also presented in this report, is an assessment of the quantity of plastic that is not currently being recycled or subject to a long term PFI/PPP contract, that would be suitable for polymer cracking. It should be noted that plastic subject to PFI/PPP contract may be released, should it suit the contractors' situation[8], in which case additional plastic material would become available for recycling or alternative end markets[9].

A Steering Group was set up to oversee the project, containing representatives from WRAP, BIS, Defra, Valpak and industry.

1.0 Project Context

The recent target announced within the provisional European Union's (EU) Circular Economy Package[10] to reduce landfill to a maximum of 10% of all waste by 2030 is likely to mean that more and more plastic will be required to be recycled or recovered going forward.

Despite the current plateauing of plastic packaging arising in the UK and the increasing UK and EU plastic packaging recycling targets, the EU landfill target could considerably increase the quantity of material required to be recycled / treated.

Polymer cracking technologies, such as Advanced Conversion Technologies (ACT) and Advanced Thermal Technologies (ATT) have not been widely adopted in the UK. The

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[7] http://www.wrap.org.uk/sites/files/wrap/Plastics_Market_Situation_Report.pdf

[8] *For example freeing up space in current EfW facilities or reducing the calorific value (CV) of material feeding EfW facilities*

[9] *There is the potential for polymer cracking to be classed as 'recycling' rather than 'recovery' should the process outputs be polymers rather than liquid or gas; this would enable PRNs to be claimed on the packaging element of waste plastics should it be approved by Defra.*

[10] *http://ec.europa.eu/environment/circular-economy/index_en.htm*

long term commercial success of these facilities is dependent on having a ready supply of raw material in the form of recovered plastic.

This project was undertaken to assess where plastic arises, in what quantities, how much of it is currently recycled or subject to PFI/PPP contract, and consequently how much plastic arising could be used for processes such as plastics recycling or ACT/ATT[11]. The target audience for this report is therefore any individual or organisation interested in understanding the quantities of plastic arising not currently recycled or subject to PFI/PPP contracts. The project covered plastics arising in packaging, carpets, waste electrical and electronic equipment (WEEE), construction & Demolition (C&D), end of life vehicles (ELV), agricultural waste plastics (AWP) and toys.

The future growth in the availability of plastic for end markets will depend upon the amount of plastic that local authorities and commercial collectors can divert from residual treatment or landfill. In turn this will depend upon an appreciation of the cost/benefit of extracting plastic out of existing, but under-utilised waste streams (for example agriculture) or diverting plastic away from current un-contracted and contracted treatment routes such as EfW/MBT and towards other end markets. The cost of collecting and sorting 'more difficult to recycle plastic from sources such as doing so is likely to change over time as new processes develop while the cost of diverting material away from residual treatment is likely to vary on a case by case, region by region basis depending on current contract conditions where material is under contract and factors such as the cost of transporting plastic to end market facilities.

2.0 Objectives

The key objectives of this project were to:

1. Establish the current flow, and quantities, of un-recycled post-household plastic packaging material in the UK and its final destination. Assess how much of the plastic is locked into PFI/PPP contracts and therefore may not be available to plastic reprocessing or ACT/ATT. Determine the geographical location of available arisings, and the amount of plastic arising at key commercial aggregation points.

2. Establish the current flow, quantities and geographical location of un-recycled post-household and commercial plastic packaging material which would be suitable for ACT/ATT.

3. Assess the quantities of plastic and polymer types available in the residual waste stream in particular toys, carpets, WEEE, C&D. Also assess whether there is any residual un-recycled plastic remaining from the ELVs.

4. Assess the various technologies available for ACT/ATT, their feedstock requirements and product outputs.

[11] *It should be noted that plastic subject to PFI/PPP contract may be released, should it suit the contractors' situation , in which case additional plastic material would become available for recycling or polymer cracking*

3.0 Deliverables

The key deliverables that this project has provided are listed below:

- Provide flows, quantities and an assessment of the ease of diverting each of the plastic streams identified from their current final destination.
- An excel database of plastic arising and available by region.
- Provide information on the suitability of the feedstock for various ACT/ATT technologies.
- A final report in a format agreed by the project partners. The report includes methodology, assumptions and overall results.

4.0 Methodology

The project was undertaken in the following phases:

4.1 Phase 1 – Flow of Waste Plastic (Household & Commercial)

Previous reports undertaken by Valpak/WRAP were reviewed along with secondary research

4.2 Phase 2 – Analysis & mapping of Household Data

An Excel data base was established using secondary research and published data and details local authority (LA) plastic arisings, residual plastic that is subject to a PFI/PPP contract, PFI/PPP EfW facilities that are treating residual waste and collection/management details of plastic recyclables.

Household plastic arisings and plastic arisings currently (2013) un-recycled currently under a PFI/PPP contract have been mapped to show where in the UK quantities are arising (LA quantities were grouped in NUTS 2[12] sub-regions for the purpose of mapping).

4.3 Phase 3 – Analysis & Mapping of Commercial Data

Commercial plastic arisings were allocated across UK NUTS 2 sub-regions firstly through applying commercial[13] plastic arising tonnages to one of 12 Defra business sectors as per their 2010 C&I waste survey. Office for National (ONS) Gross Value Added (GVA) data was then applied to these sectors in order to establish sub-regional arisings; GVA being used to represent output and as a proxy for waste arisings.

Commercial plastic arisings and plastic arisings currently (2013) un-recycled have been mapped to show where in the UK quantities are arising. Household and commercial data were then combined and mapped to illustrate 'total' plastic waste quantities arising.

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[12] *The NUTS classification (Nomenclature of territorial units for statistics) is a hierarchical system for dividing up the economic territory of the EU; UK NUTS 2 areas are illustrated in Appendix III*

[13] *Commercial excludes C&D and AWP data*

4.4 Phase 4 – Technology Review

A high level review was undertaken using secondary research and industry consultation; it provides a basic assessment of the various technologies available for polymer cracking, their feedstock requirements and product outputs.

4.5 Phase 5 – Reporting

Further detail on the methodologies adopted and data sources used are provided throughout the report as and where relevant.

Plastic Flow

5.0 Introduction

This section of the report details the quantity of plastic arising and flowing through to be recycled, re-used or managed through other end-of-life scenarios. This 'flow' is first presented for all plastic arisings, with division into household and commercial plastic arisings where feasible.

It should be noted that the data has been estimated for the year 2013 and represents only a snapshot; changes in recycling collections within LAs, a shifting political landscape or the economic sustainability of end markets, for example, could all affect the quantities of plastics being diverted to recycling and therefore potentially available for treatments such as EfW, MBT or ACT/ATT (these and other factors are discussed in more detail in section 12).

Plastic arising that is not currently recycled or subject to a PFI/PPP contract[14] is presented split into potential polymer fractions, which are then assumed 'suitable', 'unsuitable' or 'potentially suitable' for ACT/ATT treatment.

Within Appendix II a breakdown of the flow is presented for each of the seven key sectors from which plastic arises:

- Packaging
- Carpets
- Construction & Demolition (C&D)
- Waste Electrical and Electronic Equipment (WEEE)
- End of Life Vehicles (ELV)
- Agriculture
- Toys

The vast majority of data used to map the flows of plastic was found through secondary research, the sources and the robustness of which are presented alongside each dataset. The robustness assessment method can be found in Appendix I. In order to provide an indication of the level of uncertainty pertaining to tonnage data, error margins were assumed for arisings, by sector, and accumulated error margins were calculated for total plastic arising, total collected plastics and total residual waste plastics. Please see Appendix I for further details.

The future growth in the availability of plastic for end markets will depend upon the amount of plastic that local authorities and commercial collectors can divert from residual treatment or landfill. In turn this will depend upon an appreciation of the cost/benefit of extracting plastic out of existing, but under-utilised waste streams such

[14] *Waste PFI schemes aim to help the UK meet EU Landfill Directive diversion and recycling targets. They also encourage greater partnership working between authorities resulting in efficiency gains, more integrated waste management solutions and the benefits of economies of scale that flow from this and a more strategic approach to planning and procurement (Source: Defra)*

as agriculture or diverting plastic away from current un-contracted and contracted treatment routes such as EfW/MBT and towards other end markets.

Note that the tables and maps are presented as was in 2013. It should be noted that plastic, not currently being recycled but subject to Private Finance Initiative (PFI)/Public Private Partnership (PPP) contract can be targeted for capture should it suit the contractors'/ local authority's situation[15], in which case additional plastic material could become available for other end uses such as mechanical recycling or polymer cracking[16]. In all circumstances where plastics are not currently targeted or segregated from residual waste the current 'owners' of that material (public or private sector) would need to be clear about the business case for doing so. Go to section 12 for more details on the outlook for recovered plastic arisings and availability, and further details on costs.

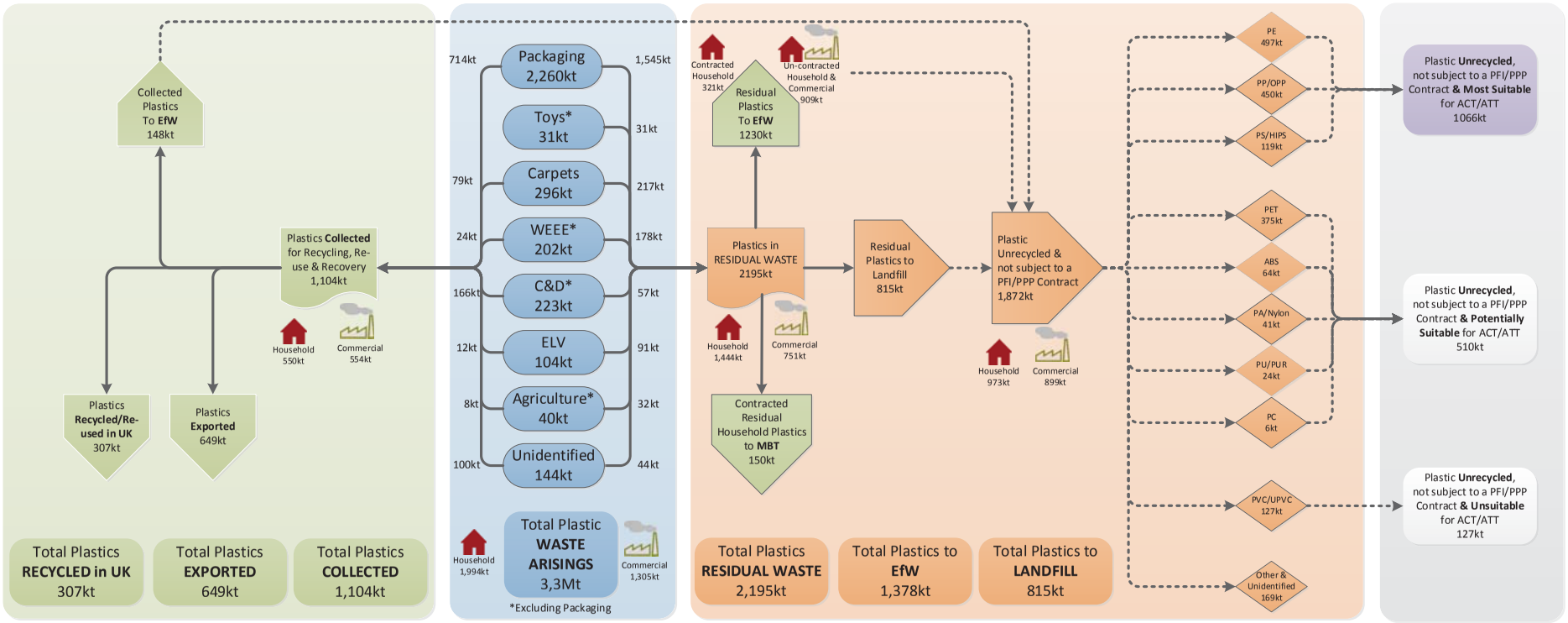
6.0 Overview of Plastic Flow

Figure 1 illustrates the flow of plastics in the UK from the point it arises as waste, through to recycling/re-use, EfW, MBT or landfill. On the right hand side the data shows whether plastic that is not recycled or subject to a long-term PFI/PPP contract is suitable for ACT/ATT. Household plastic that is not recycled, but is under PFI/PPP contract is shown in the centre of the diagram going to either EfW or MBT. The key data points are highlighted at the bottom of each column and outlined in sections 6.1 to 6.10 below.

[15] For example freeing up space in current EfW facilities or reducing the calorific value (CV) of material feeding EfW facilities.

[16] There is the potential for polymer cracking to be classed as 'recycling' rather than 'recovery' should the process outputs be polymers rather than liquid or gas; this would enable PRNs to be claimed on the packaging element of waste plastics should it be approved by Defra.

Figure 1 UK Plastic Flow 2013



6.1 Total Plastic Arisings (3.3Mt)

Plastic arisings in the UK arise predominantly in the form of packaging (69%). Plastic packaging placed on the market (POM) is commonly used as a proxy for plastic packaging arisings, due to the short period of time between purchase and disposal of plastic packaging and the availability of data as a result of compliance reporting. In 2013, plastic packaging POM was estimated to be 2.3Mt[17] in the UK; further details on packaging plastics can be found in Appendix II, section 16.0.

In addition to packaging, six sectors believed to produce the majority of the remaining plastic waste were researched in order to estimate total plastic arisings. The estimates made and the data sources used are given in Appendix II, of this report, along with information on data robustness and error margins (Appendix I).

Total plastic arisings were therefore estimated by aggregating arisings from all seven sectors plus an allowance for unidentified plastic from all other sectors.

The accumulated error margin calculated on the 3.3Mt of total plastic arising is +/- 16%, indicating that arisings could fall between 2.8Mt and 3.8Mt (please see Appendix I for details on how error margins were calculated).

Total plastic arisings comprise approximately 60% household and 40% commercial plastic, as detailed below.

6.1.1 Total Household Plastic Arisings (1,994kt)

Household plastic arisings was calculated by summing the identified household elements of key sectors, namely packaging (1,534kt), carpets (232kt), WEEE (198kt) and toys (31kt).

6.1.2 Total Commercial Plastic Arisings (1,305kt)

Commercial plastic arisings was calculated by summing the identified commercial elements of key sectors, namely packaging (726kt), C&D (223kt), ELV (104kt), carpets (64kt), AWP (40kt), WEEE (4kt) and Other/Unidentified (144kt).

6.2 Total Plastic Collected for Re-use, Recycling or Recovery (1,104kt)

The total plastic collected figure represents all plastic that has been separated from residual waste, through collections such as household kerbside recycling collections, recycling banks at supermarkets or civic amenity sites, commercial recycling collections, etc. Collected plastics are estimated to arise evenly from household and commercial sources and again the majority (65%) is estimated to be packaging.

The accumulated error margin calculated on total plastic waste collected is +/- 24% (please see Appendix I for details on how error margins were estimated). This was based on initial research findings of 1,042kt of collected plastic and means that collections could fall between 839kt and 1,245kt. The original quantity of collected plastics identified

[17] *WRAP/Valpak, Plastic Packaging Market Study (Plastic Flow), 2014* www.wrap.org.uk/content/plastic-packaging-market-study-plastic-flow-2014-0

was perceived to be too low[18] and did not allow for any unidentified plastic collections, which are now represented by 100kt 'Unidentified' in total plastic arisings.

6.2.1 Total Household Plastic Collected (550kt)

Household plastic collected was calculated by summing the identified household elements of key sectors, namely packaging (464kt), carpets (62kt) and WEEE (24kt).

6.2.2 Total Commercial Plastic Collected (554kt)

Commercial plastic collected was calculated by summing the identified commercial elements of key sectors, namely packaging (250kt), C&D (166kt), carpets (17kt), ELV (12kt), AWP (8kt), WEEE (<0.5kt) and Other/Unidentified (100kt).

6.3 Plastics Recycled/Re-used in the UK (307kt)

This is believed to be a conservative estimate of plastic recycled in the UK and includes some plastics that will be re-used rather than mechanically recycled, particularly those arising in carpets and C&D. Again, packaging represents the largest proportion of this material; over 90%.

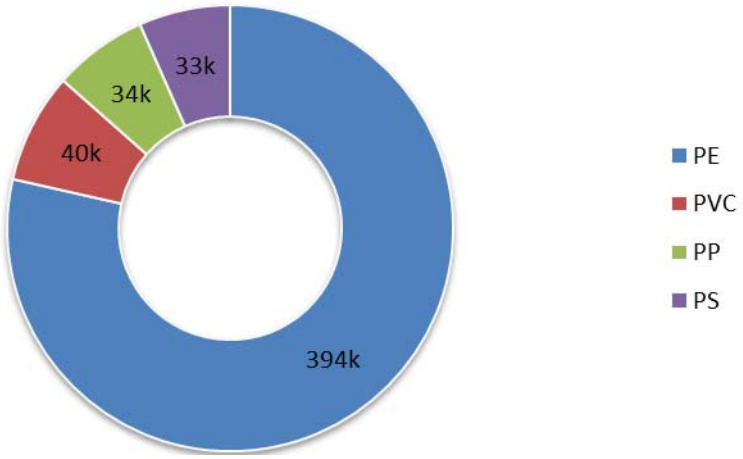
The quantity of plastics recycled/re-used in the UK was calculated by subtracting the quantities of plastic exported and sent to EfW, from total plastics collected.

[18] *The original Total Collected Plastic figure of 1,042kt was perceived to be too low due to the quantity of recycled/re-used plastic that was left after published quantities of waste plastic exported and estimated quantities of collected plastics going to EfW were subtracted from the Total Plastics Collected figure. Due to the publication of the quantity of packaging plastic recycled by NPWD, a minimum recycling figure was known, which was not achievable with only 1, 042kt of collected plastic. Therefore 100kt of 'unidentified' plastic was added into waste arisings to enable the plastic recycling figure to be feasible. This 100kt falls well within the error margins calculated and should be considered conservative.*

6.4 Plastics Exported (649kt)

The plastics exported figure is derived from HMRC's online uktradeinfo database[19], from 2013. The majority of plastic exported is packaging (66%) and the majority of the plastic is made of PE (61%). See Figure 2.

Figure 2 Breakdown of Plastic Exported by Polymer, 2013, tonnes



6.5 Plastics Collected and sent to EfW: (148kt)

Where possible the proportion of plastics sent to EfW was identified for the sectors researched. Proportions for carpets and C&D were identified at 47kt and 102kt respectively.

6.6 Plastics in Residual Waste (2,195kt)

Comprising approximately 66% household and 34% commercial plastic arising, plastics in residual waste in the UK arise predominantly in the form of packaging (68%).

The accumulated error margin calculated on the 2,195kt of total plastic arisings is +/- 25%, indicating that residual plastic arisings could fall between 1,646kt and 2,744kt (please see Appendix I for details on how error margins were estimated).

6.6.1 Total Household Plastic in Residual (1,444kt)

Household plastic in residual waste was calculated by summing the identified household elements of key sectors, namely packaging (1,069kt), WEEE (174kt), carpets (170kt) and toys (31kt).

6.6.2 Total Commercial Plastic in Residual (751kt)

Plastic in commercial residual waste was calculated by summing the identified commercial elements of key sectors, namely packaging (476kt), ELV (91kt), C&D (57kt), carpets (47kt), AWP (32kt), WEEE (3kt) and other/unidentified (44kt).

[19] *https://www.uktradeinfo.com/Pages/Home.aspx*

6.7 Plastics in Residual Waste sent to EfW (1,230kt)

An estimated 6.2Mt of LA managed waste went to EfW in the UK in 2013/14[20]. Around 11% of this is estimated to be plastic (packaging and non-packaging), based on taking the average of three residual waste composition analysis studies:

- The composition of municipal solid waste in Scotland, ZWS 2010
- The composition of municipal solid waste in Wales, WRAP Cymru 2010
- Municipal Waste Composition: A Review of Municipal Waste Component Analyses, Defra 2009

An estimated 696kt of plastic in the commercial sector was sent to EfW in 2013[21]. This has been derived using the assumption that around 10%[22] was sent to EfW and 12% of this was plastic[23].

Therefore it is estimated that a total of 1,378kt of plastic was sent to EfW in 2013. However as indicated in section 6.5, 148kt of plastic collected was subsequently sent for EfW, therefore it is estimated that 1,230kt of total residual plastic was sent directly to EfW.

6.8 Plastics in Residual Waste sent to Landfill (815kt)

This is the estimated tonnage of plastics that was landfilled in 2013. It was calculated by subtracting the quantities of plastics in residual waste that are currently being sent to EfW (from household and commercial sources) or for MBT (from household sources only). This means there will be a (unknown) quantity of commercial plastic included in the residual plastics to landfill that may be going to MBT.

6.9 Plastics Un-recycled and not subject to a PFI/PPP Contract (1,872kt)

This tonnage was derived by adding the quantities of plastic sent to EfW following collection and the quantities of household and commercial plastics wastes being sent to EfW or MBT that are not subject to a PFI/PPP contract, to residual plastic waste to landfill.

6.10 Plastics un-recycled, not subject to a PFI/PPP contract and suitable for ACT/ATT (1,066kt)

The most desirable polymers for ACT/ATT are polyolefins such as HDPE, LDPE, LLDPE and PP and styrenics such as PS and EPS. A polymer composition for 'plastics un-recycled, not subject to a PFI/PPP contract and suitable for ACT/ATT' was derived through combining the polymer compositions of:

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[20] *Local authority managed waste going for incineration with energy recovery: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/375945/Statistics_Notice_Nov_2014_Final__3_.pdf*

[21] *COMMERCIAL, ENERGY FROM WASTE A GUIDE FOR DECISION-MAKERS: http://www.r-e-a.net/pdf/energy-from-waste-guide-for-decision-makers.pdf*

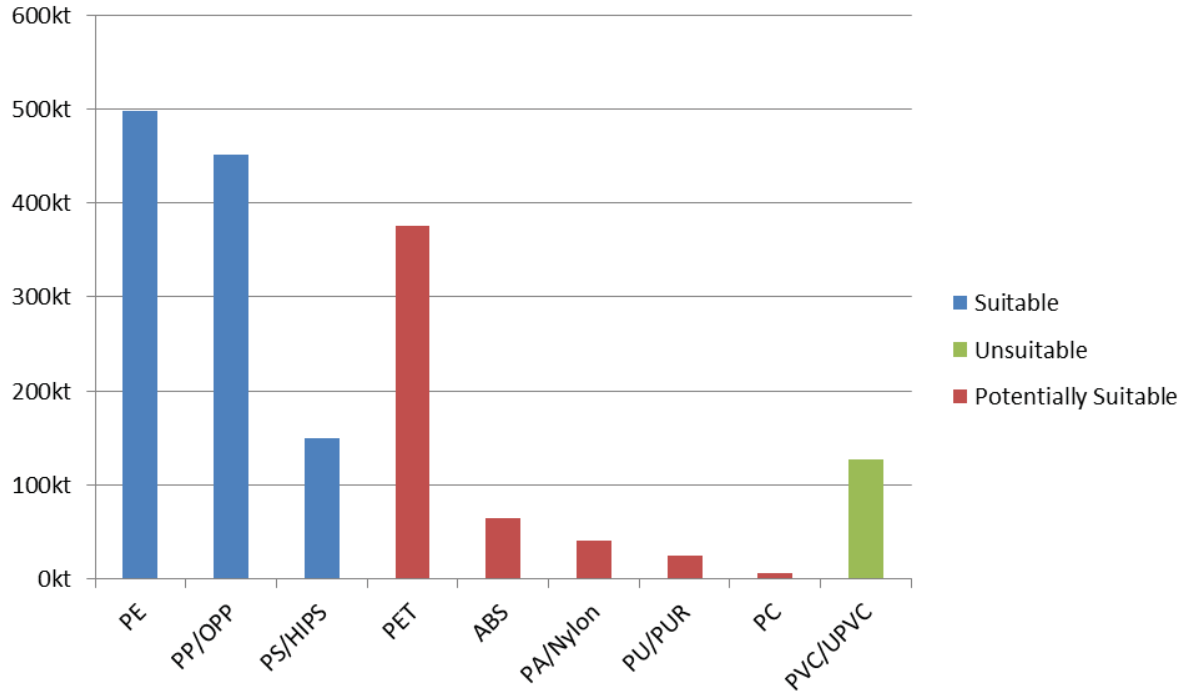
[22] *In 2009/10 approximately 58Mt of commercial & industrial waste (commercial) was generated in the UK, of which 50% was recycled and 25% was landfilled. The remaining 25% of commercial waste was subjected to other forms of treatment, with energy recovery in EfW plants contributing a very small fraction. We have assumed 10% of 58 Mt for the purposes of this report, since EfW has increased over years.*

[23] *Based on split of PRNs, 12% assumed plastic (696kt)*

- 'Residual plastics to landfill' (which mirrors the polymer composition of residual waste);
- 'Commercial & household residual plastics sent to EfW, but not subject to a PFI/PPP contract' (which mirrors the polymer composition of residual waste); and
- 'Collected Plastics to EfW' (which is an amalgamation of the polymer compositions of carpet and C&D waste plastics, proportioned appropriately).

The error margins around the polymer composition are therefore likely to be wide, in the region of +/-25%, and the tonnages derived should be treated with caution. They are illustrated in Figure 3 below.

Figure 3 Quantity of Polymers Un-recycled, not subject to a PFI/PPP Contract & Suitability for ACT/ATT (2013 Snapshot)

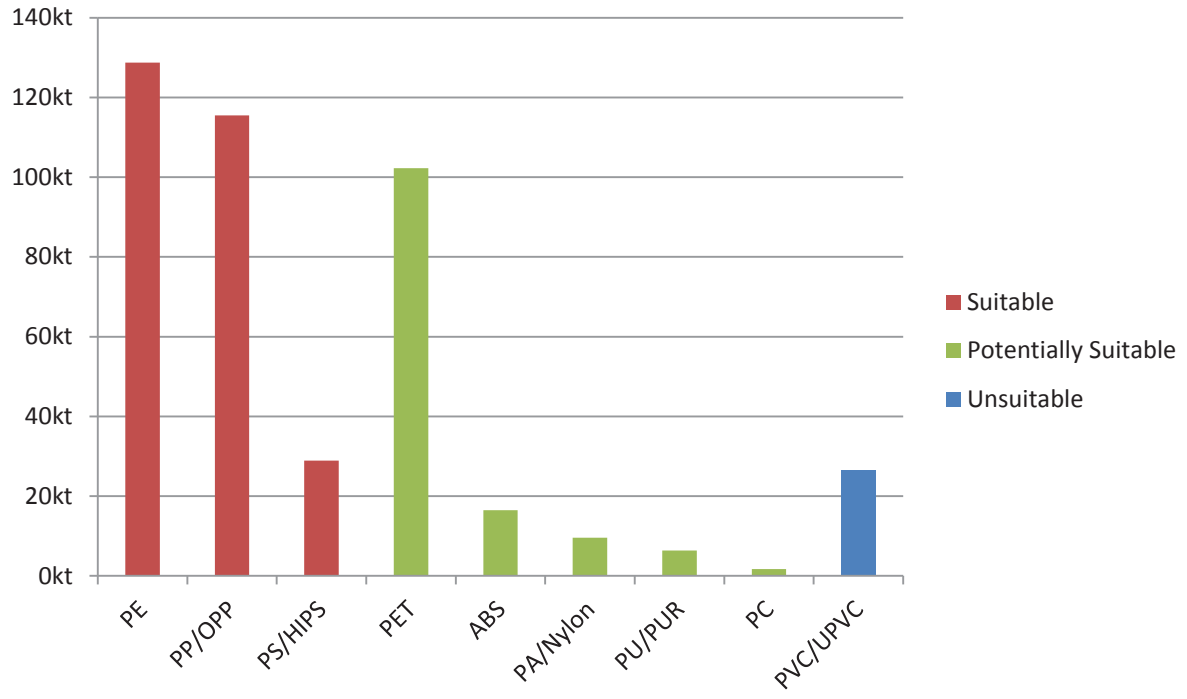


The desirability of each polymer type in terms of its usefulness in ACT/ATTs is described as either 'suitable', 'unsuitable' or 'potentially suitable'. 'Suitable' has been assigned to those polymers that are desirable or highly desirable, 'unsuitable' has been assigned to those that are potentially damaging to ACT/ATT outputs or equipment and 'potentially suitable' has been assigned to those polymers which may be suitable in certain restricted quantities for certain specific treatments, depending on the outputs desired. Please see Appendix III for further details.

6.11 Plastics Un-recycled and subject to a PFI/PPP Contract (471kt)

This tonnage was derived by adding the quantities of household plastic sent to EfW that is under a PFI/PPP contract to the quan tity of household plastic sent to MBT which is also under a PFI/PPP contract. Of this total material an estimated 273kt is suitable for ACT/ATT.

Figure 4 Quantity of Polymers Un-recycled, subject to a PFI/PPP Contract & Suitability for ACT/ATT (2013 Snapshot)



6.12 Summary of Plastic Flow

This project estimates total plastic arisings in the UK in 2013 at 3.3Mt. The majority of plastic arisings is packaging (~69%), of which approximately 32% is collected for recycling. In total 1,104kt of plastic is collected for re-use, recycling or recovery, of which the majority (~59%) is exported. The remaining 2,195kt of plastic goes to residual disposal routes (67%), where it is either sent to EfW (~1,230kt), MBT (~150kt[24]) or landfill (815kt).

Plastic not recycled or subject to PFI/PPP contacts amounts to approximately 1,872kt. Of this it is estimated that 1,066kt is PE, PP/OPP and PS/HIPS, and is suitable for ACT/ATT. Meanwhile, of the estimated 471kt of plastic that is not recycled but is under PFI/PPP contract around 268kt is thought to be PE, PP/OPP and PS/HIPS, and is suitable for ACT/ATT.

[24] *This is a minimum as it only represents LA MSW going to MBT under long-term PFI/PPP contracts*

7.0 Ease of Diversion of Plastic Types

This section of the report assesses the ease of diversion of plastic from each key sector. The sectors are presented in the order of largest plastic arisings to smallest and are shown in Figure 5 below.

Figure 5 Suitable Polymers for Polymer Cracking and Associated Key Sectors

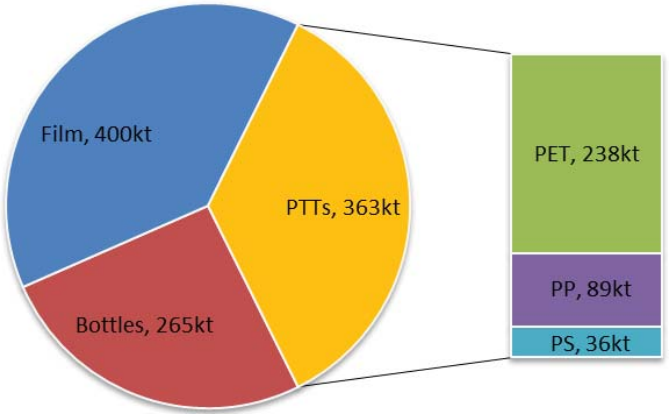
7.1 Packaging Plastics (Click here for packaging flow data & diagram)

The majority of plastic packaging in residual waste can be found in the household waste stream (~69%). Pots, tubs and trays (PTTs) and film constitute the majority of this packaging (~75%). Approximately 56% of the film is made of PE, PP/OPP and PS. The majority of PTTs are PET (~59%), followed by PP (~22%) and PS (~9%). These packaging formats are already collected by some LAs, particularly PTTs, which in 2013 were collected by 271 LAs[25]. PET and PP are polymers readily mechanically recycled. Mechanical recycling of PS in the UK is thought to be negligible, but as with PP it is highly desirable for ACT/ATT.

In those LAs not targeting PTTs and films a certain proportion will already be collected within waste plastic bottle collections, undertaken by 400 LAs[25] in the UK. Of the plastic bottles remaining in the household stream, the majority (~84%) are PET; a polymer easily mechanically recycled, but less suitable to polymer cracking.

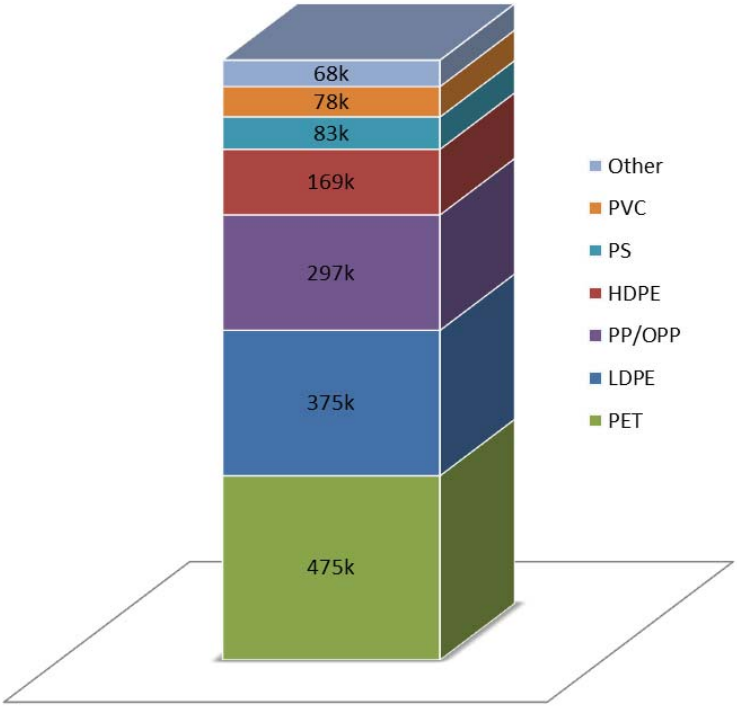
[25] *RECOUP UK Household Plastics Collection Survey 2014, www.recoup.org/news/7263/recoup-2014-uk-household-plastics-collection-survey-now-available*

Figure 6 Breakdown of Household Packaging in Residual Waste, by Format[26]



Considering both household and commercial waste streams together, PET, LDPE and PP account for almost 75% of them. PET is mainly found in household PTTs and bottles, LDPE is mainly found in films (both household and commercial) and PP in films, household PTTs and commercial rigid plastic packaging.

Figure 7 Breakdown of Packaging in Residual Waste, by Polymer Type



Accessing household plastic packaging currently going to residual waste would require additional household collections of PTTs and film by LAs; whilst the majority of this would suit mechanical recycling, certain elements such as PS PTTs and some films which are not currently recycled in the UK, could supply EfW or ACT/ATT processes. In order for collections to increase, LAs have to be confident the collected material holds a value, which will come from sufficient economically sustainable end markets (for as many

[26] *Breakdown is approximate and established using data from WRAP/Valpak Plastic Packaging Composition 2011 Report*

fractions of the plastic as possible), quality of recyclate and sufficient volumes of material.

Where household and commercial plastic packaging has been sorted at a MRF or PRF, it is possible that there are plastic packaging out throws that hold little or negative value (e.g. if landfill gate fees and taxes are paid for disposal), that may be of interest to polymer cracking processes. This level of detail was not explored in this project, but could be an area for further research in the future.

Please see Section 16.0 in Appendix II for further details on packaging plastic, including a diagram illustrating the flow.

7.2 Plastics in Carpets (Click here for carpet flow data & diagram)

Waste carpets, constituting approximately 74% plastic[27], arise mainly from the household sector (~78%[28]). Currently around 33kt of plastic from carpets is believed to be recycled/re-used[29] and from the research undertaken for this project, approximately 247kt of plastic in carpets is currently un-recycled or not subject to a long term PFI/PPP contract.

The key to accessing this plastic lies not simply in boosting the collection/separation of waste carpets (collected by 38 LAs in 2013[25]), but in identifying and separating the desirable PP polymer fraction. Carpet has two main constituent parts: pile and substrate/backing. Pile can be made of PP, wool, or in the case of carpet tiles, Polyamides (PA)[30] and bitumen. Carpet substrate is predominantly made of PP, although it was originally made of jute.

A case study undertaken by Reflex Polymers and Carpet Recycling UK estimates 160kt of PP carpet goes to landfill each year. This is much higher than the landfill estimate in Figure 25, which assumes that a proportion of waste carpet is sent to EfW and MBT along with other household waste. If the quantity of PP in 'Plastics in Carpet in Residual Waste' is considered, this is of a more similar size at 172kt.

The feasibility of identifying/separating PP from carpet waste was not researched as part of this project, but is an important element of further research that should be undertaken if this PP fraction is to be pursued.

Please see Section 17.0 in Appendix II for further details on plastic in carpets, including a diagram illustrating the flow.

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[27] *http://www.wrap.org.uk/sites/files/wrap/HWRC%20Guide%20recycling%20carpets%20and%20mattresses.pdf*

[28] *http://www.carpetrecyclinguk.com/downloads/flooring_draft_8_9_09.pdf*

[29] *http://www.carpetrecyclinguk.com/downloads/2013_Achievements_and_Targets_for_2014.pdf*

[30] *Commonly known as nylon*

7.3 Plastics in C&D (Click here for C&D Flow Data & Diagram)

The C&D sector are already reporting a 74% diversion rate[31] of plastics from landfill, much of which is enabled through sending waste material to EfW. This project has identified approximately 159kt of plastic in C&D that is currently un-recycled. The main polymers of interest are PE, used in piping, and PS used as an insulation material.

Accessing these polymers requires the ability to identify PE piping from PVC piping and PS insulation materials from polyurethane (PU), two polymer fractions that are mainly unsuitable in ACT/ATT processes.

Please see Section 18.0 in Appendix II for further details on plastic in C&D, including a diagram illustrating the flow.

7.4 Plastics in WEEE (Click here for WEEE flow data & diagram)

The main polymer fraction to be found within WEEE plastics appears to be PET, which due to it releasing oxygen when burnt is undesirable in pyrolysis, but is potentially suitable for gasification. The main polymer fractions found in WEEE plastics that are most suitable for ACT/ATT technologies are:

- PP: found in small mixed WEEE and large domestic appliances
- PS/HIPS: found in small mixed WEEE, cooling appliances and display screens

These polymer fractions hold a value if separated out, so may become unattractive for ACT/ATT processes.

Please see Section 19.0 in Appendix II for further details on waste plastic in WEEE, including a diagram illustrating the flow.

7.5 Plastics in ELV (Click here for ELV flow data & diagram)

A limited amount of plastic separation and polymer segregation is currently undertaken within ELV recycling, despite overall recycling levels reaching 89%[32] in 2013. This is due to the light weight of plastic components, compared to metal components, and due to energy recovery not being added to recycling targets until 2015.

This project has identified approximately 91kt of plastics in ELV that is currently un-recycled, of which 28kt is PP. Accessing this PP, which is used in the interior trim of vehicles, in dashboards, seats and bumpers, is likely to happen through acquisition of the light fraction of the automotive shredder residue (ASR) that is produced after the

[31] *WRAP, Smartwaste Tool, 2012*

[32] *http://www.letsrecycle.com/news/latest-news/elv-recycling-rate-nears-89/*

heavy metal fractions of the car are removed and the remains crushed. However this residue, which contains around 25% plastic[33], also contains polymers such as ABS, PU and PVC which are potentially unsuitable for ATT/ACT technologies.

Please see Section 20.0 in Appendix II for further details on plastic in ELV, including a diagram illustrating the flow.

7.6 Agricultural Waste Plastics (Click here for AWP flow data & diagram)

The majority of AWP is non-packaging plastics (~90%) and can be subject to very high levels of contamination. It is this contamination, rather than the plastic/polymer types which can be prohibitive to ACT/ATT technologies as it is expensive to clean AWP plastics to a sufficient degree to enable shredding.

Please see Section 21.0 in Appendix II for further details on AWP, including a diagram illustrating the flow.

7.7 Plastic in Toys (Click here for toys flow data & diagram)

As toys mainly arise in household waste, whether they have been re-used (through charity shops, etc.) or not, their collection would most naturally tie in with other LA recycling collections. However, neither the quantity of toy's arising nor the end markets for toy waste (outside of WEEE) provide sufficient incentive for them to be collected.

Furthermore the identification of polymer types of plastic can be extremely difficult, with few or no markings, except on packaging.

Please see Section 22.0 in Appendix II for further details on waste plastic in toys, including a diagram illustrating the flow.

7.8 Conclusions on Ease of Diversion of Plastic from Current Final Destination

By far the largest quantity of plastic arises as packaging from the household waste stream (1,069kt). Due to extensive existing household collections and the potential for expanding these collections, it also appears to be the most accessible.

For LAs to expand household collections of plastic (or undertake campaigns to encourage greater participation in collections), will depend on the value they believe they will gain from selling the additional material, the avoided cost of residual disposal and the cost of improving collections. LAs have to be confident that there are strong economically sustainable end markets for as many fractions of the plastic as possible that collected materials will be of sufficient quality.

[33] *https://www.recyclingtoday.com/article/rtge-may-june-auto-shredder-fluff*

In line with the waste hierarchy, re-using and then recycling materials are preferable to sending them to EfW, therefore additional LA household collections would first and foremost feed additional plastics recycling. They could also provide plastics for ACT/ATTs, such as less desirable PTTs (PS for example) or films.

Combined, residual commercial plastic packaging, plastics in carpets and plastics in WEEE provide a further 871kt of waste plastics (including a proportion subject to PFI/PPP contract). Ease of access is more challenging for these streams either because their collection relies on a business/organisation paying for uplift or because extraction of plastics is difficult. In the case of household carpets, 38 LAs reported collecting them in Waste Data Flow (WDF) in 2013.

Plastics Database & Maps

8.0 Household Plastics Database

This section of the report details the data and data sources used to build the accompanying Excel spreadsheet on household plastic arisings and the treatment of municipal waste.

The spreadsheet is split into four sections:

- Administrative Details
- PFI/PPP Facilities
- Waste Arisings
- Plastic Collections/Processing

Each type of data collected, and the source, is given in Figure 8 below, along with a sample LA entry. It should be noted that the data in this figure has been transposed vertically for ease of viewing in this report. The database was generated completely through secondary research; the information provided is all in the public domain, therefore available for use by readers of this report, including details of the commercial aggregators (as illustrated in rows 31, 35 and 37 of Figure 8).

The following assumptions and calculations were made in order to provide the necessary information.

8.1 Assumptions and calculations

- PFI/PPP contract length: where no contract length could be identified, a period of 25 years was assumed. This data is highlighted in yellow in the spreadsheet;
- PFI/PPP contract end date: this was calculated based on the contract start date and contract length. Where the contract length has been estimated this and the contract end date are highlighted in yellow;
- Household plastic arisings: Total household plastic arisings of 1,994kt were identified as part of this project (see Section 6.1.1), and were allocated across LAs according to the number of households (ONS);
- All plastics from household collections: Total packaging plastics from household collections of 550kt were identified as part of this project (see Section 6.2.1), and were allocated across LAs according to proportion of plastic packaging collected as reported in WDF;
- Household plastic in residual waste was calculated by subtracting plastics from household collections from household plastic waste arisings, on a LA by LA basis;
- Residual waste contracted to MBT: Where it has been identified that a LA is engaged in a PFI/PPP waste contract and the MBT facility is known to have been operating in 2013, then the LA's of household plastic in residual waste is assumed to be going to MBT;
- Residual waste contracted to EfW: Where it has been identified that a LA is engaged in a PFI/PPP waste contract and the EfW facility is known to have been operating in 2013, then the LA's proportion of Household Plastic in Residual Waste is assumed to be going to EfW; and

- Un-contracted household residual plastic: Where it has not been identified that a LA is engaged in a PFI/PPP waste contract, then the LA's proportion of household plastic in residual waste is assumed to be going to landfill;

8.2 Extract of Household Database with Data Sources (all publicly available)

Figure 8 Extract of Household Database

	A	B	C	F
1		**Title in Spreadsheet**	**Sample Data Entry**	***Data Source***
2	Administrative Details	**JPP Order**	179	*WDF*
3		**Authority**	Coventry City Council	*LAs appear more than once if associated with more than one project*
4		**No of Households**	125kt	*ONS*
5		**No of Households(%)**	0%	*Calculated from No of Households (row 4)*
6		**NUTS area**	West Midlands	*ONS*
7		**Authority Type**	UA	*WDF*
8	PFI/PPP Facilities	**Project Name**	Coventry Energy from Waste Project	*Defra FOI update on Local authority funding: Private Finance Initiative (PFI) projects***
9		**Classifcation**	PPP	*Defra FOI update on Local authority funding: Private Finance Initiative (PFI) projects***
10		**Plant Type**	EfW	*Defra FOI update on Local authority funding: Private Finance Initiative (PFI) projects***
11		**Operational in 2013**	Yes	*Set based on start date*
12		**Start date**	2010	*Defra FOI update on Local authority funding: Private Finance Initiative (PFI) projects***
13		**End date**	2035	*Calculated: start date + contract length (yellow if estimated)*
14		**Duration of contract**	25	*Various sources, if unknown estimated as 25 yrs (in yellow)*
15		**Capacity (ktpa)**	234	*Various secondary research and Defra FOI update on Local authority funding: Private Finance Initiative (PFI) projects***
16		**Output (MW)**		*Various secondary research*
17		**Output (other)**		*Various secondary research and Defra, Local authority funding: Private Finance Initiative (PFI) projects**
18		**Technology**	Incineration - CHP	*Various secondary research*
19		**Feedstock**	Municipal & Commercial	*Various secondary research*
20	Waste Arisings	**Household Plastic Waste Arisings (t)**	7kt	*Calculated: Consumer Plastic Waste Arisings of 1,394kt (identified as part of this project) * No of Households % (row 5)*
21		**Packaging plastics from Household Collections (t)**	2kt	*Calculated (t): Total of 464kt taken from RECOUP UK Household Plastics Collection Survey 2014*** and allocated across LAs according to proportion of plastic packaging collected/reported in WDF*
22		**Packaging plastics from Household Collections (%)**	0kt	*Calculated: Proportion of LA plastic packaging collected as % of total plastic packaging collections as reported in WDF*
23		**All Plastics from Household Collections (t)**	2kt	*Calculated: All Plastics from Household Collections of 550kt (identified as part of this project) * proportion of plastic packaging collected (row 24)*
24		**Household Plastics in Residual Waste (t)**	4kt	*Calculated: Household Plastic Waste Arisings (row 22) minus All Plastics from Household Collections (row 25)*
25		**Residual Plastic Contracted 2013**	Yes	*Yes' if 2013 falls between 'Start Date' and 'End Date' in rows 14 & 15*
26		**Residual Waste Contracted to MBT (t)**		*If 'Residual Plastic Contracted 2013' is YES (row 26) and 'Plant Type' is BMBT/LFMBT (row 12), the tonnage of Consumer Residual Waste is shown (row 23)*
27		**Residual Waste Contracted to EfW (t)**	4kt	*If 'Residual Plastic Contracted 2013' is YES (row 26) and 'Plant Type' is EfW (row 12), the tonnage of Consumer Residual Waste is shown (row 23)*
28		**Un-Contracted Consumer Residual Plastic (t)**		*If 'Residual Plastic Contracted 2013' is NO (row 26), the tonnage of Consumer Residual Waste is shown (row 23)*
29	Plastic Collections	**Packaging plastics from HH Collections (t)**	7kt	*WRAP*
30		**Drg recycling collection contract**	DSO / In house	*WRAP*
31		**Drg recycling WMC**		*WRAP*
32		**drg_kerb_plasticbottles**	Yes	*WRAP*
33		**drg_kerb_mixedplastics**	Yes	*WRAP*
34		**MRF Operator 1**	Ward Recycling Ltd	*WRAP*
35		**Site Name 1**	Middlesbrough Container Sorting Line	*WRAP*
36		**Operator 2**		*WRAP*
37		**Site Name 2**		*WRAP*
38	*http://webarchive.nationalarchives.gov.uk/20130123162356/http://www.defra.gov.uk/environment/waste/local-authorities/ridp/pfi-projects/*			
39	**https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/266436/project_list_EIR16Dec.pdf*			
40	***www.recoup.org/news/1263/recoup-2014-uk-household-plastics-collection-survey-now-available*			

8.3 MBT Facilities Producing RDF and SRF

The following list shows the PFI/PPP MBT facilities that produced RDF or SRF in 2013 and the associated LAs:

Figure 9 PFI/PPP EfW Facilities Producing RDF & SRF

Project Name	PPP/PFI	Plant Type	Capacity (ktpa)	MBT Output	LAs
Cambridgeshire County Council Waste Management Project	PFI	LFMBT*	110	SRF	South Cambridgeshire District Council Huntingdonshire District Council Fenland District Council East Cambridgeshire District Council Cambridge City Council Cambridgeshire County Council
Cumbria Waste PPP (South)	PPP	BMBT**	75	SRF	Cumbria County Council
Cumbria Waste PPP Project (North)	PPP	BMBT	75	SRF	Cumbria County Council
East London Waste Authority Integrated waste Management (ELWA) 1	PFI	BMBT	180	RDF	Redbridge LB Newham LB Havering LB Barking and Dagenham LB East London Waste Authority
East London Waste Authority Integrated waste Management (ELWA) 2	PFI	BMBT	180	RDF	Redbridge LB Newham LB Havering LB Barking and Dagenham LB East London Waste Authority
Greater Manchester WDA - Longley Lane MBT	PFI	BMBT	89	SRF	Manchester City Council MBC
Greater Manchester WDA - N Manchester MBT	PFI	BMBT	84	SRF	Tameside MBC
Greater Manchester WDA - Oldham MBT	PFI	BMBT	66	SRF	Oldham MBC
Greater Manchester WDA - Salford MBT	PFI	BMBT	96	SRF	Salford City Council MBC
Greater Manchester WDA - Stockport MBT	PFI	BMBT	86	SRF	Stockport MBC
Isle of Wight Waste Management Project	PFI	BMBT	80	SRF	Isle of Wight Council
Lancashire Waste Partnership - 1	PFI	LFMBT	175	RDF	Blackpool Borough Council Lancashire County Council
Lancashire Waste Partnership -2	PFI	LFMBT	175	RDF	Blackpool Borough Council Lancashire County Council
Leicester City Council Integrated Waste Management Project	PFI	LFMBT	175	RDF	Leicester City Council
Leicestershire County Council Waste Management Project	PPP	LFMBT	50	RDF	Leicestershire County Council
London Borough of Southwark Integrated Waste Management Solutions Project	PFI	BMBT	100	SRF	Southwark LB
New Earth Solutions Waste Management Project - gloucs	M	BMBT	120	RDF	Bath and North East Somerset Council Bristol City Council North Somerset Council South Gloucestershire Council
Newcastle-upon-Tyne City Council Waste Management	PPP	BMBT	100	RDF	Newcastle-upon-Tyne City Council MBC
Whites Pit Waste Management Project	PPP	LFMBT	50	RDF	Bournemouth Borough Council

**LFMBT - Landfill Mechanical Biological Treatment*

***BMBT - Biodrying Mechanical Biological Treatment*

9.0 Household Plastic Arisings

9.1 Household Plastic Arisings (1,994kt)

Household plastic arisings were calculated by summing the identified household element of key sectors, namely packaging (1,534kt), carpets (232kt), WEEE (198kt) and toys (31kt).

In order to allocate household plastic arisings across the UK, ONS data on the number of households in each LA was used. The results of this allocation are given in Figure 10 below.

9.2 Household Plastic in Residual Waste (1,444kt)

The total quantity of plastic in household residual waste was calculated by summing the identified household element of key sectors, namely packaging (1,069kt), WEEE (174kt), carpets (170kt) and toys (31kt).

As packaging constitutes the majority of plastics collected (84%) and as WDF provides data on a LA level, it was possible to calculate the proportion of packaging plastics collected by each LA and apply this to the total tonnage of plastic collected to give an estimate of all plastics collected per LA.

In order to allocate household plastic in residual waste across the UK, the quantity of plastic collected for recycling, re-use or recovery per LA was subtracted from the quantity of household plastic arisings per LA.

The results of this are also given in Figure 10 below.

9.3 Household Plastic in Residual Waste not subject to PFI/PPP Contract (973kt), Household Plastic in Residual Waste subject to PFI/PPP Contract (471kt)

Grouped into regions and sub-regions, the results of these LA arisings are shown below.

Figure 10 Household Plastic Arisings

Region	Sub region (NUTS 2)	Household Plastic Waste Arisings	Plastic in Household Residual Waste (t)	Household Plastic in Residual Waste not subject to PFI/PPP Contract (t)	Household Plastic in Residual Waste and subject to PFI/PPP Contract (t)
East of England	Bedfordshire and Hertfordshire	58k	40kt	40kt	0kt
South East	Berkshire, Buckinghamshire and Oxfordshire	69k	46kt	39kt	8kt
North West	Cheshire	20k	8kt	8kt	0kt
South West	Cornwall and Isles of Scilly	12k	10kt	10kt	0kt
North West	Cumbria	23k	19kt	8kt	11kt
East Midlands	Derbyshire and Nottinghamshire	80k	59kt	55kt	4kt
South West	Devon	42k	33kt	33kt	0kt
South West	Dorset and Somerset	40k	31kt	28kt	2kt
East of England	East Anglia	99k	75kt	57kt	18kt
Wales	East Wales	15k	7kt	7kt	0kt
Yorkshire and The Humber	East Yorkshire and Northern Lincolnshire	20k	12kt	9kt	3kt
Scotland	Eastern Scotland	48k	34kt	34kt	0kt
East of England	Essex	67k	48kt	48kt	0kt
South West	Gloucestershire, Wiltshire and Bristol/Bath area	63k	39kt	28kt	12kt
North West	Greater Manchester	109k	89kt	63kt	27kt
South East	Hampshire and Isle of Wight	68k	56kt	2kt	54kt
West Midlands	Herefordshire, Worcestershire and Warwickshire	53k	39kt	38kt	1kt
Scotland	Highlands and Islands	11k	9kt	9kt	0kt
London	Inner London - East	79k	65kt	12kt	53kt
London	Inner London - West	49k	40kt	4kt	36kt
South East	Kent	66k	50kt	0kt	50kt
North West	Lancashire	58k	43kt	18kt	25kt
East Midlands	Leicestershire, Rutland and Northamptonshire	63k	42kt	25kt	17kt
East Midlands	Lincolnshire	31k	22kt	8kt	14kt
North West	Merseyside	65k	56kt	56kt	0kt
Scotland	North Eastern Scotland	11k	10kt	10kt	0kt
Yorkshire and The Humber	North Yorkshire	30k	23kt	23kt	0kt
Northern Ireland	Northern Ireland	39k	25kt	25kt	0kt
North East	Northumberland and Tyne and Wear	39k	25kt	7kt	18kt
London	Outer London - East and North East	53k	37kt	7kt	30kt
London	Outer London - South	23k	15kt	11kt	4kt
London	Outer London - West and North West	67k	52kt	52kt	0kt
West Midlands	Shropshire and Staffordshire	52k	32kt	25kt	7kt
Scotland	South Western Scotland	55k	39kt	39kt	0kt
Yorkshire and The Humber	South Yorkshire	29k	20kt	12kt	8kt
South East	Surrey, East and West Sussex	112k	88kt	63kt	25kt
North East	Tees Valley and Durham	20k	11kt	11kt	0kt
West Midlands	West Midlands	56k	38kt	3kt	36kt
Wales	West Wales	55k	21kt	21kt	0kt
Yorkshire and The Humber	West Yorkshire	47k	36kt	30kt	7kt
Grand Total		1994kt	1444kt	973kt	471kt

9.4 Household Plastic Arisings Maps

The household plastic arisings data have been mapped to better illustrate where in the country the highest arisings are:

Figure 11 Household Plastic Arisings (Map)

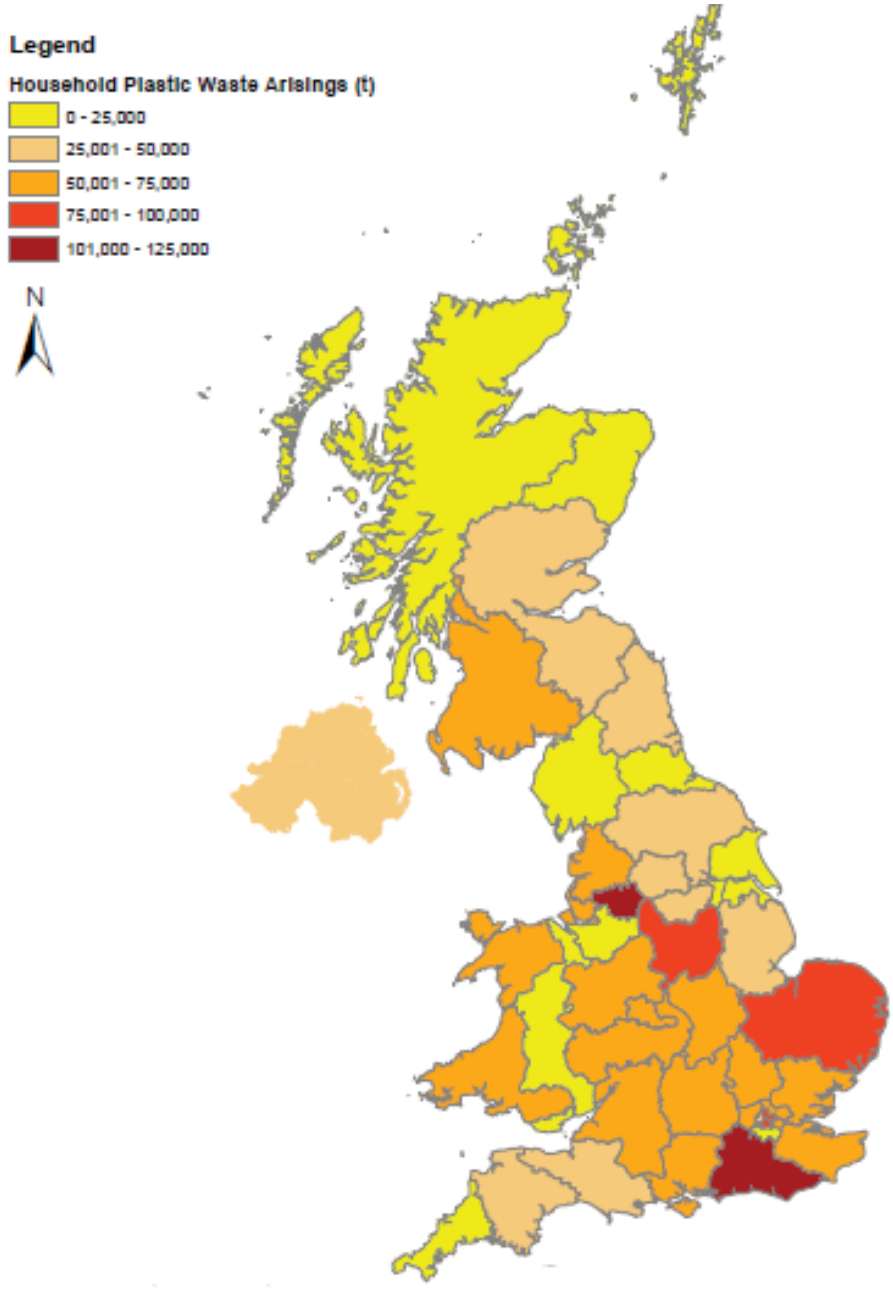


Figure 11 above shows that the highest plastic arisings are to be found in the sub-regions of Surrey, East and West Sussex (112kt), Greater Manchester (109kt) and East Anglia (99kt). Note that due to the scale of the map individual sub-regions within London do not appear prominently on the map even though their combined level of plastic arising's is high.

9.5 Household Plastic un-recycled and subject to a PFI/PPP contract

Household plastic not recycled but subject to a PFI/PPP contract has been mapped in Figure 12 below:

Figure 12 Household Plastic Un-recycled and Subject to a PFI/PPP Contract (Map)

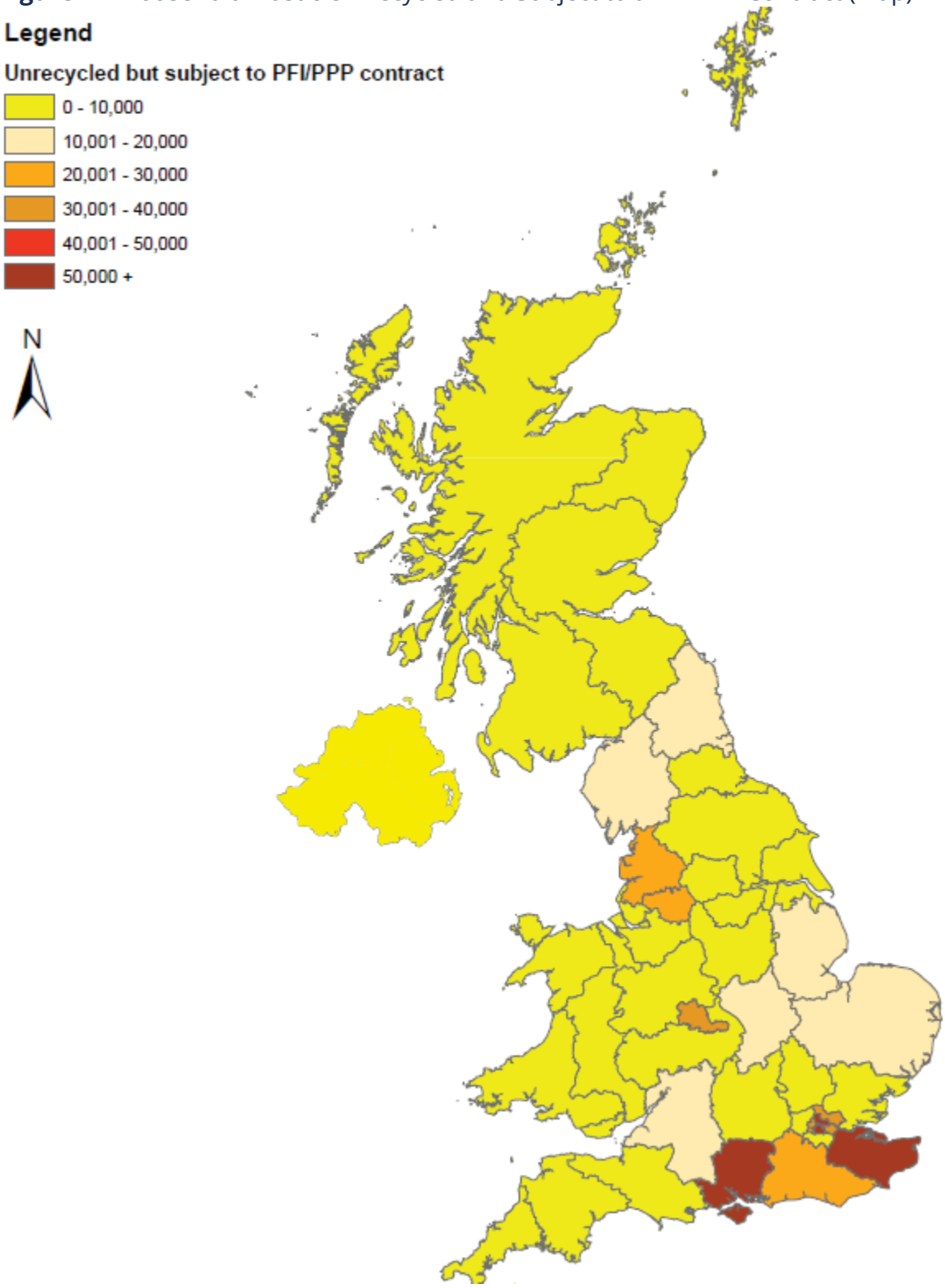
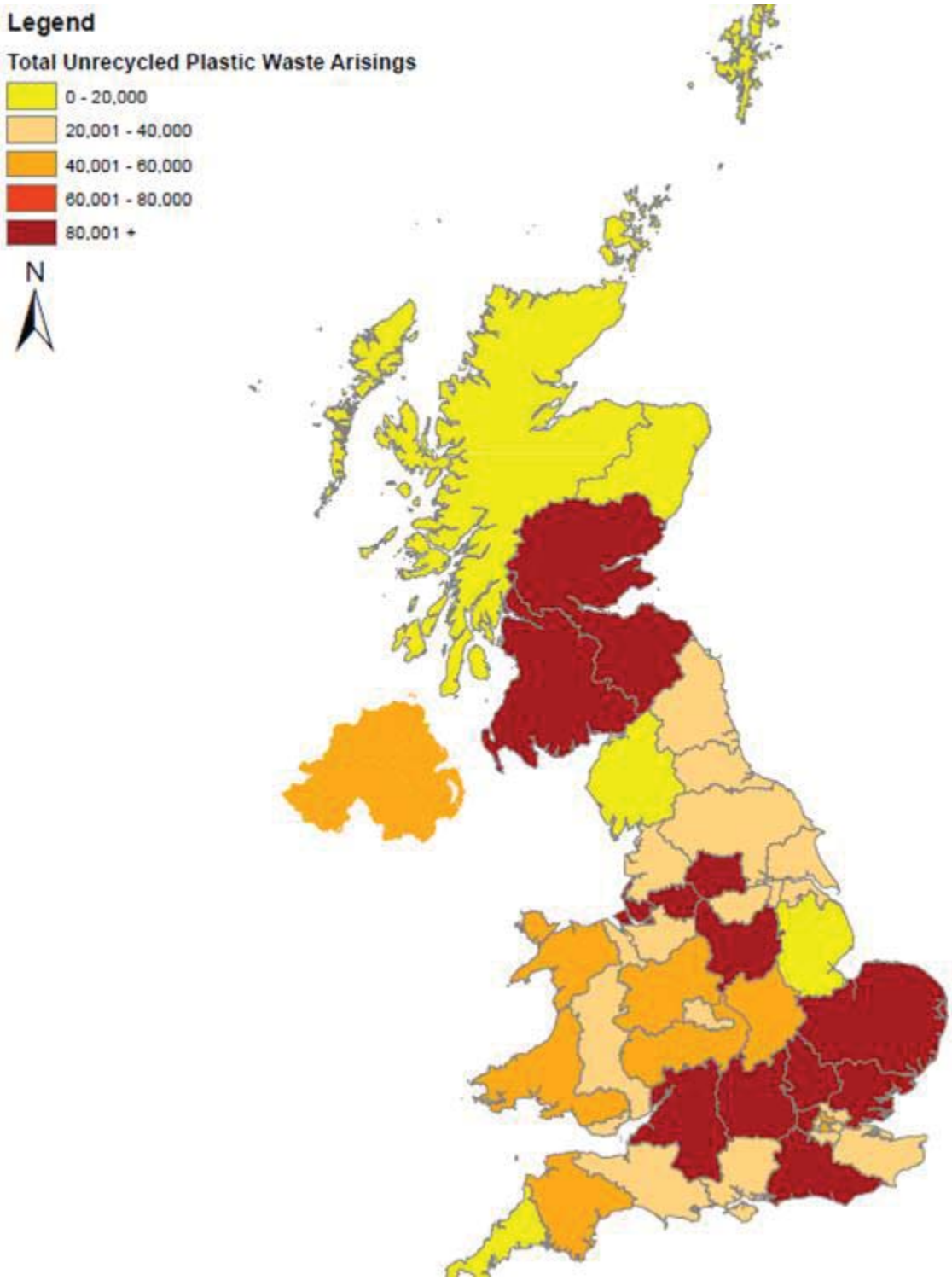


Figure 13 Household Plastic Un-recycled and Subject to a PFI/PPP Contract (Map)



9.7 Summary - Household Plastic Arisings

Household plastic arisings were allocated across the UK according to number of households, therefore the areas with highest arisings correspond to those with the highest number of households. When organised into NUTS 2 areas, these are Surrey, East and West Sussex (112kt), Greater Manchester (109kt) and East Anglia (99kt).

Plastic in household residual waste was allocated across the UK in a different way, due to additional information being available around plastic packaging collections (See Section 9.2 for details). However, the three NUTS 2 areas of Surrey, East and West Sussex (88kt), Greater Manchester (89kt), and East Anglia (75kt) are also the areas with highest residual plastic arising.

When residual plastic waste subject to PFI/PPP contracts is removed, these three areas are those estimated to hold the highest plastic arisings; Surrey, East and West Sussex (63kt), Greater Manchester (63kt), and East Anglia (57kt).

Where household residual plastic is subject to PHI/PPP contracts the regions with the highest contracted arising's are Hampshire and the Isle of Wight (54kt), East Inner London (53kt) and Kent (50kt).

10.0 Commercial Plastics Arisings

10.1 Commercial Plastics Arisings (1,305kt)

Commercial plastic arisings were calculated by summing the identified commercial elements of key sectors, namely packaging (726kt), C&D (223kt), ELV (104kt), carpets (64kt), AWP (40kt), WEEE (4kt) and other/unidentified (144kt).

In order to allocate commercial plastic arisings across the UK, the tonnage classified as C&I plastic arisings (i.e. excluding C&D and AWP), were first allocated a 'substance oriented classification' or SOC, as per Defra's 2009 C&I waste survey 2010. This simply means that the plastic arising's were allocated to one of 12 sectors as shown below:

Figure 14 Commercial Plastic Arising, by SOC

SOC	% of Plastic Waste Arisings (as per Defra 2010 C&I Waste Survey)	% of Plastic Waste Arisings Applied to Total Tonnes of Commercial Plastic Waste Arisings
Food, drink & tobacco	6%	66kt
textiles/wood/paper/publishing	7%	69kt
Power and utilities	2%	16kt
Chemicals/ non-metallic minerals manu.	20%	214kt
metals manufacturing	1%	14kt
machinery & equipment (other manu)	8%	80kt
Retail & wholesale	32%	332kt
Hotels & catering	2%	26kt
Public administration & social work	3%	31kt
Education	2%	19kt
Transport & storage	13%	139kt
Other Services	3%	36kt
Total C&I	100%	**1042kt**
C&D		**223kt**
Agri		**40kt**
	TOTAL	**1305kt**

Organising the data in this way then enabled it to be allocated across the UK using estimates of GVA, which show economic activity by area. GVA is believed to be the best representation of industries' activity levels and provides better granularity of data than, for example, number of jobs, and therefore was selected as the most suitable proxy for plastic arising. 15 below illustrates the allocation of plastic arising for five sectors using this methodology, as mapping all 14 renders the text too small to be readable; please see Appendix IV for the full table.

Figure 15 Allocation of Commercial Plastic Arisings (tonnes), allocated by GVA

		Total Commercial Plastic Waste Arisings	Agriculture, forestry and fishing			Chemicals/Non-metallic Minerals Manufacturing			Construction			Education			Food, Drink & Tobacco		
Region	Sub Region name (NUTS 2)	(t)	GVA £ million	% GVA	Plastic (t)	GVA £ million	% GVA	Plastic (t)	GVA £ million	% GVA	Plastic (t)	GVA £ million	% GVA	Plastic (t)	GVA £ million	% GVA	Plastic (t)
East Midlands	Derbyshire and Nottinghamshire	44k	287	3%	1,073	1495	4%	8,868	2505	3%	6,137	3054	3%	600	1008	4%	2,472
	Leicestershire, Rutland and Northamptonshire	42k	276	3%	1,032	968	3%	5,742	2186	2%	5,356	2778	3%	546	1559	6%	3,823
	Lincolnshire	14k	498	5%	1,862	176	0%	1,044	799	1%	1,958	987	1%	194	753	3%	1,846
East of England	Bedfordshire and Hertfordshire	45k	162	2%	606	2003	6%	11,882	3493	4%	8,558	2496	3%	491	485	2%	1,189
	East Anglia	55k	1291	12%	4,827	1707	5%	10,126	3145	3%	7,705	4109	4%	808	1782	7%	4,369
	Essex	31k	285	3%	1,066	475	1%	2,818	3135	3%	7,681	2170	2%	427	283	1%	694
London	Inner London - East	40k	6	0%	22	157	0%	931	3642	4%	8,923	4900	5%	963	312	1%	765
	Inner London - West	44k	6	0%	22	114	0%	676	3155	3%	7,730	4690	5%	922	154	1%	378
	Outer London - East and North East	28k	13	0%	49	354	1%	2,100	3090	3%	7,570	2335	2%	459	505	2%	1,238
	Outer London - South	18k	12	0%	45	116	0%	688	2324	3%	5,694	1653	2%	325	48	0%	118
	Outer London - West and North West	46k	13	0%	49	465	1%	2,758	3504	4%	8,585	2707	3%	532	1300	5%	3,188
North East	Northumberland and Tyne and Wear	25k	215	2%	804	1050	3%	6,229	1470	2%	3,601	1849	2%	364	351	1%	861
	Tees Valley and Durham	22k	139	1%	520	1259	3%	7,468	1249	1%	3,060	1628	2%	320	269	1%	660
North West	Cheshire	37k	147	1%	550	3271	9%	19,404	1394	2%	3,415	1058	1%	208	318	1%	780
	Cumbria	13k	189	2%	707	424	1%	2,515	737	1%	1,806	585	1%	115	257	1%	630
	Greater Manchester	51k	53	0%	198	1354	4%	8,032	3370	4%	8,256	4094	4%	805	1038	4%	2,545
	Lancashire	29k	202	2%	755	918	3%	5,446	1953	2%	4,785	2196	2%	432	697	3%	1,709
	Merseyside	31k	41	0%	153	2077	6%	12,321	1475	2%	3,614	2097	2%	412	381	1%	934
Northern Ireland	Northern Ireland	35k	461	4%	1,724	1020	3%	6,051	1736	2%	4,253	2605	3%	512	1572	6%	3,855
Scotland	Eastern Scotland	39k	638	6%	2,385	944	3%	5,600	2790	3%	6,835	3532	4%	694	1051	4%	2,577
	Highlands and Islands	13k	320	3%	1,196	398	1%	2,361	843	1%	2,065	512	1%	101	730	3%	1,790
	North Eastern Scotland	13k	228	2%	852	119	0%	706	899	1%	2,203	761	1%	150	326	1%	799
	South Western Scotland	43k	351	3%	1,312	837	2%	4,965	3239	4%	7,935	3071	3%	604	1706	6%	4,183
South East	Berkshire, Buckinghamshire and Oxfordshire	63k	261	2%	976	1713	5%	10,162	3944	4%	9,663	5308	5%	1,044	877	3%	2,150
	Hampshire and Isle of Wight	37k	243	2%	909	732	2%	4,342	3074	3%	7,531	2891	3%	568	332	1%	814
	Kent	33k	407	4%	1,522	728	2%	4,319	3402	4%	8,335	2451	2%	482	227	1%	557
	Surrey, East and West Sussex	55k	325	3%	1,215	1497	4%	8,880	4581	5%	11,223	4185	4%	823	349	1%	856
South West	Cornwall and Isles of Scilly	9k	235	2%	879	116	0%	688	758	1%	1,857	548	1%	108	239	1%	586
	Devon	19k	337	3%	1,260	393	1%	2,331	1525	2%	3,736	1776	2%	349	265	1%	650
	Dorset and Somerset	22k	351	3%	1,312	361	1%	2,141	1751	2%	4,290	1557	2%	306	617	2%	1,513
	Gloucestershire, Wiltshire and Bristol/Bath area	49k	385	4%	1,439	1479	4%	8,773	3464	4%	8,487	3447	3%	678	952	4%	2,334
Wales	East Wales	21k	129	1%	482	621	2%	3,684	1222	1%	2,994	1759	2%	346	798	3%	1,957
	West Wales and The Valleys	29k	205	2%	766	1033	3%	6,128	1895	2%	4,643	2550	3%	501	508	2%	1,246
West Midlands	Herefordshire, Worcestershire and Warwickshire	27k	518	5%	1,937	591	2%	3,506	2002	2%	4,905	1547	2%	304	485	2%	1,189
	West Midlands	43k	47	0%	176	770	2%	4,568	3177	3%	7,784	4558	5%	896	442	2%	1,084
	Shropshire and Staffordshire	30k	360	3%	1,346	839	2%	4,977	1993	2%	4,883	1853	2%	364	846	3%	2,074
Yorkshire and The Humber	East Yorkshire and Northern Lincolnshire	25k	339	3%	1,267	1485	4%	8,809	1014	1%	2,484	1037	1%	204	664	2%	1,628
	North Yorkshire	18k	538	5%	2,011	281	1%	1,667	933	1%	2,286	1184	1%	233	853	3%	2,092
	South Yorkshire	21k	87	1%	325	517	1%	3,067	1604	2%	3,930	2332	2%	458	373	1%	915
	West Yorkshire	44k	134	1%	501	1137	3%	6,745	2559	3%	6,269	3651	4%	718	1080	4%	2,648
Grand Total		**1305k**	**11k**	**100%**	**40k**	**36k**	**100%**	**214k**	**91k**	**100%**	**223k**	**99k**	**100%**	**19k**	**27k**	**100%**	**66k**

10.2 Un-recycled Commercial Plastics Arisings (899kt)

'Un-recycled' commercial plastic arisings represent the commercial plastic arising that isn't assumed to be recycled currently (2013). This was calculated by applying an 'un-recycled' rate of 69% across the country; the 69% was derived by calculating a recycling rate for commercial plastic (31%). This recycling rate was derived by dividing the tonnage of commercial plastic recycled/exported by the total tonnage of commercial plastic arisings (406kt of 1,305kt represents 31%).

The results of applying a 69% 'un-recycled' rate for commercial plastic across the UK are shown in Figure 16 below, along with total commercial plastic arisings.

Figure 16 Commercial Plastic Arisings & Un-recycled Plastic Arising by Region

		Total Commercial Plastic Waste Arisings	Commercial Plastic Waste Arisings Unrecycled @ 69% (t)
Region	**Sub Region name (NUTS 2)**	**(t)**	
East Midlands	Derbyshire and Nottinghamshire	44k	30k
	Leicestershire, Rutland and Northamptonshire	42k	29k
	Lincolnshire	14k	10k
East of England	Bedfordshire and Hertfordshire	45k	31k
	East Anglia	55k	38k
	Essex	31k	21k
London	Inner London - East	40k	27k
	Inner London - West	44k	30k
	Outer London - East and North East	28k	20k
	Outer London - South	18k	13k
	Outer London - West and North West	46k	32k
North East	Northumberland and Tyne and Wear	25k	18k
	Tees Valley and Durham	22k	15k
North West	Cheshire	37k	25k
	Cumbria	13k	9k
	Greater Manchester	51k	35k
	Lancashire	29k	20k
	Merseyside	31k	21k
Northern Ireland	Northern Ireland	35k	24k
Scotland	Eastern Scotland	39k	27k
	Highlands and Islands	13k	9k
	North Eastern Scotland	13k	9k
	South Western Scotland	43k	29k
South East	Berkshire, Buckinghamshire and Oxfordshire	63k	44k
	Hampshire and Isle of Wight	37k	26k
	Kent	33k	23k
	Surrey, East and West Sussex	55k	38k
South West	Cornwall and Isles of Scilly	9k	6k
	Devon	19k	13k
	Dorset and Somerset	22k	15k
	Gloucestershire, Wiltshire and Bristol/Bath area	49k	34k
Wales	East Wales	21k	15k
	West Wales and The Valleys	29k	20k
West Midlands	Herefordshire, Worcestershire and Warwickshire	27k	19k
	West Midlands	43k	30k
	Shropshire and Staffordshire	30k	21k
Yorkshire and The Humber	East Yorkshire and Northern Lincolnshire	25k	17k
	North Yorkshire	18k	12k
	South Yorkshire	21k	14k
	West Yorkshire	44k	30k
Grand Total		**1305k**	**899k**

10.3 Commercial Plastic Arising Maps

The commercial plastic arising's data have been mapped to better illustrate where in the country the highest commercial plastic arisings are:

Figure 17 Commercial Plastic Arisings (Map)

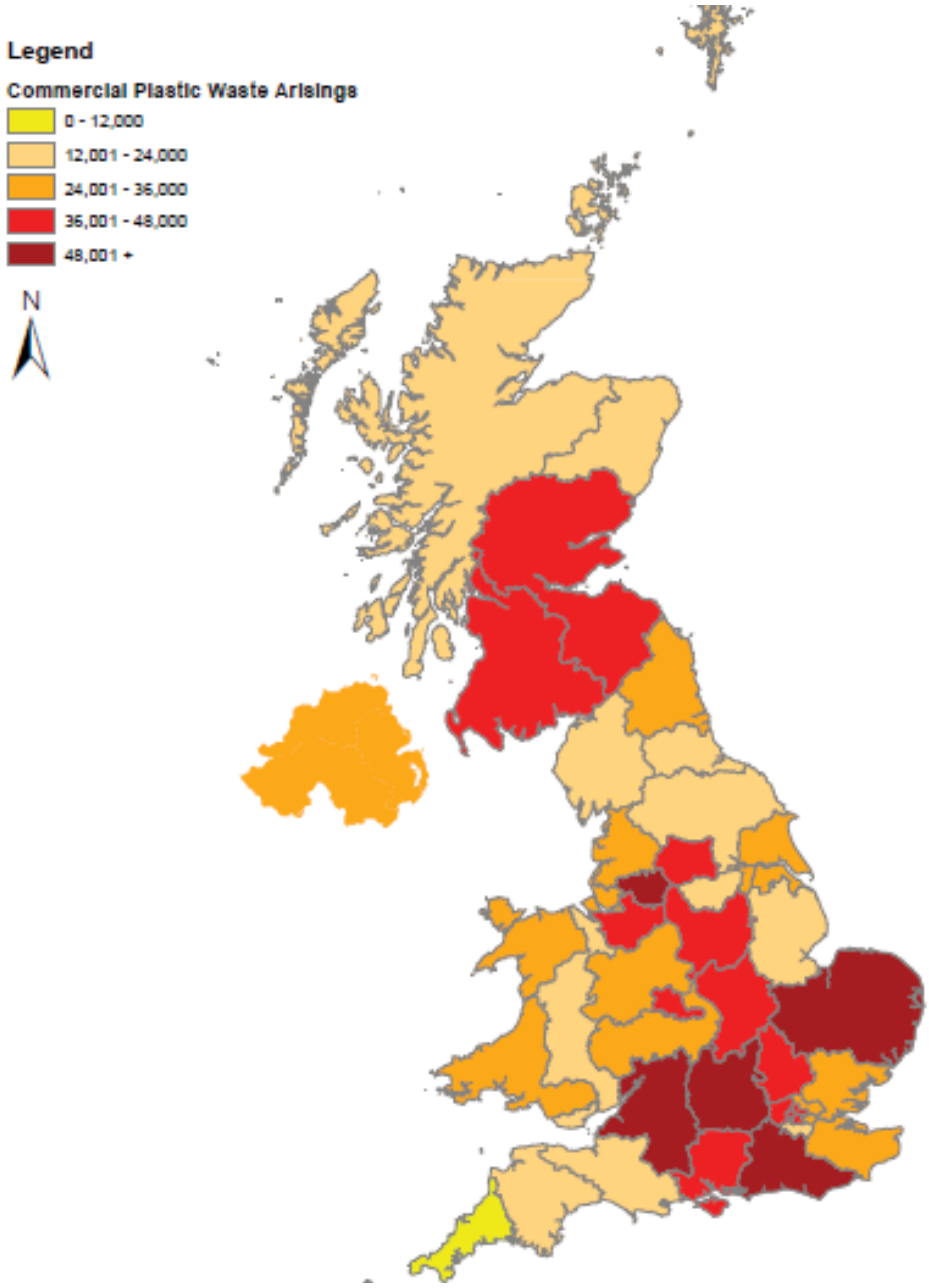


Figure 17 above shows that the highest commercial plastic arisings are to be found in the sub-regions of Berkshire, Buckinghamshire and Oxfordshire (63kt), East Anglia (55kt) and Greater Manchester (51kt). Note that due to the scale of the map individual sub-regions within London do not appear prominently on the map.

As the 'un-recycled' commercial plastic figure was applied across all the sub-regions, the highest un-recycled commercial plastic arisings are also to be found in the sub-regions of Berkshire, Buckinghamshire and Oxfordshire (44kt), East Anglia (38kt) and Greater Manchester (35kt).

10.4 Summary – Commercial Plastic Arisings

Commercial plastic arisings were allocated across the UK according to recorded GVA , therefore the areas with highest arisings correspond to those with the highest GVA. When organised into NUTS 2 areas, these are Berkshire, Buckinghamshire and Oxfordshire (63kt), East Anglia (55kt) and Greater Manchester (51kt). These areas also represent the highest 'unrecyled' tonnage, as a flat rate of 69% 'un-recycled' was applied across the country.

11.0 Total Plastics Arising (3.3Mt)

Total plastic waste arising was calculated by summing the identified household and commercial elements of key sectors, as described in Section 6.1 above. Likewise total plastic un-recycled and not subject to a PFI/PPP contract was calculated by summing the household and commercial data. The results are presented below as both a data table (Figure 18) and maps (Figure 19 and Figure 20).

Figure 18 Total Plastic Arising & Total Plastic in Residual Waste not Subject to a PFI/PPP Contract (Data Table)

Region	Sub region (NUTS 2)	TOTAL Plastic Waste Arisings	TOTAL Plastic Unrecycled and not subject to PFI/PPP Contract
East of England	Bedfordshire and Hertfordshire	104k	71k
South East	Berkshire, Buckinghamshire and Oxfordshire	132k	82k
North West	Cheshire	56k	33k
South West	Cornwall and Isles of Scilly	21k	16k
North West	Cumbria	36k	16k
East Midlands	Derbyshire and Nottinghamshire	124k	85k
South West	Devon	61k	46k
South West	Dorset and Somerset	62k	44k
East of England	East Anglia	153k	94k
Wales	East Wales	36k	21k
Yorkshire and The Humber	East Yorkshire and Northern Lincolnshire	45k	26k
Scotland	Eastern Scotland	87k	61k
East of England	Essex	98k	70k
South West	Gloucestershire, Wiltshire and Bristol/Bath area	112k	62k
North West	Greater Manchester	160k	98k
South East	Hampshire and Isle of Wight	105k	27k
West Midlands	Herefordshire, Worcestershire and Warwickshire	80k	57k
Scotland	Highlands and Islands	24k	18k
London	Inner London - East	119k	39k
London	Inner London - West	92k	34k
South East	Kent	99k	23k
North West	Lancashire	88k	38k
East Midlands	Leicestershire, Rutland and Northamptonshire	105k	54k
East Midlands	Lincolnshire	45k	18k
North West	Merseyside	96k	77k
Scotland	North Eastern Scotland	24k	19k
Yorkshire and The Humber	North Yorkshire	48k	35k
Northern Ireland	Northern Ireland	74k	49k
North East	Northumberland and Tyne and Wear	64k	25k
London	Outer London - East and North East	82k	27k
London	Outer London - South	42k	23k
London	Outer London - West and North West	113k	84k
West Midlands	Shropshire and Staffordshire	82k	46k
Scotland	South Western Scotland	98k	68k
Yorkshire and The Humber	South Yorkshire	50k	27k
South East	Surrey, East and West Sussex	167k	101k
North East	Tees Valley and Durham	42k	26k
West Midlands	West Midlands	99k	32k
Wales	West Wales	84k	41k
Yorkshire and The Humber	West Yorkshire	91k	60k
Grand Total		3299k	1872k

Figure 19 Total Plastic Arising (Map)

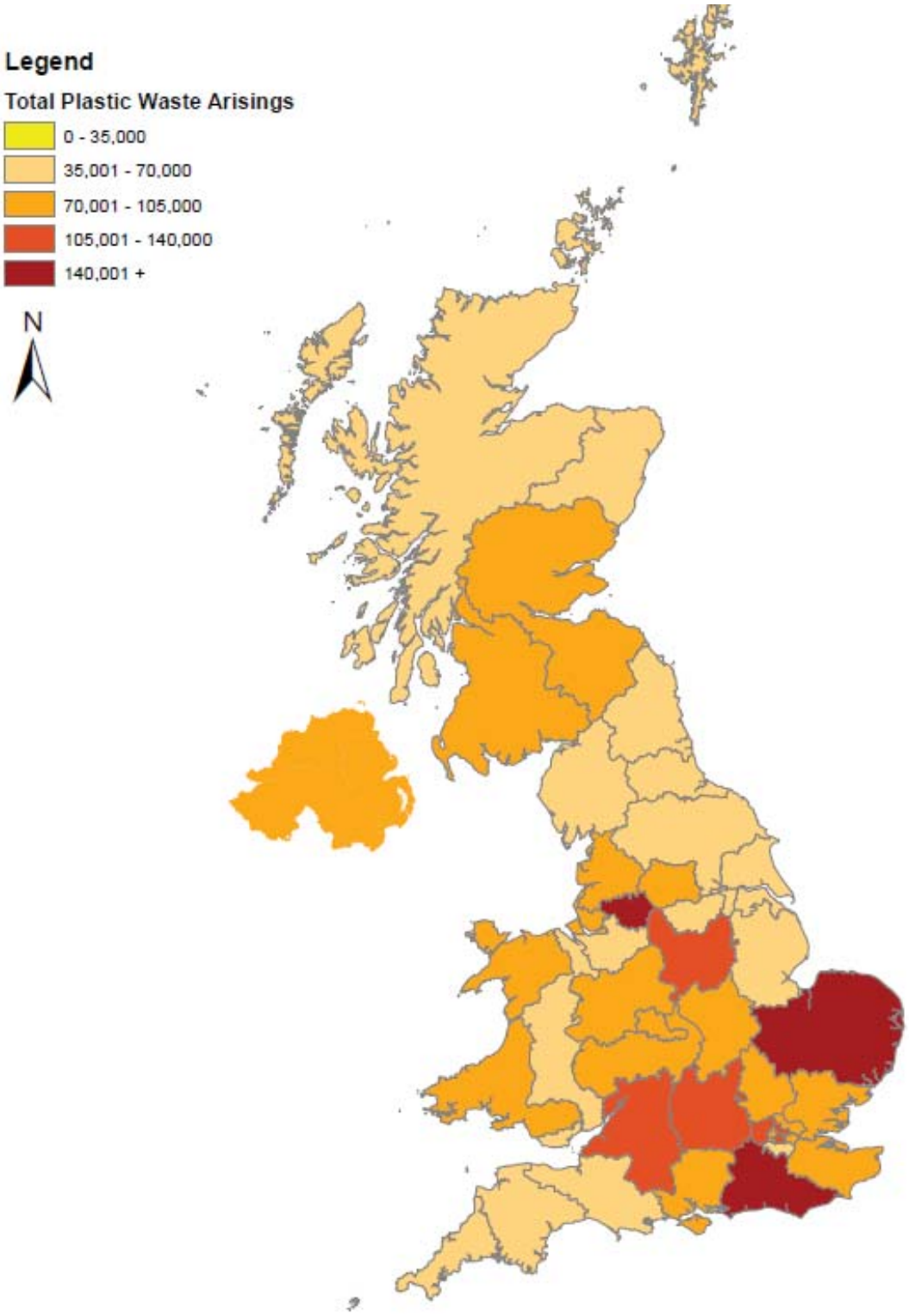


Figure 19 shows that the highest total plastic arisings are to be found in the sub-regions of Surrey, East and West Sussex (167kt), Greater Manchester (160kt) and East Anglia (153kt).

Figure 20 Total Plastic Un-recycled and not Subject to a PFI/PPP Contract (Map)

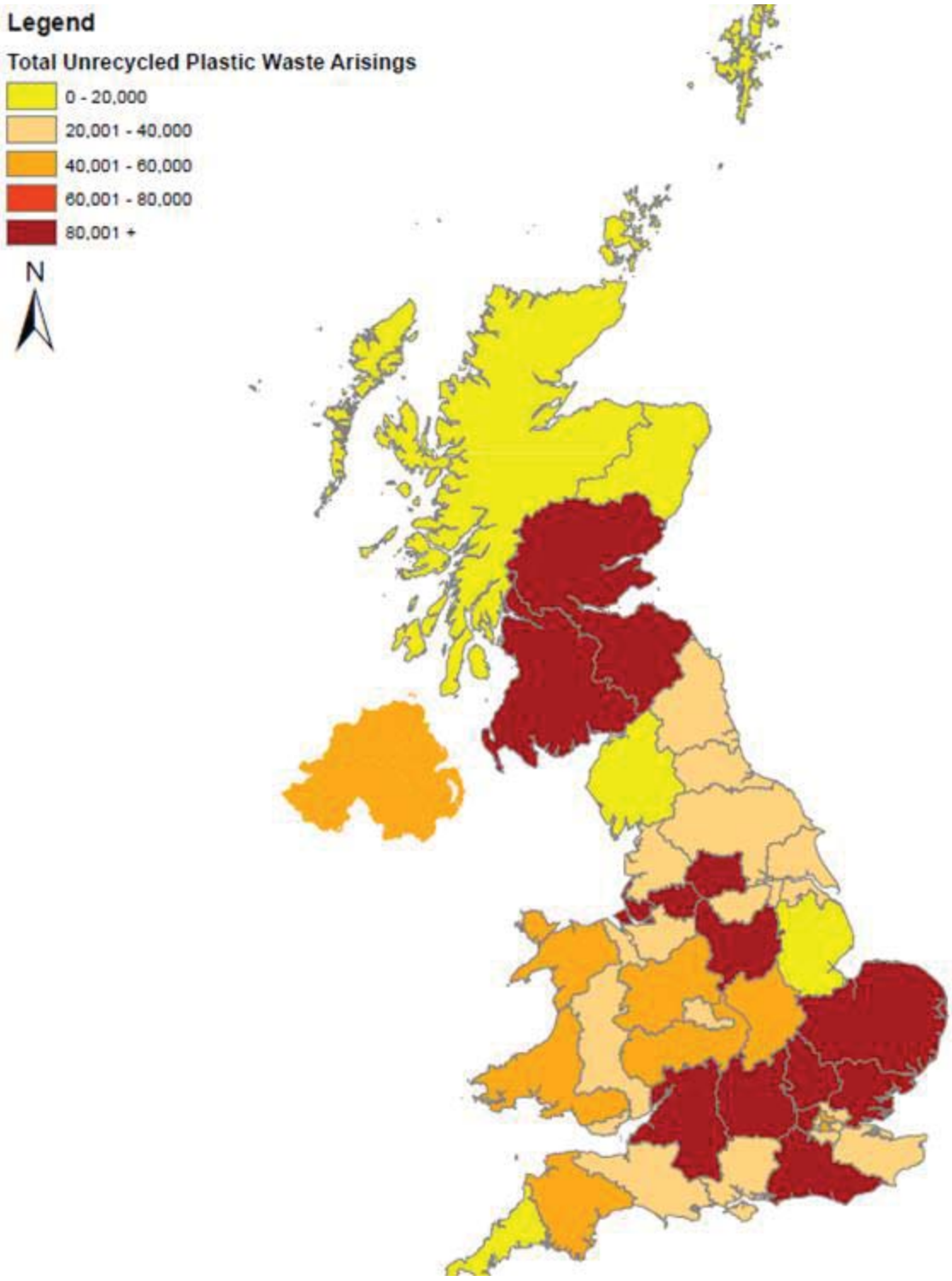


Figure 20 above show that the highest total plastic arisings not currently sent to recycling or subject to a PFI/PPP contract are to be found in the sub-regions of Surrey, East and West Sussex (94kt), East Anglia (87kt) and Derbyshire and Nottinghamshire (84kt).

11.1 Summary - Total Plastic Arising

Household plastics dominate the plastics data, therefore once the household and commercial data are combined, the areas of the UK with highest plastic arisings are Surrey, East and West Sussex (167kt), Greater Manchester (160kt) and East Anglia (153kt).

12.0 The Outlook for Plastic Arisings and Availability and Cost of Extraction

Central to any investment case for the use of any recovered plastic is not just the current availability of plastic (by polymer, geographical location and contractual availability), but how this could evolve over the lifetime of an investment period.

Before considering what future arisings of plastic could look like, it's worth first discussing the main macro factors that affect current plastic arisings. As the main section of this report shows, arisings of plastic are split roughly 60/40 between the household and commercial streams.

There are several socio-economic variables which may influence household waste arisings including household consumption, population, number of households, the number of persons per household, number of people on low income and share of population living in rural areas.

In terms of factors that affect commercial waste arisings the most important one is output growth in particular industry sectors. Efficiency savings have and are likely to continue to be introduced by businesses across supply chains, meaning that the commercial sector is likely to continue to produce more with less (although it is unclear what level of additional marginal returns to resource efficiency are available).

Econometric modelling carried out by Defra in 2015 projects that overall UK local authority collected waste (LACW) will grow by almost 29% by 2030, when measured against a 2012 baseline. This projection is based on an autoregressive distributed lag (ARDL) model since, apart from considering waste arising's from previous periods, it accounts for changes in household expenditures and the ratio between waste and economic activity in the commercial sector. There is considerable uncertainty over future arisings of LACW in particular. Defra's low case is growth of 12% vs 2012 and the high case is 37% growth. Meanwhile, Defra project that municipal commercial waste could also grow by 29% based on forecast economic growth in the commercial sector.[34]

Defra modelling suggests that plastic arisings (packaging and non-packaging) could rise from 3.3Mt in 2013 to around 4.3Mt, assuming the current composition of the waste stream. However, the composition and indeed the breakdown of polymer usage and applications in the period to 2030 are likely to change. The following section details some of the factors that could have an influence.

12.1 Macro Factors

The outlook for virgin plastic prices could have an influence on the importance designers place on light-weighting of plastic packaging and other plastic products. Anecdotal evidence suggests that the strong rise in oil prices (reflected in higher virgin plastic prices) since the early 2000's, and through to when oil prices fell sharply in mid-2014,

[34] *Un-published research from Defra*

was one of the main contributing factors affecting the use of plastic in packaging and product design.

Since mid-2014 the impact on virgin plastic prices has been mixed with HDPE and LDPE prices remaining strong while PET has seen sharp declines. However, if oil prices remain low on an extended basis then this could feed into lower virgin plastic prices. Low plastic prices may then act as a disincentive against further investment in light-weighting technology, while at the same time encouraging greater use of plastic (perhaps instead of other materials).

12.2 Micro Factors

12.2.1 Circular Economy proposals

The future policy direction of the European Union could be one of the main drivers of plastic availability. Although currently still at an early stage, proposed EU circular economy directives point to a gradual limitation of landfilling of municipal waste to 10% by 2030. In 2013, an estimated 612kt of household plastic arising was diverted to landfill.

If we make the assumption that plastics are diverted from landfill in proportion to this directive then this could mean that an additional 550kt of plastic arising from the household may become available to be used in alternative end markets, whether that is mechanical recycling, ATT/ACT applications or other.[35]

Additional household plastics diverted from landfill and collected by LAs are likely to be lower quality plastic, perhaps without an existing established end market, or currently of insufficient volume to recycle sustainably.

12.2.2 Packaging

Should simple weight based recycling targets continue to be used then it is possible that certain pack designs may indeed change to simpler formats that are relatively easy to recycle and can easily contain increased recycled content (formats with these characteristics may indeed be heavier). Those already struggling to absorb 'recycled plastic' into products, due either to technical complexity or to regulatory hurdles, may still opt for ever increasing light weighting as a means of mitigating compliance costs in the above scenario.

Should, however, measurement of wider eco credentials, such as full product/pack life cycle carbon saving analysis, be used to assess Extended Producer Responsibility (EPR), then packaging design behaviours become more difficult to project. Extension of shelf life and reduction of product wastage (particularly around the life extension of food and to cope with the likely growth in home delivery options) are likely to be retailers/brands main priorities.

[35] *Assumes that the split of waste plastics ending up in landfill is in proportion to the household/ commercial plastic arising's split and that waste plastic arising's remain unchanged.*

It isn't just the weight of plastic used in packaging that could change over the next 15 years; the mix of polymers used in packaging could also evolve considerably. The polymers characteristics' (environmental impact, how recyclable it is etc.) as well as relative price differences are important factors. Packaging design technology has evolved considerably over the past 15 years and further technological developments are likely, but by definition unpredictable.

WRAP analysis undertaken as part of the Plastics Flow report found that overall plastic packaging arisings were broadly stable between 2006 and 2013. The report suggested that any increase in plastic packaging consumption (on a unit basis) had been negated by packaging light-weighting activity. The reports base case assessment of future plastic packaging flows is that they are likely to remain broadly stable until 2020 (the timescale considered as part of the report).[36]

12.2.3 Non-Packaging Applications

For WEEE/ELV growth in the small WEEE stream relative to the large WEEE stream is likely to be the main determinant of future plastics arising from this sector, and to a large degree that will be determined by future technological innovations and household preferences. The plastics fraction of waste electrical and electronic equipment (WEEE) is estimated to be 12%-16% for large WEEE (such as washing machines, fridges and televisions) and around 30% for small WEEE.[37] The proportion of small WEEE in household WEEE collections has risen sharply from 16kt (16% of overall household WEEE collected) in 2008 to 31kt (25%) in 2014. Meanwhile, large WEEE collected has remained broadly stable at around 90kt.[38]

Time series data on plastics arising from carpets and the C&D sector is sparse and so reasoned expectations of future plastic waste arising's based on evidence is not possible. Demand for new carpets is likely to be closely linked to housing market activity - both new house construction and families moving house. More broadly, household confidence is one of the main determining factors.

Agricultural plastics include soil fumigation film, irrigation drip tape/tubing, nursery pots and silage bags, but the term is most often used to describe all kinds of plastic plant/soil coverings. Such coverings range from plastic mulch film, row coverings, high and low tunnels (polytunnels), to plastic greenhouses.

Polyethylene (PE) is the plastic film used by the majority of growers because of its affordability, flexibility and easy manufacturing. These can be modified by addition of certain elements to the plastic that give it properties beneficial to plant growth such as reduced water loss, UV stabilization to cool soil and prevent insects etc. Polymer substitution is happening in agricultural markets, for example polystyrene is often used for horticultural seed trays, but this is slowly being replaced by polyethylene terephthalate (PET).

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[36] *Plastic Flow, WRAP (2014) http://www.wrap.org.uk/content/plastic-packaging-market-study-plastic-flow-2014-0*

[37] *Plastics Market Situation Report, WRAP (2016) http://www.wrap.org.uk/sites/files/wrap/Plastics_Market_Situation_Report.pdf*

[38] *EA*

Given the specific nature of the plastic demand from agriculture it appears unlikely that there will be a significant change in overall UK plastics arising from this sector, although as noted the composition of this could change.

12.3 Recovered Plastic Availability

Overall plastic arisings, while important, do not necessarily determine what amount of plastic is potentially available to be accessed. If LAs, in the case of household plastic, or waste management companies, in the case of commercial plastic, collect plastics along with other recyclate then they are potentially currently available to an end user. For LAs to be willing to expand household collections of plastic (or undertake campaigns to encourage greater participation in collections), LAs have to be confident that there are strong economically sustainable end markets for as many fractions of the plastic as possible, that collected materials will be of sufficient quality to sell and that the volumes collected will generate enough income to cover the cost of collection.

A move towards a more consistent household collection system could result in a higher amount of plastics recovered for end markets, and importantly, of a higher quality. This could reduce costs across the supply chain as contamination levels are likely to be significantly lower.

WRAP's Plastic Market Situation Report (published in early 2016) provides a detailed analysis of current end markets for recovered plastic, both in the UK and overseas.[39]

12.4 Costs

The third barrier is obtaining commercially viable quantities. This report identifies a number of unexploited areas where plastic arises; including carpets, WEEE, C&D, ELV, toys and agriculture. This section details the current economics of accessing and extracting plastics from these streams, for those sectors where information is available.

12.4.1 Agricultural Film

Due to the high level of contamination in agricultural plastics there is typically a significant yield loss, in the order of 70%. Historically, because of the high contamination level the material has been charged at a gate fee. However, more recently the high cost of virgin LDPE polymer has meant that some exporters are willing to pay up to £60 per tonne for LDPE film sourced from the sector, even accounting for the high cost of cleaning. It is thought that much of the AWP that is exported goes to Eastern Europe for manual cleaning before returning to the UK for reprocessing.

12.4.2 ELV

The recovery of plastics from ELV is primarily a derived activity based on the cost/benefit of extracting and selling metals (predominantly steel) recovered from a car or other vehicle. Here the value of steel in particular affects the economics of ELV recovery and plastics as a by-product, as no costs for extracting polymers from ELV were identified. The sharp fall in the price of steel scrap over the past few years is likely to have negatively affected the economics of these operations. The main source of recoverable

[39] *Plastics Market Situation Report, WRAP (2016) http://www.wrap.org.uk/sites/files/wrap/Plastics_Market_Situation_Report.pdf*

plastics from ELV is from damaged bumpers. These are largely made of PP, bales of which currently fetch around £230 per tonne in the UK.

One of the challenges in recovering and then recycling plastics from ELV (and WEEE) is the wide range of plastics (including ABS, PE and polyesters) as well as other materials within each product, often used together as part of a composite. Note that rising ELV recovery targets has increased the incentive to send shredder residue for ACT/ATT to extract the plastics.

12.4.3 Carpets

As discussed in section 7.2 the feasibility of identifying/separating PP from carpet waste was not researched as part of this project, but is an important element of further research that should be undertaken if this PP fraction is to be accessed in commercial quantities.

12.4.4 Residual

The plastic recovered from the residual is likely to be a mixed polymer stream. This stream will require some pre-processing, for example converting it into a Solid Recovered Fuel (SRF) type material which could then be used in an ACT/ATT facility. The exact specification is likely to depend on the technology used. For more information on the types of ACT/ATT technology see Appendix III.

An estimated 815kt of plastic was sent to landfill in 2013. Assuming a landfill cost of £100 per tonne (including both landfill tax and gate fee) then the potential savings from diverting material from landfill could amount to almost £82 million.

Diverting plastic from residual disposal routes such as incineration helps to reduce costs for EfW facilities. Due to the high calorific value of plastics operators of EfW facilities prefer if the waste plastic component is low to allow them to maximise throughput in their facility.

12.5 Plastic prices

Recovered plastic prices depend upon their demand, i.e. what applications are they used in, what size is the market, is it growing or contracting, are recovered plastics competing with virgin polymer prices? Prices are also determined by their supply, i.e. are they available to a high and consistent quality?

The plastics collected by LAs and commercial organisations typically have established end markets and so their price reflects this (see table below). As the previous section shows there are costs to extracting plastics from certain streams (for example agriculture) and/or converting plastics recovered from the residual stream into a feedstock that can be used. Nevertheless, being able to access waste plastics currently going to residual disposal routes is likely to increase their value. ACT/ATT plants may offer the market a recovery route for a significant amount of plastic that are currently going to residual, putting a higher value on plastics that LA's are currently sending for residual disposal.

Figure 21 Indicative recovered plastic prices, £ per tonne (Q1 2016)

Clear PET	95
Natural HDPE	300
LDPE 98:2	255
PP	230
PS	125

Sources: WRAP Materials Pricing Reports, WRAP sources

Price trends for many recovered plastics can be found on WRAPs Market Knowledge Portal with detailed historical data obtained by subscribing to WRAPs Materials Pricing Report.

12.6 Summary

Overall household plastic arising's may grow during the period to 2030 as UK household numbers increase and consumption of plastic increases. At the same time plastic arising's from the commercial sector are also likely to grow as demand for construction, agriculture, electrical and automotive products rises. However, not all sectors and / or applications are likely to grow at the same rate. For example, previous WRAP research into plastic packaging points to arising's being broadly stable over the short to medium term as growth in unit consumption of packaging is negated by light-weighting.

The future policy direction (in particular the European Circular Economy proposals), the outlook for commodity prices and the relative competitiveness of plastic versus other materials, how end markets for recovered plastic evolve (e.g. future technological and improvements making 'hard to recycle' plastics more recyclable) and the decisions made by LAs in respect of the diversion of plastic from residual disposal routes will all affect the amount of recovered plastic that is potentially available to be used by any particular end market.

The costs of accessing plastics that are not currently recycled depends on their source. For example plastics that have been used in agricultural applications are likely to be contaminated and may require expensive cleaning. Meanwhile, depending on the technology being considered, mixed plastics recovered from the residual will require some level of pre-processing in order for them to be used as a feedstock.

Conclusions

13.0 Conclusions and Key Findings of Plastic Spatial Flow

An estimated 2.3Mt of plastic was not recycled in 2013. Just over 1Mt of plastic (of the right polymers and not under a PFI/PPP contract) is potentially available for ACT/ATT. There is around 270kt of additional plastics, which are suitable for ACT/ATT and that is currently subject to a PFI/PPP contract, but which could potentially be negotiated access to.

Overall household plastic arising's may grow during the period to 2030 as UK household numbers increase and consumption of plastic increases. Meanwhile, plastic arising's from the commercial sector are also likely to grow as demand for construction, agriculture, electrical and automotive products rises. Set against this product design, commodity prices and legislation amongst other factors may lead to lower amounts of plastic being used per product unit. For example arising's of plastic packaging have been broadly stable as the growth in unit consumption has been negated by light-weighting and this trend could continue.

At present there are a limited number of end markets for 'more difficult to recycle' waste plastics such as from AWP, ELV etc. Alternatives to mechanical recycling, such as ACT/ATT may give confidence to LAs that alternative end markets could develop that are capable of taking plastics that are currently going to the residual, whether they are contracted or not. In all circumstances where plastics are not currently targeted or segregated from residual waste the current 'owners' of that material (public or private sector) would need to be clear about the business case for doing so.

Appendix I Data Uncertainty

14.0 Data Robustness

Where possible the secondary data used in this report has been assessed for robustness and completeness, to provide the reader with a sense of 'reliability' of the data. They were also assessed for 'degree of agreement around the findings' to show were more than one source supports the data used. It should be noted that a low score here does not mean disagreement in the data, just that there is little additional supporting evidence. The following table is a template of how robustness was assessed:

Figure 22 Data Robustness Template

Data
Source

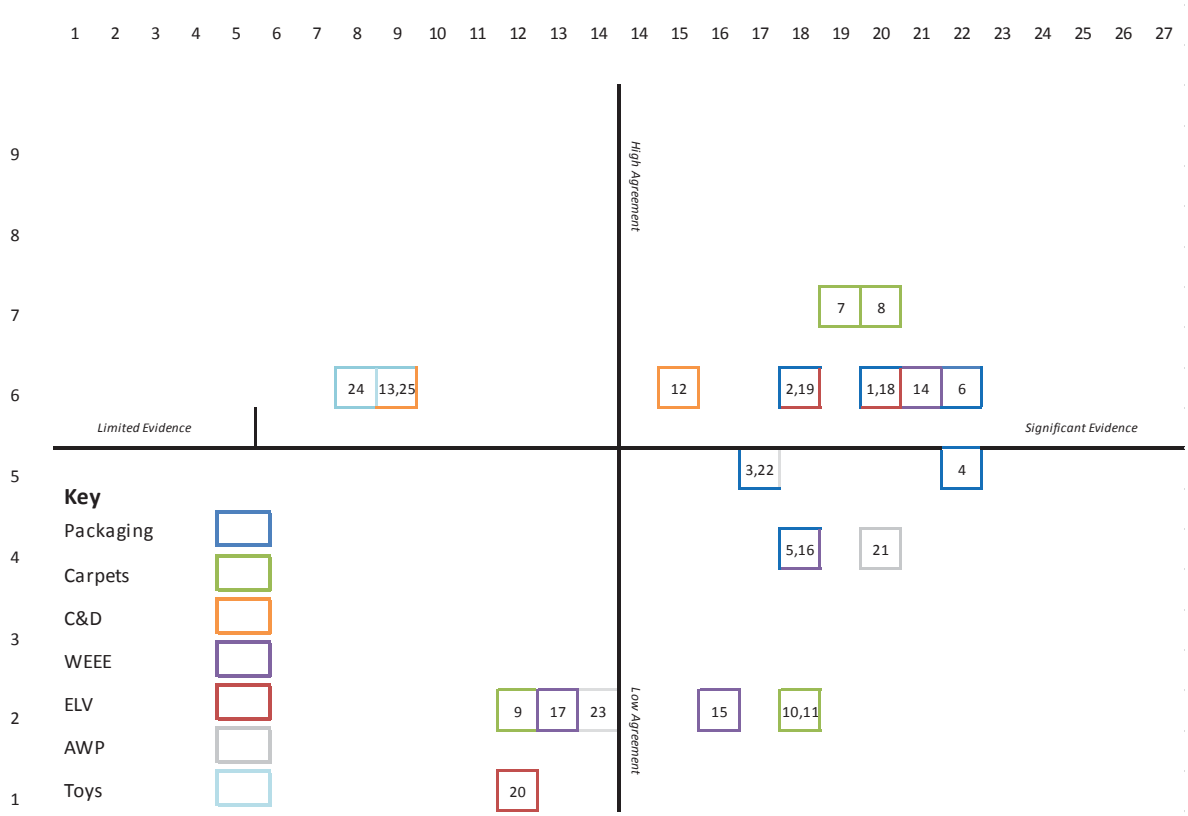
Evidence (Robustness and Completeness):	Scoring (Max 27)	
Does the data cover the correct time-frame?		
Does the data provide complete coverage?		
Has the data been sourced from credible, up-to-date sources?		
Is the underlying data reasonably free from concerns (e.g. official data from the ONS)?		
Have the findings been independently peer-reviewed?		
Is the methodology/calculation reasonably free from concerns?		
Have the methodology/calculations been independently checked (internally or externally)?		
Is the quantitative evidence well rooted in a wider qualitative understanding of the issue?		
Have the findings been sense-checked against credible alternative sources (incl. inconclusively)?		
Total		**0**

Degree of agreement around the findings :	Scoring (Max 09)	
Does more than one data source confirm the findings (within +/- 5%)?		
Do the key stakeholders/experts actively agree with the findings?		
Has feedback from the key stakeholders been incorporated in the reporting of findings?		
Total		**0**

Scoring	*Score*
Yes	*3*
Yes with some reservations	*2*
More yes than no, but equivocal	*1*
No	*0*

A summary of the scores for each piece of secondary data assessed is given in Figure 23

Figure 23 Summary of Data Robustness



	Data & Source	Evidence (Robustness and completeness, max 27):	Degree of agreement around the findings (max 9):
1	Consumer Waste Packaging Plastic Arisings (1,534kt):	20	6
2	Non-consumer Waste Packaging Plastic Arisings (726kt):	18	6
3	Polymer Split of Waste Packaging Plastic Arisings	17	5
4	Waste Packaging Plastic Recycled (284kt) and Exported:	22	5
5	Polymer Split of Waste Packaging Plastic Recycled & Exported (726kt):	18	4
6	Consumer Waste Packaging Plastic Collected	22	6
7	Total Carpet Waste Arisings of 400,000	19	7
8	Plastic % in Carpets	20	7
9	Consumer and Non-consumer Split of Waste Plastic Arisings from Carp	12	2
10	Total Carpet Collected 2013 107kt	18	2
11	Waste Plastic Arisings from Carpet Recyled/Re-used or sent to EfW	18	2
12	Plastics Waste in C&D	15	6
13	Polymer split C&D Plastics	9	6
14	EEE on the Market and WEEE Collected for Recycling	21	6
15	Proportion of plastic in WEEE (21%)	17	2
16	Polymer Split of Plastic in EEE/WEEE	18	4
17	Plastics Recyling in WEEE & ELV	13	2
18	Total ELV Waste Arisings of 1,116kt	20	6
19	Plastic % in ELV	18	6
20	Polymer split in ELV	12	1
21	AWP Arisings (2006 POM used as proxy)	20	4
22	Polymer split in AWP	17	5
23	AWP Recyled (26% LDPE/LLDPE Films) & Recyled/Exported (90%/10%)	14	2
24	Total Waste Plastic Arising from Toys (31kt)	8	6
25	Polymer Split of Waste Plastic Arisings from Toys	9	6

15.0 Error Margins

In order to provide an indication of the level of certainty/uncertainty pertaining to tonnage data, error margins were assumed for waste arisings, by sector, and accumulated error margins were calculated for Total Arisings, Total Collected Plastics and Total Residual Waste Plastics.

No secondary data sources used provided any error margins for their data, therefore error margins were applied by the project team. Where data was published by an official source (e.g. Defra, Eurostat, ONS) or the data was believed to be from a reliable source, an error margin of 5% was applied. Where data was used that was less robust or was being used as a proxy, then 10% was applied.

In order to calculate accumulated error margins for Total Arisings, Total Collected Plastics and Total Residual Waste Plastics, which each represented the sum of sector data, the following method[40] was used:

$$\delta Q = \sqrt{(\delta a)^2 + (\delta b)^2 + \cdots + (\delta c)^2 + (\delta x)^2 + (\delta y)^2 + \cdots + (\delta z)^2}.$$

[40] *http://ipl.physics.harvard.edu/wp-uploads/2013/03/PS3_Error_Propagation_sp13.pdf*

Appendix II Key Sector Flows

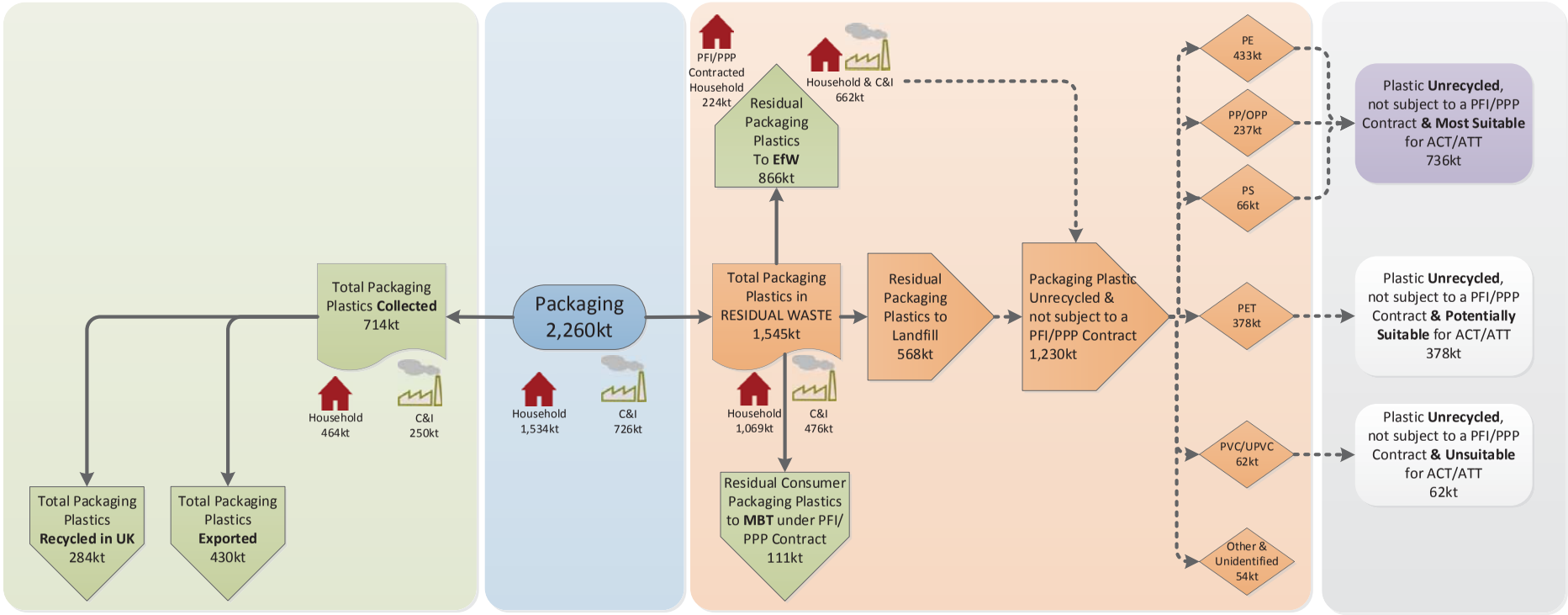
16.0 Packaging Plastics

Packaging is by far the largest component of plastic throughout its flow, even in residual waste after plastic packaging has been diverted for recycling. A summary of the packaging plastic flow is given below.

Due to the Waste Packaging Regulations and the requirement for those handling packaging to report certain data, and the suite of projects undertaken by WRAP and Valpak into plastic packaging, this is the sector where most available data exists and the robustness of data is considered higher.

The data sources, assumptions and any methodologies used to calculate the data presented in the flow of Packaging is shown below.

Figure 24 Packaging Plastics Flow, 2013[41]



[41] *See Appendix 1 for discussion of uncertainty*

16.1 Packaging Plastic Arisings

Total Packaging Plastic Arisings (2,260kt):
- Sum of household and commercial packaging plastic arisings
- Average Robustness Score - Evidence (See Appendix I): 70%
- Robustness Score - Degree of Agreement (See Appendix I): 67%
- Accumulated Error Margin: +/-7%

Household Packaging Plastic Arisings (1,534kt):
- WRAP/Valpak, Plastic Packaging Market Study (Plastic Flow), 2014
- www.wrap.org.uk/content/plastic-packaging-market-study-plastic-flow-2014-0
- Robustness Score - Evidence (See Appendix I): 74%
- Robustness Score - Degree of Agreement (See Appendix I): 67%
- Error Margin Applied: +/-5%

Commercial Packaging Plastic Arisings (726kt):
- WRAP/Valpak, Plastic Packaging Market Study (Plastic Flow), 2014
- www.wrap.org.uk/content/plastic-packaging-market-study-plastic-flow-2014-0
- Robustness Score - Evidence (See Appendix I): 67%
- Robustness Score - Degree of Agreement (See Appendix I): 67%
- Error Margin Applied: +/-5%

Polymer Split of Packaging Plastic Arisings:
- WRAP/Valpak, Plastic Packaging Composition 2011
- www.wrap.org.uk/sites/files/wrap/Plastics%20Composition%202011%20Report.pdf
- Robustness Score - Evidence (See Appendix I): 63%
- Robustness Score - Degree of Agreement (See Appendix I): 56%

16.2 Packaging Plastic Collected

Total Packaging Plastic Collected (714kt):
- Sum of packaging plastic recycled and exported
- Average Robustness Score - Evidence: 81%
- Robustness Score - Degree of Agreement: 56%
- See Appendix I for Details of Data Robustness Scoring

Packaging Plastic Recycled in the UK (284kt):
- NPWD 2013
- https://npwd.environment-agency.gov.uk/Public/PublicSummaryData.aspx
- Robustness Score - Evidence: 81%
- Robustness Score - Degree of Agreement: 56%
- See Appendix I for Details of Data Robustness Scoring
- Error Margin Applied: 5%

Packaging Plastic Exported (430kt):
- NPWD 2013
- https://npwd.environment-agency.gov.uk/Public/PublicSummaryData.aspx
- Robustness Score - Evidence: 81%

- Robustness Score - Degree of Agreement: 56%
- See Appendix I for Details of Data Robustness Scoring
- Error Margin Applied: 5%

Polymer Split of Packaging Plastic Recycled & Exported (714kt):
- WRAP/Valpak, End Markets Assessment, 2015 (not yet published)
- Robustness Score - Evidence: 67%
- Robustness Score - Degree of Agreement: 44%
- See Appendix I for Details of Data Robustness Scoring

This report estimates UK packaging plastic reprocessed by polymer; due to a lack of further information this polymer split was also applied to plastics exported. The robustness of the polymer split for exported packaging plastic would therefore be lower.

Household Packaging Plastic Collected (464kt)
- RECOUP UK Household Plastics Collection Survey 2014[42]
- www.recoup.org/news/7263/recoup-2014-uk-household-plastics-collection-survey-now-available
- Robustness Score - Evidence: 81%
- Robustness Score - Degree of Agreement: 67%
- See Appendix I for Details of Data Robustness Scoring

Commercial Packaging Plastic Collected (250kt)
This was calculated through subtracting the Household element from the Total Packaging Plastic Collected.

16.3 Packaging Plastic in Residual Waste

Total Plastic in Residual Plastic Waste (1,545kt):
- Estimated by subtracting Total Packaging Plastics Collected from Total waste Packaging Plastic Arisings.

Residual Packaging Plastics to EfW (866kt):
- This was calculated by taking the proportion of packaging plastic in residual plastic waste (70%) and applying this proportion to the quantity of residual waste going to EfW.

Residual Packaging Plastics to MBT under PFI/PPP Contract (111kt):
- This was calculated by taking the proportion of household packaging plastic in residual household plastic (74%) and applying this proportion to the quantity of plastic residual waste going to MBT under PFI/PPP Contract.

Residual Packaging Plastics to Landfill (568kt):
- This was calculated by subtracting the tonnages of residual packaging plastics going to EfW and MBT from the total tonnage of plastic packaging in residual waste

[42] *It should be noted that WDF also provides tonnage data for waste plastics collected by LAs, but was not selected for use in this project. This is primarily because the RECOUP data is commonly accepted by industry as the most robust data and has been used in previous Valpak/WRAP/Defra reports referring to waste plastic packaging collections. WDF plastic packaging gives a higher (9%) estimate of approximately 507kt*

Packaging Plastics Un-recycled and not subject to a PFI/PPP Contract (1,230kt)

- This tonnage was derived by adding the quantities of Residual Packaging Plastic sent to Landfill with those sent to EfW that are not subject to a PFI/PPP contract

Packaging Plastics un-recycled, not subject to a PFI/PPP contract and suitable for ACT/ATT (736kt)

- The polymer composition used for packaging plastics un-recycled, not subject to a PFI/PPP contract and suitable for ACT/ATT mirrors the polymer composition of Packaging Plastics in Residual Waste

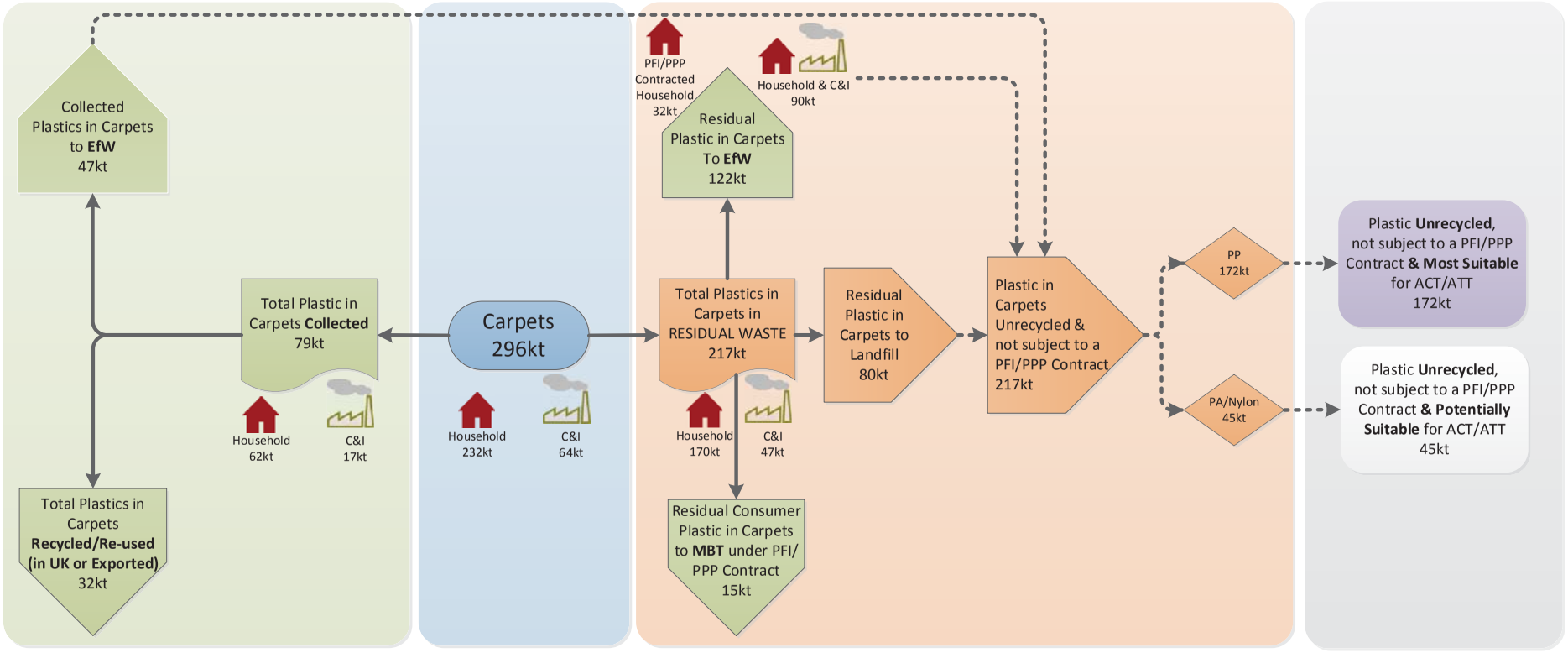
Packaging Plastics Un-recycled and subject to a PFI/PPP Contract (335kt)

- This tonnage was derived by adding the quantities of Residual Packaging Plastic sent to MBT with those sent to EfW that are subject to a PFI/PPP contract

Packaging Plastics un-recycled, subject to a PFI/PPP contract and suitable for ACT/ATT (200kt)

17.0 Plastics in Carpets

Figure 25 Plastics Flow of Carpets[43]



[43] *See Appendix 1 for discussion of uncertainty*

The data sources, assumptions and any methodologies used to calculate the data presented in the Flow of plastics in Carpet shown above are given below.

17.1 Plastic Arisings from Carpets

Total Plastic Arisings from Carpets (296kt):

- Total carpet arisings of 400kt
- Carpet Recycling UK - website, accessed January 2015
- http://www.carpetrecyclinguk.com/
- Of which 60% is PP, 16% is Nylon/Bitumen and 24% is wool
- WRAP, Carpet and Mattress Recycling at HWRC Sites, 2013/2014
- http://www.wrap.org.uk/sites/files/wrap/HWRC%20Guide%20recycling%20carpets%20and%20mattresses.pdf
- Total Waste Plastics Arisings from Carpets is therefore 74% (60%+14%)
- 74% of 400kt is 296kt
- Robustness Score - Evidence for Carpet Waste Arisings: 70%
- Robustness Score - Degree of Agreement for Carpet Waste Arisings: 78%
- Robustness Score - Evidence for Plastics in Carpet: 74%
- Robustness Score - Degree of Agreement for Plastics in Carpet: 78%
- See Appendix I for Details of Data Robustness Scoring

Household & Commercial Plastic Arisings from Carpet (232kt & 64kt):

- Contract Flooring Association, FLOORING: Towards a Resource Efficiency Plan September 2009
- http://www.carpetrecyclinguk.com/downloads/flooring_draft_8_9_09.pdf
- Approximately 22% of Carpet sold into 'Contract' sector and 78% to Domestic
- Robustness Score - Evidence: 44%
- Robustness Score - Degree of Agreement: 22%
- See Appendix I for Details of Data Robustness Scoring

Polymer Split of Plastic Arisings from Carpet:

- 60% is PP, 16% is Nylon/Bitumen and 24% is wool
- WRAP, Carpet and Mattress Recycling at HWRC Sites, 2013/2014
- http://www.wrap.org.uk/sites/files/wrap/HWRC%20Guide%20recycling%20carpets%20and%20mattresses.pdf
- Robustness Score - Evidence: 74%
- Robustness Score - Degree of Agreement: 78%
- See Appendix I for Details of Data Robustness Scoring

17.2 Plastic in Carpets Collected

Total Plastic in Carpet Collected (79kt):

- Total Carpet Collected 2013 107kt
- Carpet Recycling UK - website, accessed January 2015
- http://www.carpetrecyclinguk.com/downloads/2013_Achievements_and_Targets_for_2014.pdf
- Proportion of plastic (74%) as in 'Total Plastic Arisings from Carpets' above

- 74% plastic of 107kt carpets collected gives 79kt of plastic waste in carpet collected
- Average Robustness Score - Evidence (Total Carpet Collected): 67%
- Robustness Score - Degree of Agreement: 22%
- See Appendix I for Details of Data Robustness Scoring

Plastic in Carpet Collected Recycled/Re-used & sent to EfW (32kt & 47kt):
- Proportion of carpets recycled/re-used is 41% and sent to EfW 59%
- Applied to 79kt Plastic in Carpet Collected gives 32kt and 47kt respectively
- Carpet Recycling UK - website, accessed January 2015
- http://www.carpetrecyclinguk.com/downloads/2013_Achievements_and_Targets_for_2014.pdf
- Robustness Score - Evidence: 67%
- Robustness Score - Degree of Agreement: 22%
- See Appendix I for Details of Data Robustness Scoring

Household & Commercial Plastic in Carpets Collected (62kt & 17kt):
- Assumer 'Domestic' and 'Contracted' split of 78%/22% as in carpet arisings above

Polymer Split of Plastic in Carpets Collected:
- Assumed 60% is PP, 16% is Nylon/Bitumen and 24% is wool as in carpet arisings above

17.3 Plastic in Carpet in Residual Waste

Plastics in Carpet in Residual Plastic Waste (217kt):
- Estimated by subtracting Total Waste Plastic in Carpet Collected from Total Waste Plastic Arisings from Carpets.

Plastics in Carpet in Residual Plastic Waste sent to EfW (122kt):
- This was calculated by taking the proportion of plastics in carpet in residual plastic waste (10%) and applying the proportion to the quantity of residual waste going to EfW.

Plastics in Carpet in Residual Plastic Waste sent to MBT under PFI/PPP Contract (15kt):
- This was calculated by taking the proportion of plastics in carpet in household residual plastic waste (12%) and applying the proportion to the quantity of plastic in carpet in residual waste going to MBT under PFI/PPP Contract.

Plastics in Carpet in Residual Plastic Waste sent to Landfill (80kt):
- This was calculated by subtracting the tonnages of residual plastic in carpet sent to EfW and MBT from the total tonnage of plastic in carpet in residual waste.

Plastics in Carpet Un-recycled and not subject to a PFI/PPP Contract (217kt)
- This tonnage was derived by adding the Plastics in Carpet in Residual Plastic Waste sent to Landfill with those sent to EfW (from Collected or Residual) that are not subject to a PFI/PPP contract.

Plastics in Carpet un-recycled, not subject to a PFI/PPP contract and suitable for ACT/ATT (172kt)

- Due to lack of data the same polymer composition used for Plastics in Carpet Waste arisings (see above) was used.

Plastics in Carpet Un-recycled and subject to a PFI/PPP Contract (47kt)

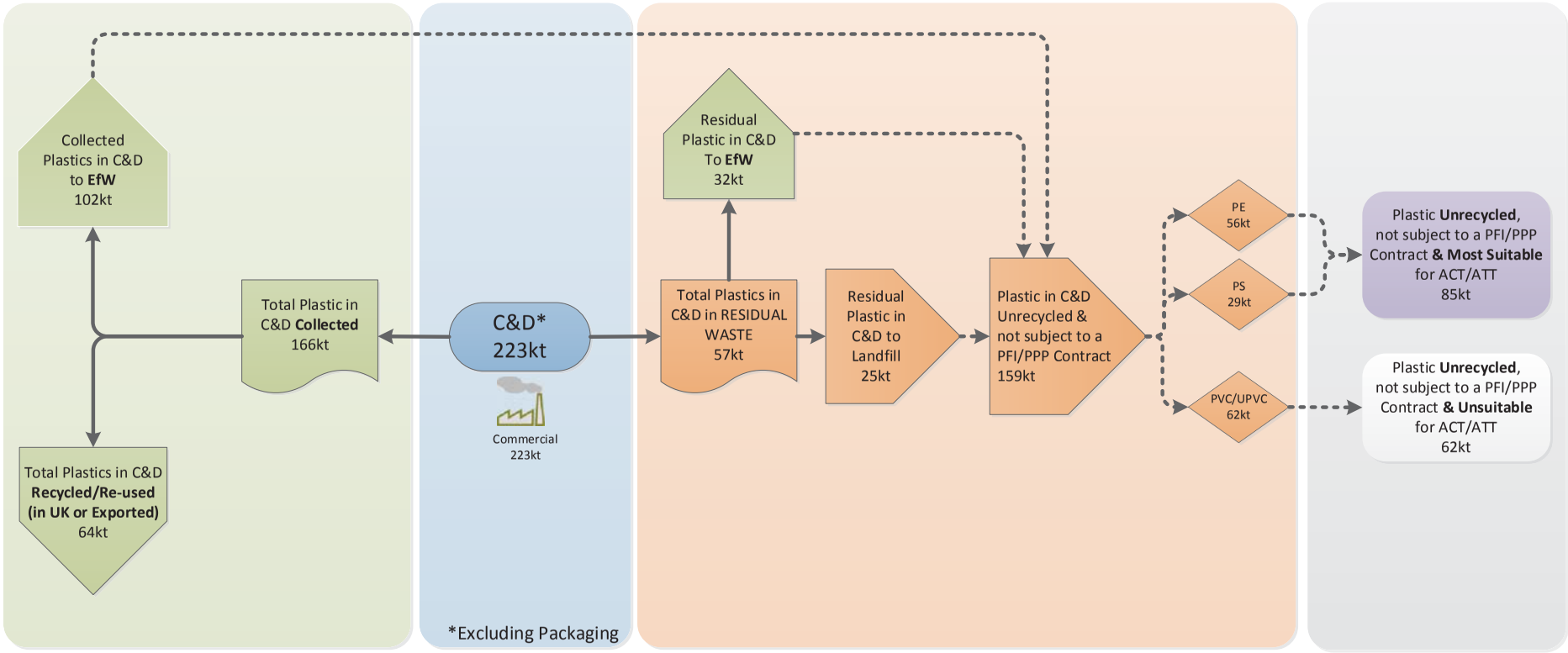
- This tonnage was derived by adding the Plastics in Carpet in Residual Plastic Waste sent to MBT with those sent to EfW that are subject to a PFI/PPP contract.

Plastics in Carpet un-recycled, subject to a PFI/PPP contract and suitable for ACT/ATT (37kt)

- Due to lack of data the same polymer composition used for Plastics in Carpet Waste arisings (see above) was used.

18.0 Plastic in Construction & Demolition (C&D)

Figure 26 Flow of Plastics in C&D[44]



[44] *See Appendix 1 for discussion of uncertainty*

The data sources, assumptions and any methodologies used to calculate the data presented in the Flow of plastics in C&D waste, shown in Figure 26 above, are given below.

18.1 Plastic Arisings from C&D

Total Plastic Arisings from C&D (223kt):

- WRAP, Smartwaste Portal, 2012
- Robustness Score - Evidence: 56%
- Robustness Score - Degree of Agreement: 67%
- See Appendix I for Details of Data Robustness Scoring

Polymer Split of Plastic Arisings:

- PVC 47%, PE 35% and PS/EPS 18%
- APPRICOD - Assessing the Potential of Plastic Recycling in the Construction and Demolition Activities, 2003-2006
- http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n_proj_id=2321&docType=pdf
- Robustness Score - Evidence: 33%
- Robustness Score - Degree of Agreement: 67%
- See Appendix I for Details of Data Robustness Scoring

18.2 Plastic from C&D Collected

Total Plastic in C&D Collected (166kt):

- Sum of Waste Plastic in C&D Collected Re-used, Recycled & sent to EfW (below)

Plastic in C&D Collected Re-used, Recycled & sent to EfW (20kt, 44kt & 102kt):

- 8.9% reused, 19.8% recycled and 45.6% recovered
- WRAP, Smartwaste Portal, 2012
- Robustness Score - Evidence: 56%
- Robustness Score - Degree of Agreement: 67%
- See Appendix I for Details of Data Robustness Scoring

Polymer Split of Waste Plastic in C&D Collected:

- Assumed to be as above in Polymer Split of Waste Plastic Arisings from C&D

18.3 Plastics from C&D in Residual Waste

Plastics in C&D in Residual Plastic Waste (57kt):

- Estimated by subtracting Total Waste Plastic in C&D Collected from Total Waste Plastic Arisings from C&D.

Plastics in C&D in Residual Plastic Waste sent to EfW (32kt):

- This was calculated by taking the proportion of plastics in C&D in residual plastic waste (3%) and applying the proportion to the quantity of residual waste going to EfW.

Plastics in C&D in Residual Plastic Waste sent to Landfill (25kt):

- This was calculated by subtracting the tonnage of C&D waste plastic sent to EfW from Residual Plastic Waste from the total tonnage of C&D Residual Plastic Waste.

Plastics in C&D Un-recycled and not subject to a PFI/PPP Contract (159kt)

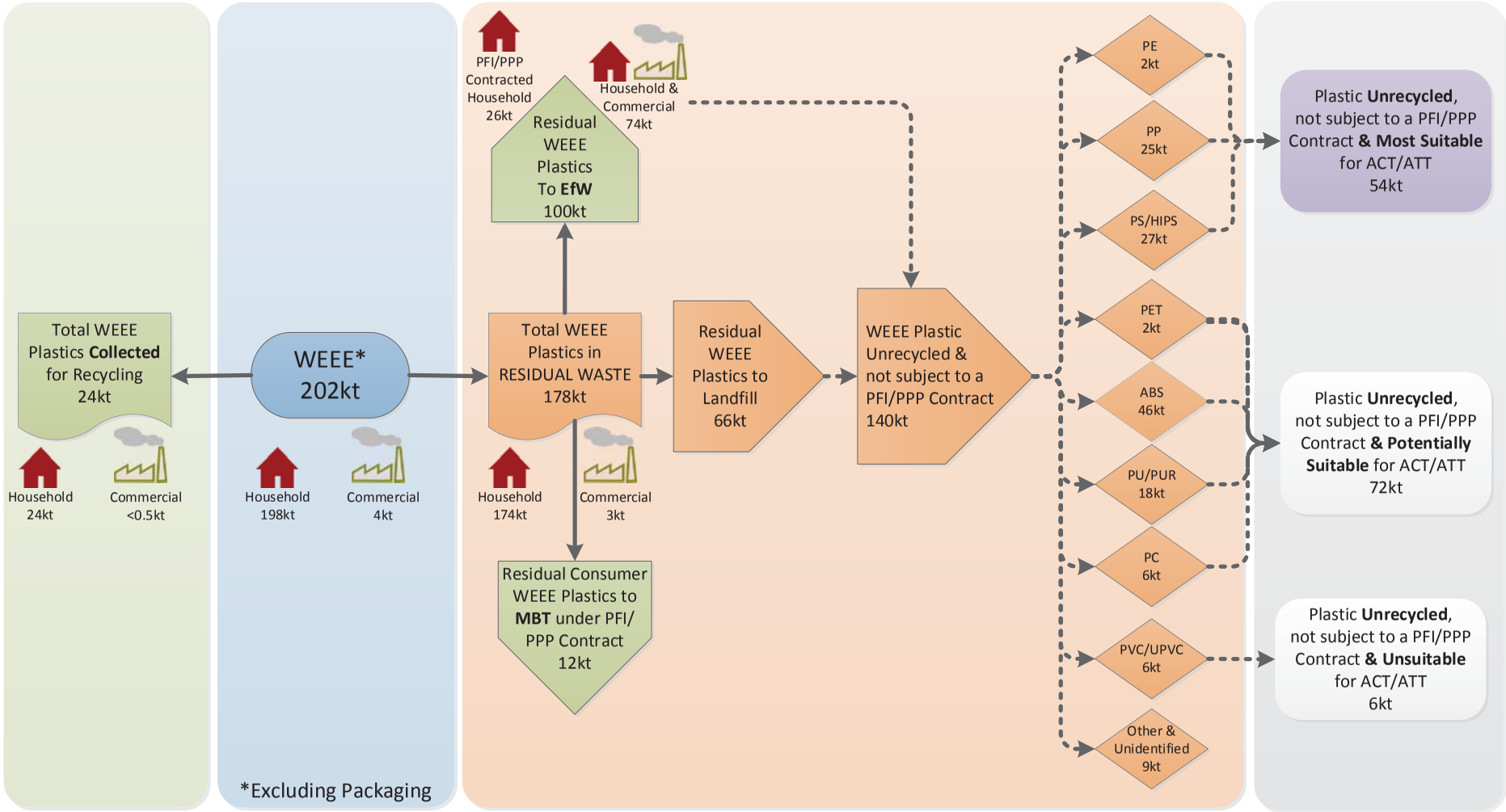
- As all C&D waste plastic is commercial, none of it is subject to long term PFI/PPP contracts and therefore all residual C&D waste plastic is classed as available for ACT/ATT treatment in this project. In addition, C&D waste plastic collected and sent to EfW is also classed as available and is included in this tonnage.

Plastics in C&D un-recycled, not subject to a PFI/PPP contract and suitable for ACT/ATT (85kt)

The same polymer composition has been assumed for Plastics in C&D plastic waste arisings (see above), C&D plastic waste collected and C&D residual plastic waste.

19.0 Plastics in Waste Electrical and Electronic Equipment (WEEE)

Figure 27 Flow of plastics in WEEE[45]



[45] *See Appendix 1 for discussion of uncertainty*

The data sources, assumptions and any methodologies used to calculate the data presented in the Flow of WEEE, shown in Figure 27 above, are given below.

19.1 Plastic Arisings from WEEE

Total Plastic Arisings from WEEE (202kt):

- EA producer reported data for B2C and B2B combined, gave a tonnage of reported WEEE collected for recycling
- Robustness Score - Evidence: 78%
- Robustness Score - Degree of Agreement: 67%
- See Appendix I for Details of Data Robustness Scoring

- EFRA, Closed Loop Recycling of Plastics Containing Flame Retardants
- 21% of WEEE is plastic
- Robustness Score - Evidence: 63%
- Robustness Score - Degree of Agreement: 22%
- See Appendix I for Details of Data Robustness Scoring

Household & Commercial Plastic Arisings from WEEE (198kt & 4kt):

- EA producer reported data is presented for both B2C and B2B. Therefore the total is a combination of both household and Commercial, which are initially split out as reported here
- Robustness Score - Evidence: 78%
- Robustness Score - Degree of Agreement: 67%
- See Appendix I for Details of Data Robustness Scoring

- EFRA, Closed Loop Recycling of Plastics Containing Flame Retardants
- 21% of WEEE is plastic
- Robustness Score - Evidence: 63%
- Robustness Score - Degree of Agreement: 22%
- See Appendix I for Details of Data Robustness Scoring

Polymer Split of Plastic Arisings from WEEE:

- Polymer split has been derived from UN data, ABS, PS and PP assumed as recycled.
- Robustness Score - Evidence: 67%
- Robustness Score - Degree of Agreement: 44%
- See Appendix I for Details of Data Robustness Scoring

19.2 Plastic from WEEE Collected

Total Plastic in WEEE Collected for Recycling (24kt):

- EFRA, Recycling WEEE Plastics, A Challenge to Achieve the WEEE Directive Targets!, 2011 Data
- 12% of WEEE plastic is recycled, this is assumed as maximum and coverage is for the EU not just the UK.
- Robustness Score - Evidence: 48%
- Robustness Score - Degree of Agreement: 22%

- See Appendix I for Details of Data Robustness Scoring

Polymer Split of Plastic in WEEE Collected:
- Assumed to be as above in Polymer Split of Waste Plastic Arisings from WEEE

19.3 Plastics from WEEE in Residual Waste

Plastics in WEEE in Residual Plastic Waste (178kt):
- Estimated by subtracting Total Waste Plastic in WEEE Collected from Total Waste Plastic Arisings from WEEE.

Plastics in WEEE in Residual Plastic Waste sent to EfW (100kt):
- This was calculated by taking the proportion of plastics in WEEE in residual plastic waste (8%) and applying the proportion to the quantity of residual waste going to EfW.

Plastics in WEEE in Residual Plastic Waste sent to MBT under PFI/PPP Contract (12kt):
- This was calculated by taking the proportion of plastics in household WEEE in household residual plastic waste (12%) and applying the proportion to the quantity of household residual waste going to MBT under PFI/PPP Contract.

Plastics in WEEE in Residual Plastic Waste sent to Landfill (66kt):
- This was calculated by subtracting the tonnages of residual plastic in WEEE sent to EfW and MBT from the total tonnage of plastic in WEEE in residual waste.

Plastics in WEEE Un-recycled and not subject to a PFI/PPP Contract (140kt)
- This tonnage was derived by adding the Plastics in WEEE in Residual Plastic Waste sent to Landfill with that sent to EfW from Residual that is not subject to a PFI/PPP contract.

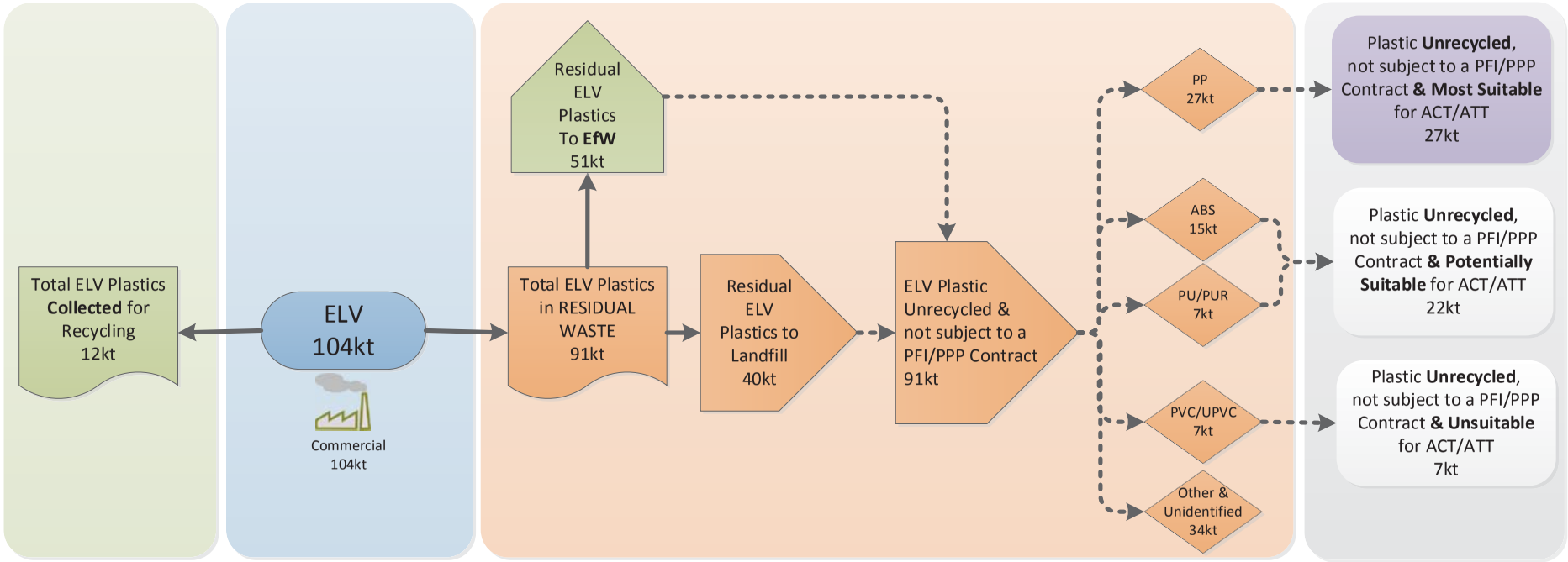
Plastics in WEEE un-recycled, not subject to a PFI/PPP contract and suitable for ACT/ATT (54kt)
- This composition was achieved by subtracting the tonnages of polymers recycled from the tonnages arising as waste and then subtracting the tonnages of polymers assumed to be going to EfW or MBT from residual WEEE plastic.

Plastics in WEEE Un-recycled and subject to a PFI/PPP Contract (38kt)
- This tonnage was derived by adding the Plastics in WEEE in Residual Plastic Waste sent to MBT with that sent to EfW from Residual that is subject to a PFI/PPP contract.

Plastics in WEEE un-recycled, subject to a PFI/PPP contract and suitable for ACT/ATT (15kt)

20.0 Plastic in End of Life Vehicles (ELV)

Figure 28 Flow of Plastics in ELV[46]



[46] *See Appendix 1 for discussion of uncertainty*

The data sources, assumptions and any methodologies used to calculate the data presented in the Flow of plastics in ELV waste, shown in Figure 28 above, are given below.

20.1 Plastic Arisings from ELV

Total Plastic Arisings from ELV (104kt):

- Total tonnage of ELV Arisings in 2013 was 1,116kt
- Eurostat for 2013
- http://ec.europa.eu/eurostat/data/database
- Plastic Proportion of ELV 9%
- Plastics: A Material of Choice for the Automotive Industry" (Brussels, Belgium: Association of Plastics Manufacturers in Europe, 1999)[47]
- http://www.tms.org/pubs/journals/jom/0308/kanari-0308.html
- 9% of 1,116kt is 104kt
- Robustness Score – Evidence (Total ELV Arisings): 74%
- Robustness Score - Degree of Agreement (Total ELV Arisings): 67%
- Robustness Score – Evidence (Total Plastics in ELV Arisings): 67%
- Robustness Score - Degree of Agreement (Total Plastics ELV Arisings): 67%
- See Appendix I for Details of Data Robustness Scoring

Polymer Split of Plastic Arisings from ELV:

- The 9% plastic used in ELV is broken down into how it is used (e.g. bumper, upholstery, dashboard, etc) alongside the potential polymers used. Where more than one polymer was potentially used (e.g. dashboard could be made of PP or ABS), then the proportion of plastic relating to dashboards (14%) was divided equally between the polymers.
- Plastics: A Material of Choice for the Automotive Industry" (Brussels, Belgium: Association of Plastics Manufacturers in Europe, 1999)[48]
- http://www.tms.org/pubs/journals/jom/0308/kanari-0308.html
- Robustness Score – Evidence: 44%
- Robustness Score - Degree of Agreement: 11%
- See Appendix I for Details of Data Robustness Scoring

20.2 Plastic from ELV Collected

Total Plastic in ELV Collected & Recycled (12kt):

- It has been assumed 12% of plastics are recycled from ELV
- This is a maximum and is a figure encompassing plastics in both ELV and WEEE and relative to the EU, not just the UK
- EFRA, Recycling Weee Plastics, A Challenge To Achieve The Weee Directive Targets!, 2011 Data

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[47] *Although using data from 1999 may seem out-dated, the article points out that the average lifespan of a car in use is between 12 and 15 years, which would put the waste arisings dates around 2011-2014*

[48] *Although using data from 1999 may seem out-dated, the article points out that the average lifespan of a car in use is between 12 and 15 years, which would put the waste arisings dates around 2011-2014*

- Robustness Score – Evidence: 48%
- Robustness Score - Degree of Agreement: 22%
- See Appendix I for Details of Data Robustness Scoring

Polymer Split of Plastic in ELV Collected & Recycled:

- Due to a lack of data, the polymer split adopted for Plastic in ELV Arisings has been used

20.3 Plastics from ELV in Residual Waste

Plastics in ELV in Residual Plastic Waste (91kt):

- Estimated by subtracting Total Plastic in ELV Collected from Total Waste Plastic Arisings from ELV.

Plastics in ELV in Residual Plastic Waste sent to EfW (51kt):

- This was calculated by taking the proportion of plastics in ELV in residual plastic waste (4%) and applying the proportion to the quantity of residual waste going to EfW.

Plastics in ELV in Residual Plastic Waste sent to Landfill (40kt):

- This was calculated by subtracting the tonnage of ELV waste plastic sent to EfW from Residual Plastic Waste from the total tonnage of ELV Residual Plastic Waste.

Plastics in ELV Un-recycled and not subject to a PFI/PPP Contract (91kt)

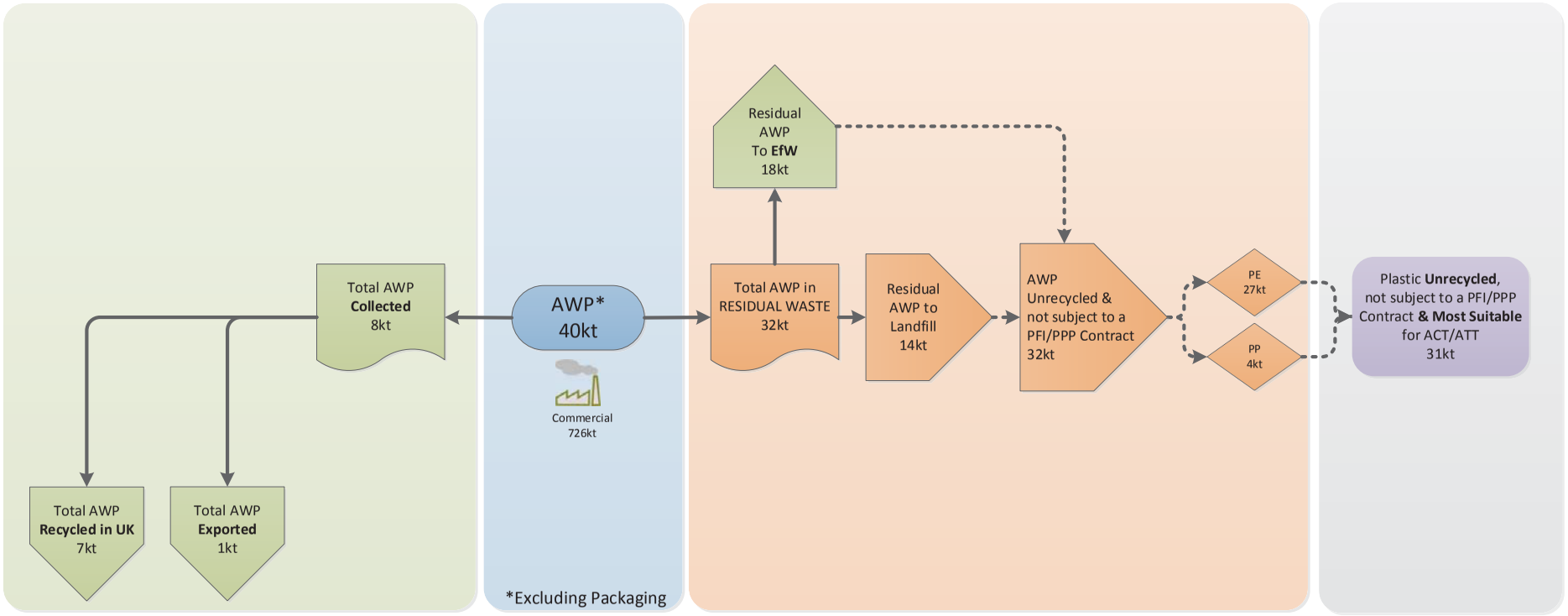
- As all ELV waste plastic is commercial, none of it is subject to long term PFI/PPP contracts and therefore all residual ELV waste plastic is classed as available for ACT/ATT treatment in this project.

Plastics in ELV un-recycled, not subject to a PFI/PPP contract and suitable for ACT/ATT (27kt)

- The polymer composition of ELV Residual Waste Plastic is therefore the relevant composition to identify the polymers most suitable for ACT/ATT

21.0 Agricultural Waste Plastics (AWP)

Figure 29 Flow of AWP[49]



[49] *See Appendix 1 for discussion of uncertainty*

The data sources, assumptions and any methodologies used to calculate the data presented in the Flow of AWP, shown in Figure 29 above, are given below.

21.1 Plastic Arisings from AWP

Total Plastic Arisings from Agriculture (40kt):

- As is done in plastic packaging, data for agricultural plastics placed on the market (POM) was used.
- The latest published data is from 2006, however this has been checked and believed to be still representative of today
- Defra/CIWM/Valpak, Agricultural Waste Plastic Programme
- Robustness Score – Evidence: 74%
- Robustness Score - Degree of Agreement: 44%
- See Appendix I for Details of Data Robustness Scoring

Polymer Split of Plastic Arisings from Agriculture:

- Defra/CIWM/Valpak, Agricultural Waste Plastic Programme
- Robustness Score – Evidence: 63%
- Robustness Score - Degree of Agreement: 56%
- See Appendix I for Details of Data Robustness Scoring

21.2 AWP Collected

Total AWP Collected (8kt):

- A recycling rate of 26% was applied to LDPE/LLDPE AWP films
- BPI email discussion (largest AWP Recycler in UK)
- Robustness Score – Evidence: 52%
- Robustness Score - Degree of Agreement: 22%
- See Appendix I for Details of Data Robustness Scoring

AWP Collected Recycled & Exported (7kt & 1kt):

- 90% recycled in UK, 10% exported
- BPI email discussion (largest AWP Recycler in UK)
- Robustness Score – Evidence: 52%
- Robustness Score - Degree of Agreement: 22%
- See Appendix I for Details of Data Robustness Scoring

Polymer Split of AWP Collected:

- Vast majority is LDPE/LLDPE film and therefore this has been assumed to be 100%

21.3 Plastics from C&D in Residual Waste

AWP in Residual Plastic Waste (32kt):

- Estimated by subtracting Total AWP Collected from Total AWP Arisings.

AWP in Residual Plastic Waste sent to EfW (18kt):

- This was calculated by taking the proportion of AWP in residual plastic waste (1%) and applying the proportion to the quantity of residual waste going to EfW.

AWP in Residual Plastic Waste sent to Landfill (14kt):

- This was calculated by subtracting the tonnage of AWP going to EfW from residual plastic waste, from the total tonnage of AWP in residual waste.

AWP Un-recycled and not subject to a PFI/PPP Contract (32kt)

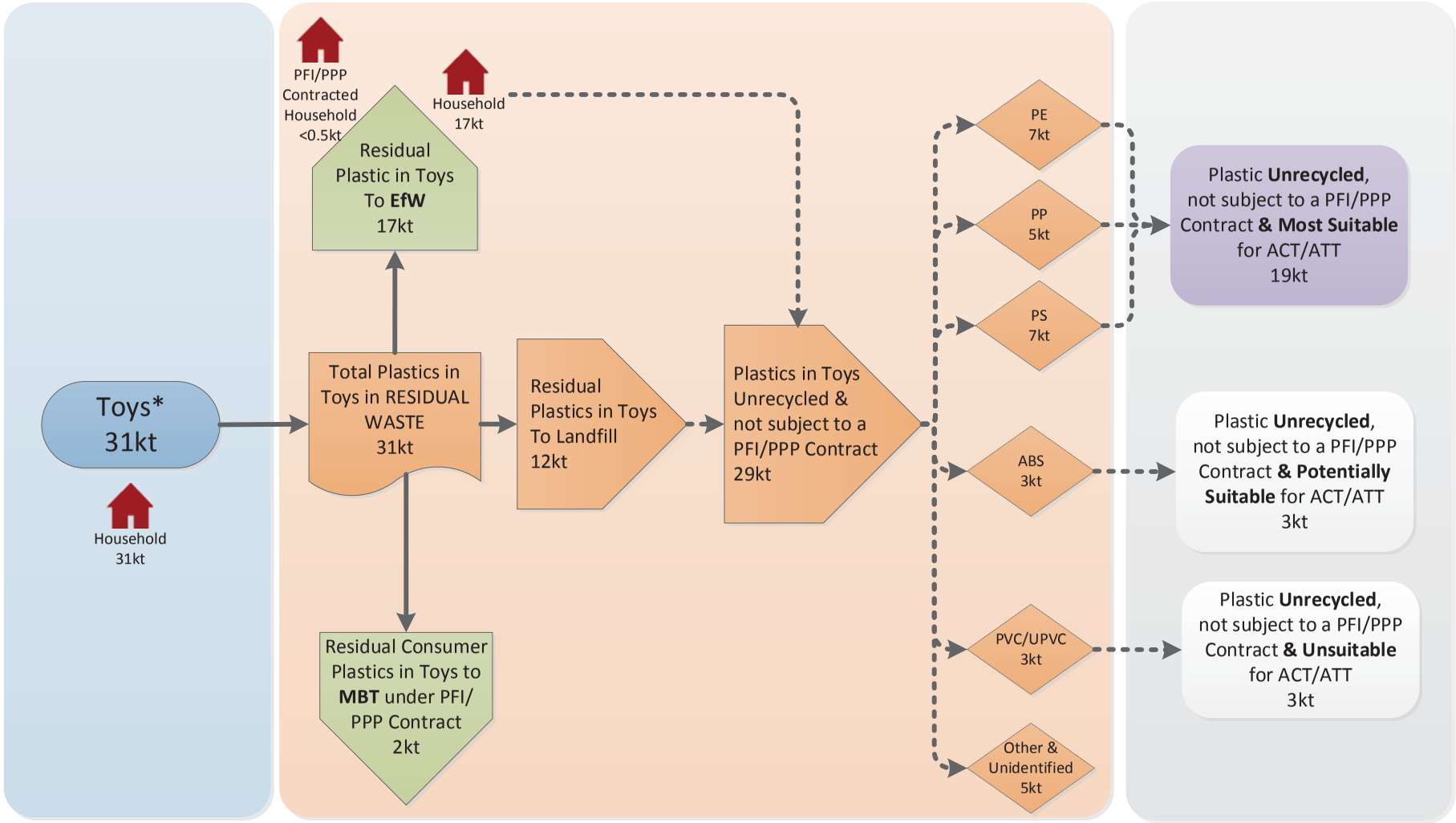
- As all AWP is commercial, none of it is subject to longterm PFI/PPP contracts and therefore all residual AWP is classed as available for ACT/ATT treatment in this project.

AWP un-recycled, not subject to a PFI/PPP contract and suitable for ACT/ATT (31kt)

The polymer composition for AWP un-recycled and suitable for ACT/ATT was derived through mirroring the polymer composition of AWP in Residual Waste (which was derived by subtracting the quantity of LDPE/LLDPE AWP Collected from the polymer composition of AWP Arisings (see above).

22.0 Plastic in Toys

Figure 30 Flow of Plastic in Toys[50]



[50] *See Appendix 1 for discussion of uncertainty*

The data sources, assumptions and any methodologies used to calculate the data presented in the Flow of Waste Plastic in Toys, shown in Figure 30 above, are given below.

22.1 Plastic Arisings from Toys

Total Plastic Arisings from Toys (31kt):

- Total Plastic Arising from Toys (in the UK) estimated at 31kt
- Packaging Matters/Valpak, The Quantity of Materials in Toy Products Placed on the European Union Market, and the Quantities that enter the Waste Stream, 2015
- Not published
- Robustness Score – Evidence: 30%
- Robustness Score - Degree of Agreement: 67%
- See Appendix I for Details of Data Robustness Scoring

Polymer Split of Plastic Arisings from Toys:

- BPF website, accessed February 2016
- www.bpf.co.uk/article/biodegradable-polymers-in-the-toy-sector-364.aspx
- Robustness Score – Evidence: 33%
- Robustness Score - Degree of Agreement: 67%
- See Appendix I for Details of Data Robustness Scoring

22.2 Plastics from Toys in Residual Waste

Plastics in Toys in Residual Plastic Waste (31kt):

- Assumed no toys currently collected for recycling (only re-used through charity shops, etc)
- Therefore all Plastic in Toys Waste Arisings equals Plastics in Toys in Residual Plastic Waste

Plastics in Toys in Residual Plastic Waste sent to EfW (17kt):

- This was calculated by taking the proportion of plastics in Toys in residual plastic waste (1%) and applying the proportion to the quantity of residual waste going to EfW.

Plastics in Toys in Residual Plastic Waste sent to MBT under PFI/PPP Contract (2kt):

- This was calculated by taking the proportion of plastics in Toys in household residual plastic waste (1%) and applying the proportion to the quantity of household residual waste going to MBT under PFI/PPP Contract.

Plastics in Toys in Residual Plastic Waste sent to Landfill (12kt):

- This was calculated by subtracting the tonnage of plastics in toys going to EfW and MBT from residual plastic waste, from the total tonnage of plastic in toys in residual waste.

Plastics in Toys Un-recycled and not subject to a PFI/PPP Contract (29kt)

- This tonnage was derived by adding the Plastics in Toys in Residual Plastic Waste sent to Landfill with those sent to EfW from Residual that is not subject to a PFI/PPP contract.

Plastics in Toys un-recycled, not subject to a PFI/PPP contract and suitable for ACT/ATT (19kt)

The same polymer composition used for Plastics in Toys Waste arisings (see above) was used (as it has been assumed no toys are collected and all go to residual waste eventually).

Plastics in Toys Un-recycled and subject to a PFI/PPP Contract (~2kt)

- This tonnage was derived by adding the Plastics in Toys in Residual Plastic Waste sent to MBT with those sent to EfW from residual that is subject to a PFI/PPP contract.

Plastics in Toys un-recycled, not subject to a PFI/PPP contract and suitable for ACT/ATT (~1kt)

The same polymer composition used for Plastics in Toys Waste arisings (see above) was used (as it has been assumed no toys are collected and all go to residual waste eventually).

Appendix III Technology Review

23.0 Introduction to Technology Review

This high level review provides a basic assessment of the various technologies available for polymer cracking, their feedstock requirements and product outputs. A useful approach for highlighting the differences between gasification and pyrolysis is also to include incineration in the comparison. The chief factors to consider in the comparison are the levels of oxygen permitted in the process, the severity of the changes brought about on the feed material and the outputs.

It is important to acknowledge that these three technology types may only represent the central technology applied to the transformation of material. Associated with them will be feed preparation stages and downstream conversion and conditioning operations. Feed preparation will comprise activities necessary to ensure the material supplied to the central technology is in the required composition range and correct physical form. Downstream conversion may be applied to produce specific products and/or generate power. Conditioning operations would be those required to ensure unacceptable emissions are eliminated.

The following descriptions are generally correct, but there are many variants and some crossover between, and combination of, technologies can occur. Also many facilities are named or described inaccurately; leading to additional confusion in the nomenclature.

24.0 Incineration

24.1 Process Characteristics

An incinerator is a relatively open system where it is normal for an excess of air to be delivered to the combustion zone. Complete oxidation of the supply material is usually the aim, converting it to (inert) ash, combustion products and heat.

24.2 Process Outputs

Incineration processes aim to achieve maximum oxidation of feed materials to form inert solid residue and combustion products. The gaseous products are cleaned to meet emission regulations, which will result in certain other solid outputs. In most cases heat produced from the combustion is used to generate power and heat – providing power export to the grid (or for process purposes) and local use of lower grade heat where a user is available. The latter use of heat can greatly improve the efficiency of the process.

24.3 Feed Specifications

There is a minimum of feed treatment for incineration processes. Removal of overly large and heavy items is necessary and material sometimes requires size reduction. The process parameters and downstream clean-up will normally be set up to meet the expected supply composition.

25.0 Gasification

25.1 Process Characteristics

In contrast, gasification involves controlling the oxygen introduced to the reaction chamber. The source of oxygen may be air, oxygen, steam or a combination of these; oxygen may also be present in the chemical make-up of the feed material (for example if biomass is included in the feed composition; a possible constituent, cellulose, comprises just under 50% oxygen). The main product anticipated from the gasification process is syngas, which is essentially a mixture of carbon monoxide and hydrogen and falls short of complete combustion. The term originates from the term 'synthesis gas', as these basic building blocks have potential to be used to synthesise further chemical products . Other components can be present with syngas as determined by the feed composition and the operating conditions. Syngas is the desired product where the feed material consists chemically of carbon and hydrogen compounds only. Typically gasification takes place at temperatures in the range 800-1400C; pressures may also be elevated. There will often be some residue associated with the process.

25.2 Process Outputs

The products of gasification have some fuel value (4-20 MJ/m3) and though not as high in calorific value as some gaseous pyrolysis products (which can be 30-100 MJ/m3) they can be suitable for direct combustion to generate heat and power. The product gas may require a clean-up step for compatibility with the generation stage. Alternative downstream processes include enhanced heat and power where more advance technologies may be used for generation. Syngas may also be used to manufacture chemical products and depending on the downstream processes employed these products can range from monomers for new plastic production, through chemical intermediates (such as methanol) to liquid and gaseous fuels (i.e. for export). These manufacturing opportunities rely on appropriate location of facilities as they require sophisticated downstream processes and services.

The use of air in gasification introduces nitrogen (which forms 78% of air by volume) and this reduces the fuel value of the product gases through dilution whilst introducing a potential NOx content in product or combustion product. This can be dealt with but is an added complexity to the process. Gasification can use oxygen or steam as alternative oxygen sources. The former requires oxygen production equipment and the latter will usually require a higher input of energy to effect gasification. Combining oxygen and steam is also a process option and will occur where feed is not dry.

25.3 Feed Specifications

The range of plastic feed materials acceptable to a gasification system without affecting its target product composition is wider than for a typical pyrolysis facility. This is because the oxygen added can be reduced for higher oxygen containing feeds – this can be an advantage in certain circumstances. Nylons and rubbers are suitable though caution has to be shown for the presence of certain additives such as sulphur in some rubber

materials. Most carbon:hydrogen containing compounds contribute to the useable content of the syngas product and co-processing with biomass can be an attractive option. An assessment of the contribution of each individual component in the feed to the product may be made in special cases but where mixed wastes are processed the separation costs may not be justified.

PVC (as with other halogen containing polymers) is generally to be avoided in feed material – the chlorine content of PVC is 57% by weight. The presence of chlorine can contaminate all phases of product – solid, liquid or gas – and can have implications for the materials of construction of plant with potentially severe cost implications. Some process offerings claim to be able to accept certain specified PVC levels in feed supplied.

26.0 Pyrolysis

26.1 Process Characteristics

Pyrolysis is a lower temperature process than gasification using external (indirect) heat to breakdown the feed material, oxygen being excluded from the process in so far as is practicable. Operating temperatures are usually in the range 400-800C, being sufficient to break down most organic feed matter, but may be higher. The conversion of feed materials in this case is less severe than for gasification and the organic content is modified rather than being broken down to small constituents. Products of the process when applied to plastics will be oils and gases with (at least) fuel value and a solid residue high in carbon content.

26.2 Process Outputs

With the lower severity of chemical breakdown occurring in pyrolysis processes it is worth dwelling on the typical outputs of such processes when applied to plastic feed. Polyolefins will crack to form a range of hydrocarbons from relatively heavy oils to gaseous materials. Polymers with oxygen content (such as PET or PVOH) will contribute less to the calorific value of the products, and some polymers can introduce materials that are a threat to the process or products (PVC, PVDC etc). The products will normally exit the reaction area as vapour and this provides the opportunity for separation of solid residue. It also sets a limit on the degree of cracking achieved in the pyrolysis chamber, depending on the physical layout of the system, as material can only leave in the product stream when it is sufficiently cracked to be in vapour form. Products may be used for onsite heat and power generation, as fuels for export or subjected to further processing. When the feed comprises other materials with plastics the range of products will be altered and when there is oxygen content the energy preserved in the product will be reduced (e.g. the oxygen content of PET is 33% by weight, whereas for polyolefins it is essentially 0%).

Pyrolysis processes can be combined with those of gasification. Normally pyrolysis would be used to effect the first stage and gasification applied to any residue produced. The chief products from a mixed feed pyrolysis process are char, oil and gas. Increasing

plastic content in the feed material will contribute to a reducing level of char. Plastic only feed comprising only polyolefins may result in less than 3% char and as much as 75% liquid product. Some processes claim to be able to derive a useable diesel product from this liquid product.

26.3 Feed Specifications

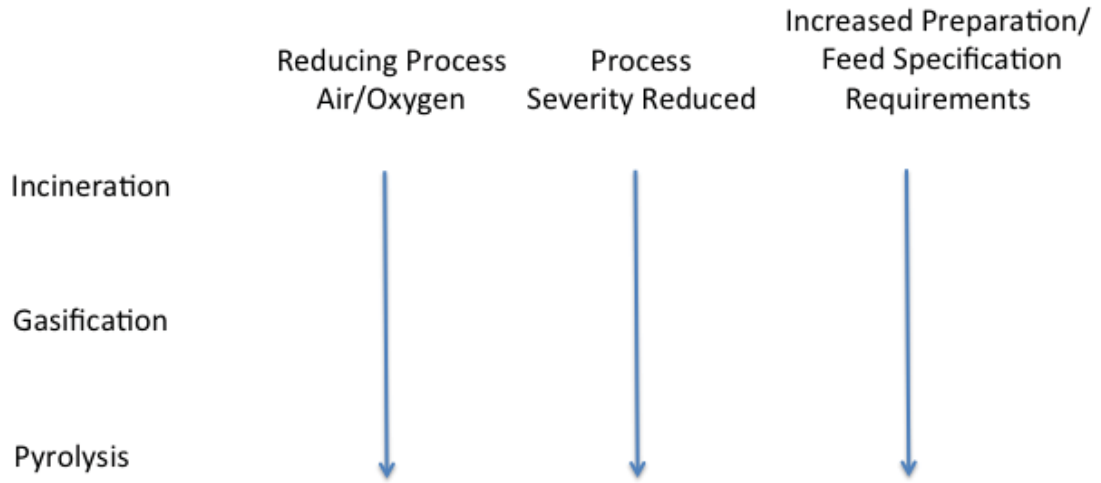
Pyrolysis processes are generally less tolerant than gasification, but this is product and technology dependent. The more refined the product requirement the tighter the specification that needs to be applied to the feed supplied.

Some pyrolysis feedstock recycling processes have been developed which claim processing of mixed plastic waste but in reality they process mixed polyolefin waste with some tolerance for polystyrene and PET. The problem with these is that once the feed stream has been prepared the material available could be suitable for mechanical recycling which may then offer a less costly and more environmentally acceptable route for recovery. This highlights an important consideration - that even when a process has economics that justify the feed preparation costs the level of preparation conducted may open the opportunity of a less capital intensive recovery solution.

27.0 Summary

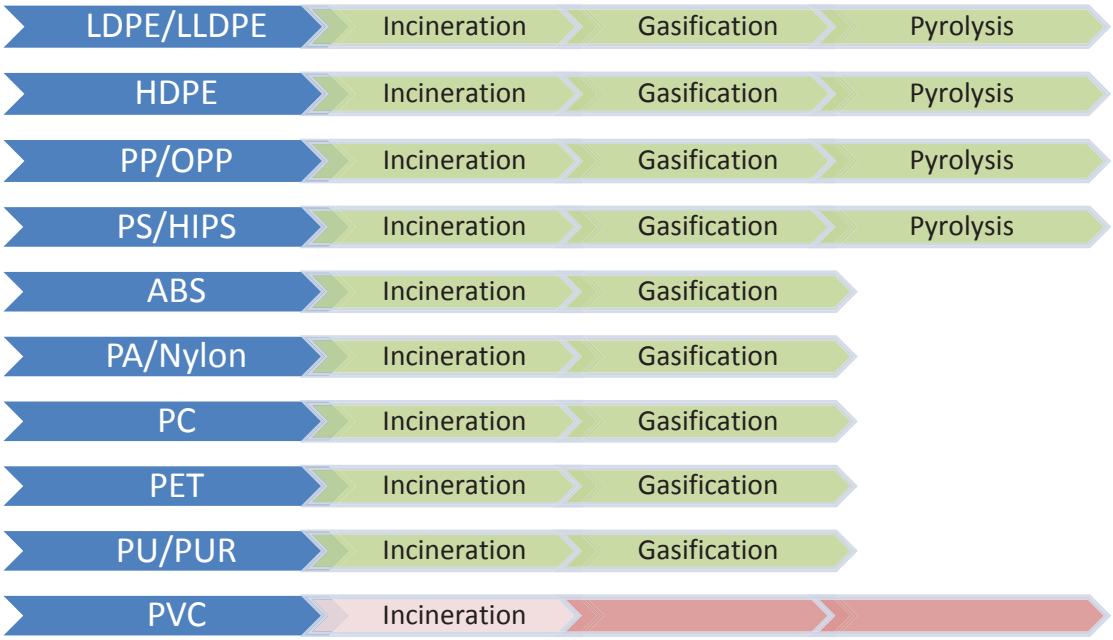
The differences in process characteristics of the technologies are summarised in Figure 31 below. It illustrates that the levels of oxygen permitted decrease for gasification (compared to incineration) and further for pyrolysis, as does the severity of the changes brought about on the feed material and the outputs. In terms of preparation of feedstock and tightness of specification, these increase for gasification (compared to incineration) and further for pyrolysis.

Figure 31 Summary of Process Characteristics

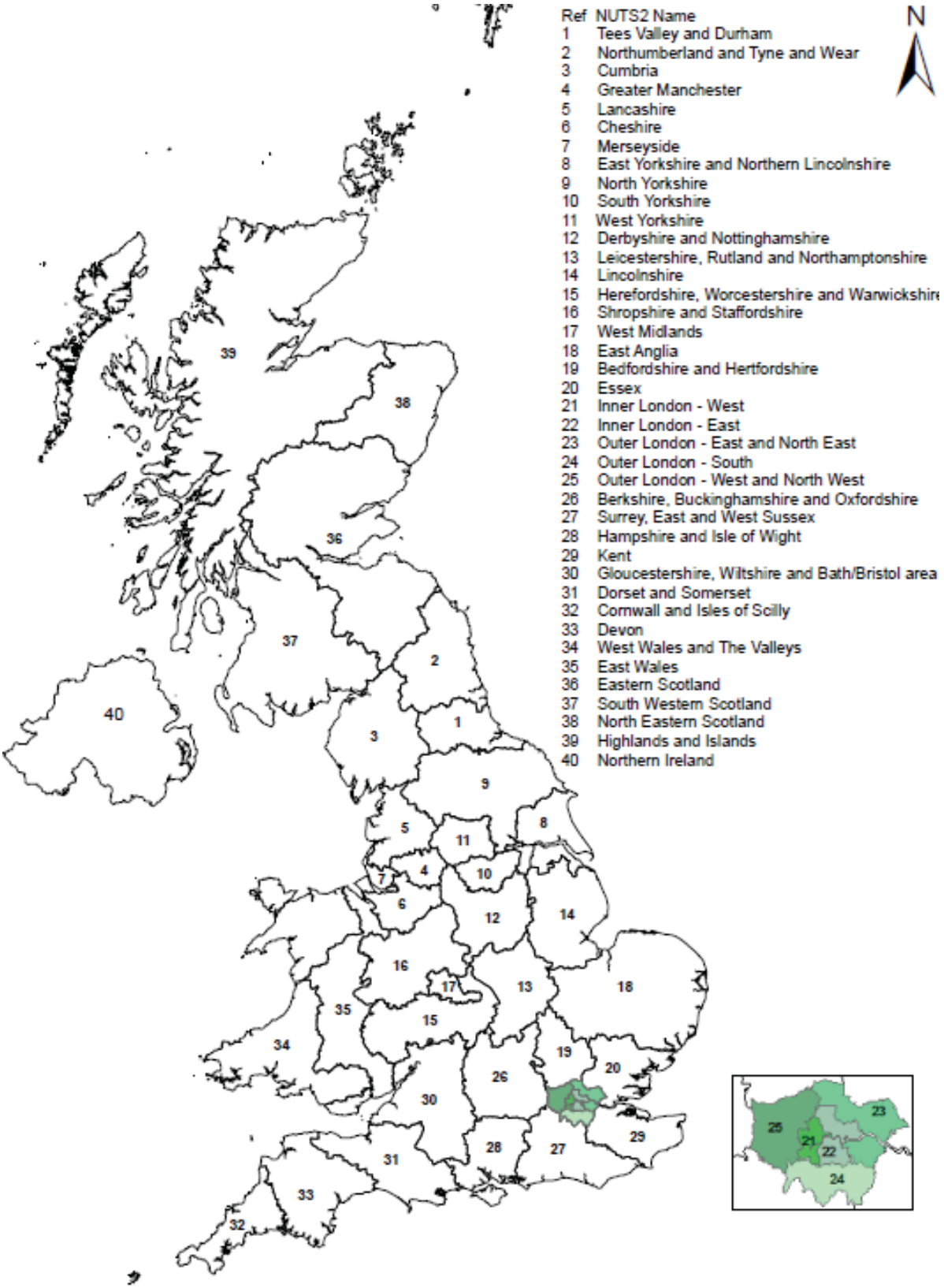


In all processes the presence of inert materials in the feed will reduce performance as some of the process energy is used to heat this fraction. The process tolerance for different polymer types are summarised in Figure 32.

Figure 32 Process Tolerance of Various Plastics



Appendix IV NUTS 2 Reference Map



Appendix V Allocation of Commercial Waste Plastic Arisings

Figure 33 Allocation of Commercial Waste Plastic Arisings, by GVA)

		Total Commercial Plastic Waste Arisings	Agriculture, forestry and fishing			Chemicals/Non-metallic Minerals Manufacturing			Construction			Education			Food, Drink & Tobacco			Hotels and Catering			Machinery and Equipment (Other Manufacturing)		
Region	Sub Region name (NUTS 2)	(t)	GVA £ million	% GVA	Plastic (t)	GVA £ million	% GVA	Plastic (t)	GVA £ million	% GVA	Plastic (t)	GVA £ million	% GVA	Plastic (t)	GVA £ million	% GVA	Plastic (t)	GVA £ million	% GVA	Plastic (t)	GVA £ million	% GVA	Plastic (t)
East Midlands	Derbyshire and Nottinghamshire	44k	287	3%	1,073	1495	4%	8,868	2505	3%	6,137	3054	3%	600	1008	4%	2,472	986	2%	572	11716	5%	4,073
	Leicestershire, Rutland and Northamptonshire	42k	276	3%	1,032	968	3%	5,742	2186	2%	5,356	2778	3%	546	1559	6%	3,823	786	2%	456	7961	3%	2,767
	Lincolnshire	14k	498	5%	1,862	176	0%	1,044	799	1%	1,958	987	1%	194	753	3%	1,846	441	1%	256	2472	1%	859
East of England	Bedfordshire and Hertfordshire	45k	162	2%	606	2003	6%	11,882	3493	4%	8,558	2496	3%	491	485	2%	1,189	1180	3%	685	7406	3%	2,574
	East Anglia	55k	1291	12%	4,827	1707	5%	10,126	3145	3%	7,705	4109	4%	808	1782	7%	4,369	1476	3%	856	10107	4%	3,513
	Essex	31k	285	3%	1,066	475	1%	2,818	3135	3%	7,681	2170	2%	427	283	1%	694	886	2%	514	5531	2%	1,923
London	Inner London - East	40k	6	0%	22	157	0%	931	3642	4%	8,923	4900	5%	963	312	1%	765	2475	6%	1,436	2358	1%	820
	Inner London - West	44k	6	0%	22	114	0%	676	3155	3%	7,730	4690	5%	922	154	1%	378	4740	11%	2,750	1361	1%	473
	Outer London - East and North East	28k	13	0%	49	354	1%	2,100	3090	3%	7,570	2335	2%	459	505	2%	1,238	710	2%	412	3541	2%	1,231
	Outer London - South	18k	12	0%	45	116	0%	688	2324	3%	5,694	1653	2%	325	48	0%	118	640	1%	371	787	0%	274
	Outer London - West and North West	46k	13	0%	49	465	1%	2,758	3504	4%	8,585	2707	3%	532	1300	5%	3,188	1482	3%	860	4291	2%	1,492
North East	Northumberland and Tyne and Wear	25k	215	2%	804	1050	3%	6,229	1470	2%	3,601	1849	2%	364	351	1%	861	794	2%	461	5770	3%	2,006
	Tees Valley and Durham	22k	139	1%	520	1259	3%	7,468	1249	1%	3,060	1628	2%	320	269	1%	660	468	1%	272	3973	2%	1,381
North West	Cheshire	37k	147	1%	550	3271	9%	19,404	1394	2%	3,415	1058	1%	208	318	1%	780	652	1%	378	7078	3%	2,460
	Cumbria	13k	189	2%	707	424	1%	2,515	737	1%	1,806	585	1%	115	257	1%	630	508	1%	295	3128	1%	1,087
	Greater Manchester	51k	53	0%	198	1354	4%	8,032	3370	4%	8,256	4094	4%	805	1038	4%	2,545	1563	4%	907	7480	3%	2,600
	Lancashire	29k	202	2%	755	918	3%	5,446	1953	2%	4,785	2196	2%	432	697	3%	1,709	953	2%	553	6796	3%	2,362
	Merseyside	31k	41	0%	153	2077	6%	12,321	1475	2%	3,614	2097	2%	412	381	1%	934	733	2%	425	4908	2%	1,706
Northern Ireland	Northern Ireland	35k	461	4%	1,724	1020	3%	6,051	1736	2%	4,253	2605	3%	512	1572	6%	3,855	830	2%	482	6914	3%	2,403
Scotland	Eastern Scotland	39k	638	6%	2,385	944	3%	5,600	2790	3%	6,835	3532	4%	694	1051	4%	2,577	1516	3%	880	6271	3%	2,180
	Highlands and Islands	13k	320	3%	1,196	398	1%	2,361	843	1%	2,065	512	1%	101	730	3%	1,790	483	1%	280	1617	1%	562
	North Eastern Scotland	13k	228	2%	852	119	0%	706	899	1%	2,203	761	1%	150	326	1%	799	433	1%	251	3023	1%	1,051
	South Western Scotland	43k	351	3%	1,312	837	2%	4,965	3239	4%	7,935	3071	3%	604	1706	6%	4,183	1329	3%	771	7454	3%	2,591
South East	Berkshire, Buckinghamshire and Oxfordshire	63k	261	2%	976	1713	5%	10,162	3944	4%	9,663	5308	5%	1,044	877	3%	2,150	1781	4%	1,033	9239	4%	3,212
	Hampshire and Isle of Wight	37k	243	2%	909	732	2%	4,342	3074	3%	7,531	2891	3%	568	332	1%	814	1392	3%	808	8407	4%	2,922
	Kent	33k	407	4%	1,522	728	2%	4,319	3402	4%	8,335	2451	2%	482	227	1%	557	885	2%	513	4093	2%	1,423
	Surrey, East and West Sussex	55k	325	3%	1,215	1497	4%	8,880	4581	5%	11,223	4185	4%	823	349	1%	856	2124	5%	1,232	8660	4%	3,010
South West	Cornwall and Isles of Scilly	9k	235	2%	879	116	0%	688	758	1%	1,857	548	1%	108	239	1%	586	589	1%	342	983	0%	342
	Devon	19k	337	3%	1,260	393	1%	2,331	1525	2%	3,736	1776	2%	349	265	1%	650	951	2%	552	3293	1%	1,145
	Dorset and Somerset	22k	351	3%	1,312	361	1%	2,141	1751	2%	4,290	1557	2%	306	617	2%	1,513	899	2%	522	4777	2%	1,661
	Gloucestershire, Wiltshire and Bristol/Bath area	49k	385	4%	1,439	1479	4%	8,773	3464	4%	8,487	3447	3%	678	952	4%	2,334	1627	4%	944	11774	5%	4,093
Wales	East Wales	21k	129	1%	482	621	2%	3,684	1222	1%	2,994	1759	2%	346	798	3%	1,957	593	1%	344	5533	2%	1,923
	West Wales and The Valleys	29k	205	2%	766	1033	3%	6,128	1895	2%	4,643	2550	3%	501	508	2%	1,246	1065	2%	618	7207	3%	2,505
West Midlands	Herefordshire, Worcestershire and Warwickshire	27k	518	5%	1,937	591	2%	3,506	2002	2%	4,905	1547	2%	304	485	2%	1,189	820	2%	476	6747	3%	2,345
	West Midlands	43k	47	0%	176	770	2%	4,568	3177	3%	7,784	4558	5%	896	442	2%	1,084	1489	3%	864	11725	5%	4,076
	Shropshire and Staffordshire	30k	360	3%	1,346	839	2%	4,977	1993	2%	4,883	1853	2%	364	846	3%	2,074	982	2%	570	6356	3%	2,209
Yorkshire and The H	East Yorkshire and Northern Lincolnshire	25k	339	3%	1,267	1485	4%	8,809	1014	1%	2,484	1037	1%	204	664	2%	1,628	398	1%	231	4874	2%	1,694
	North Yorkshire	18k	538	5%	2,011	281	1%	1,667	933	1%	2,286	1184	1%	233	853	3%	2,092	826	2%	479	2567	1%	892
	South Yorkshire	21k	87	1%	325	517	1%	3,067	1604	2%	3,930	2332	2%	458	373	1%	915	517	1%	300	3735	2%	1,298
	West Yorkshire	44k	134	1%	501	1137	3%	6,745	2559	3%	6,269	3651	4%	718	1080	4%	2,648	1044	2%	606	7997	3%	2,780
Grand Total		**1305k**	**11k**	**100%**	**40k**	**36k**	**100%**	**214k**	**91k**	**100%**	**223k**	**99k**	**100%**	**19k**	**27k**	**100%**	**66k**	**44k**	**100%**	**26k**	**230k**	**100%**	**80k**

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