Research Project WR1508

"Scenario-Building for Future Waste Policy"

Final Report

July 2010-May2011

This research was commissioned and funded by Defra. The views expressed reflect the research findings and the author's interpretations. The inclusion of or reference to any particular policy in this report should not be taken to imply that it has, or will be, endorsed by Defra.

"Scenario-Building for Future Waste Policy" Final Report

Contents

1. Executive Summary

The project "Scenario-Building for Future Waste Policy" explores the future of UK waste. The project focuses on waste arisings from households, the commercial and industrial sector, as well as from construction and demolition. It deals with recycling (including composting), incineration and landfill as treatment options over the time horizons 2020 and 2030, with a view to 2050. Commissioned by the Department for Environment, Food and Rural Affairs, the project was undertaken by the consultancy Z_punkt The Foresight Company, supported by key advisors from Resource Futures and Brook Lyndhurst.

The scenarios and quantitative analysis are meant to provide input to the Government's Review of Waste Policies as well as provide guidance to long-term waste policy making. However, it is important to be aware that neither the scenarios nor their model data can predict the future. Instead, they are think pieces condensing reflections about future developments into consistent illustrations of possible paths to 2030. If regarded as such, they can provide a valuable basis for reflecting on long-term oriented policy measures.

A collaborative, qualitative approach to scenario building was combined with a quantitative model of future waste arisings and treatment shares in order to develop the scenarios. A series of four scenario-building workshops incorporated input from over 40 experts from both government and industry. For each scenario, a qualitative and narrative element describing a possible future world is supplemented by quantitative estimates from the model for key indicators such as waste arisings, composition and treatment. Some of the developments described in the scenarios include factors of an external nature which cannot be influenced by policy.

The four scenarios describe radically different futures, covering developments in fields such as economic growth, commodity markets, consumption patterns, waste treatment technology, and waste policy. The Reference Scenario depicts a world where current trends persist. Waste management does improve over time, but only incrementally. Waste arisings continue to become more and more de-coupled from GDP growth, reaching a total of 229 Mt. in 2030. The second scenario, Sustainability Turn, describes a world where the whole country (society, industry and politics) goes deep green, with an overall focus on waste avoidance. Change is fostered mainly by a shift in behaviour, an increase in community-led action, and strong waste legislation. With 208 Mt, this is the scenario with the lowest waste arisings in 2030, an increase of 6% over 2010. By contrast, High-Tech / Large-Scale Approaches describes an industry- and technology-led scenario that focuses on smarter ways of handling waste. This scenario envisions massive investments in new recycling technology and significant changes to the waste planning system. An overall recycling rate of 81% is achieved via the deployment of post-collection sorting and treatment facilities, rather than through a change in behaviour. For this scenario, overall waste arisings rise to 229 Mt by 2030. The scenario Unlimited Wastefulness shows the highest waste arisings, reaching 239 Mt in 2030, an overall increase of 21% over 2010. Here, an economic bust-and-boom cycle leads to a lag of societal and policy responses to waste problems, leaving the UK unable to adequately deal with higher long-term waste arisings.

None of the scenarios assumes an absolute reduction in waste arisings by 2030, while all of them assume some improvement in recycling rates and overall reductions in the amount of waste sent to landfill. Furthermore, reductions in biodegradable waste sent to landfill are achieved in all scenarios except Unlimited Wastefulness, where landfill continues to be a major treatment route. Exceptionally large reductions in waste sent to landfill are achieved for Sustainability Turn and High-Tech / Large-Scale Approaches. In the Reference Scenario, the amount of household waste[1] sent to landfill is reduced from 45% to 25% by 2030. All scenarios assume an increase in the amount of energy generated from waste. Producing energy from waste by incineration or anaerobic digestion is most important in High-Tech / Large-Scale Approaches, where investment security is considered a given and strong technological progress is achieved.

Political approaches and priorities to waste differ considerably between scenarios. The Reference scenario assumes that there are no significant changes to existing waste legislation and no new legislation is passed into law, either domestically or from an EU perspective. In Sustainability Turn, significant improvements in waste management are supported strongly by society itself, and strict policies for avoiding waste are implemented. Here, people are actively engaged in more sustainable behaviour and support a stricter waste policy. The scenario High-Tech / Large-Scale Approaches takes an entirely different approach. Crucially, the overall priority of waste policy shifts from waste avoidance towards waste treatment, with a complete policy and industry focus on developing high-tech, large-scale technology approaches to waste management. Unlimited Wastefulness is characterised by a lack of initiatives from both government and industry, in particular in the early stages of the scenario. Difficult economic conditions reduce concerns about waste and sustainability and create an unfavourable climate for investments in new treatment infrastructure and capacity.

In conclusion, the scenarios highlight that there are markedly different paths for future waste arisings. Which route is chosen will not be a question of opting for one of the scenarios alone as the direction of policy, but of developing resilient long-term strategies that answer to challenges occurring across the set of scenarios.

[1] 'Household waste' as reported in WasteDataFlow: includes waste from households and waste captured under Schedule 2 of the Controlled Waste Regulations arising from other sources (such as schools, hospitals, prisons, campsites, etc.).

2. Introduction

The Project WR1508 "Scenario-Building for Future Waste Policy"

What are possible and plausible future perspectives of waste in the UK, and what might this imply for UK waste policy? These questions were at the core of the project "Scenario-Building for Future Waste Policy" which aimed to anticipate future waste arisings and management options. Funded by the Department for Environment, Food and Rural Affairs (Defra), the project was run by the foresight consultancy Z_punkt The Foresight Company, supported by the key advisors Julian Parfitt (Resource Futures) and David Fell (Brook Lyndhurst). The results will serve as input to the current waste policy review and the long-term orientation of waste policy.

In order to understand what could happen until 2030, a set of scenarios with a quantitative element was developed for 2020 and 2030, with a view to 2050. These results of the project cover waste arisings and composition as well as treatment routes likely to occur in the future - based on alternative policy developments as well as external factors such as energy prices or GDP level.

The scenario set consists of one reference scenario (which assumes current trends to continue) as well as 3 alternative scenarios that describe different but plausible futures. This approach makes it possible to cover a wide range of possible futures and compare these alternative scenarios with the reference case, highlighting different drivers and potential development paths. Furthermore, a rough model led to estimates for waste arisings and management for each scenario, allowing for a benchmarking with other studies and / or countries as well as with current policy targets. Furthermore, potential shortfalls between planned and needed waste infrastructures such as landfill sites or recycling capacities can be anticipated. The scenarios' qualitative and quantitative descriptions cover the time horizons of 2020 and 2030; a view to 2050 is provided for the reference scenario only. The project focuses on household waste[2] (HH), the commercial and industrial sector (C&I), as well as from construction and demolition activities (C&D) and deals with recycling (including composting), incineration and landfill as treatment options.

Research Approach

Methodologically, a participative qualitative scenario process bringing together key experts and stakeholders was combined with a rough modelling approach.

Participative Process

About 40 experts from different institutions (Defra, WRAP, Imperial College, AEA, Georgeson Resources, Social Marketing Practice, Shanks, BAM Construct UK, Veolia Environment UK, South East Improvement & Efficiency Programme, Construction Products Association, Energy Technologies Institute and Nottingham University) with academic, industry and policy-making backgrounds provided contributions during four workshops as well as written feedback and

[2] 'Household waste' as reported in WasteDataFlow: includes waste from households and waste captured under Schedule 2 of the Controlled Waste Regulations arising from other sources (such as schools, hospitals, prisons, campsites, etc.).

one-to-one consultations. A stakeholder dialogue on future challenges and perspectives was thus established as a by-product of the project.

Qualitative Process Steps and Tasks

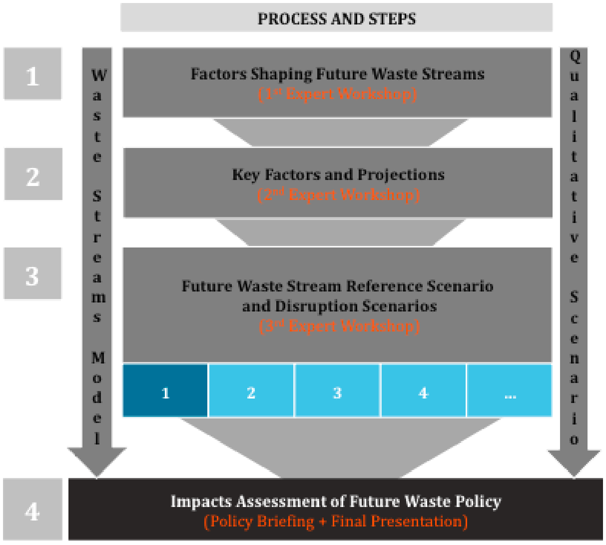

Figure 1: Overall Process and Steps

The project followed a four-step approach. In the first project step, the key factors shaping future waste streams were identified and their impacts on waste streams and treatment assessed as far as possible. Secondly, we identified plausible alternative projections (future developments) for each of the key factors until 2030. In the third stage, these served as "building blocks" for the scenario development. During phase four, a policy outlook for each scenario was developed, highlighting aspects of the scenarios which impact on future waste policies, and final feedback rounds with Defra as well as with external stakeholders were conducted (please refer to the Annex for detailed information on the approach and descriptions of key factors and projections). This morphological approach to scenario development makes the mechanisms of scenario development transparent, and does so systematically; it also makes it easy to update scenarios and re-visit individual elements of the process at a later stage.

Combined Qualitative and Quantitative Approach

Closely linked to the qualitative scenario development, a quantitative model was developed. First, parallel to the analysis of the key factors so-called parameters – i.e. the quantifiable elements of the key factors – were identified and available data collected. Next, each of the selected parameters was extrapolated into the future, with the qualitative projections determining the direction in which the parameters could develop under the specific conditions and assumptions of each scenario.

Quantitative Model Development

The model follows a three-step approach, with a core-model for arisings, composition and treatment. This core model, on a meta-level (for detailed information on the model, please refer to Section 5.2), consists of quantity factors (e.g. sectoral gross value added for commercial and industrial waste). These, in combination with area-specific waste intensity (the amount of waste per unit of quantity factor) define waste arisings within the scenarios. Quantity factors and waste intensities are influenced by waste policy and a set of various primary influencing parameters, such as fiscal, behavioural, and technological developments. Whereas most influencing parameters directly drive the level of waste intensity, waste composition, and treatment mix, the quantity factor is influenced by parameters such as economic structure or population size. Waste composition is differentiated for each waste area and, in case of C&I waste, for the industry, low-waste intense services, and high-waste intense services separately. The individual materials are managed according to their treatment rates (recycling, compost, EfW, landfill).

3. Think Pieces - Scenarios on the Future of Waste in the UK

Remarks on Limitations and Scope

The scenarios below depict a range of plausible alternatives of what our world could look like in the decades to come - focussing on future waste arisings and treatment in the United Kingdom to 2020 and 2030. As with all scenarios, it is important to stress that they are not predictions, but plausible descriptions of how the future may develop, based on a coherent and internally consistent set of assumptions about key relationships and driving forces.

All of them stem from the principle of enquiring about how the future could turn out, the "What if...?" question. The scenarios make well-founded assumptions about how key factors for the future of waste may interact to bring about alternative possible futures, and describe these alternative "pictures of the future" in a neutral as well as a narrative form. The narrative elements, written in a more journalistic style, are intended to make the scenario more directly accessible and provide a more of a colourful image rather than an abstract reflection of the future. Together with the more dispassionate descriptions, they are intended to stimulate a dialogue about future policy options and to inform long-term oriented decision-making concerning future waste policy.

But even if the scenarios cover a range of clearly different developments, they cannot cover all possible and imaginable paths. Rather, they highlight selected prototypical images of possible future developments, making future challenges visible and understandable within a range of more or less probable, not too extreme plausible future developments. And while they illustrate how the future could turn out, **they can neither provide an in-depth analysis of the complex interactions and relationships within the waste system, nor are they suited to, e.g., mapping out just how far-reaching and highly debated concepts such as sustainability may be implemented**. Thus, they imply the need for further analysis of adequate policy measures answering to short- as well as long-term demands. Furthermore, they lead to the question of what a "desired future" would be, i.e. a defined, clear vision of a "positive" future state of things to work towards.

Finally, it has to be highlighted that the model is in many cases based on assumptions made from fragmentary evidence (mostly surveys). Therefore, **the quantitative outcome for the scenarios is an indication,** illustrating implications for waste arisings and treatment.

In summary, neither the scenarios nor their model data can predict the future, but are think pieces condensing reflections about future developments into consistent illustrations of possible paths to 2030. If regarded as such, they can provide a basis for reflections on long-term oriented policy measures.

About the Set of Scenarios

The project identified a set of 4 scenarios that are the outcome of a collaborative reflection process, which systematically captured insights about the future and condensed them into cohesive stories. The scenario stories all describe radically different futures, covering developments in fields such as economic growth, commodity markets, consumption patterns, waste treatment technology, and waste policy.

Overview of Scenarios[3]

One of the scenarios answers the question "What if things don't change beyond current expectations?" bringing together existing trends that are mostly assumed to continue as well as existing policy frameworks, but no radical change: The Reference Scenario. This idea of an "extrapolated", i.e. surprise-free future, is contrasted with three disruption-based scenarios. One scenario paints a picture of a "Sustainability Turn", based on a paradigm shift towards greater resource efficiency and avoiding waste. The scenario "High-Tech / Large-Scale Approaches" is based on the principle of handling waste more smartly via technological and large-scale solutions, and the final scenario defines a future of "Unlimited Wastefulness", in which a bust-then-boom economical cycle leads to a lag of societal and policy responses to many waste problems.

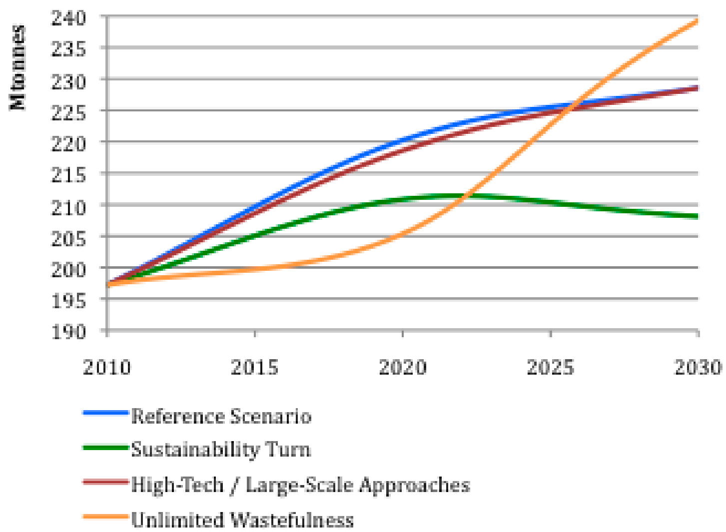

Figure 2: Scenario Overview by Total Waste Arisings 2010-2030

[3] The waste model calculates future waste arisings for the discrete time points 2020 and 2030, using an approach similar to economics comparative statistics. Hence, the graphs above describe the situation in 2020 and 2030 but not the actual development path between. For example, in reality lead times in the provision of recycling or EfW capacities cause sudden shifts of the shares of the different treatment options, once the capacities become available, thus resulting in a more crooked development path which could not be included in the model data in the scope of this project.

Scenario 1 – Reference Scenario

The scenario assumes that current trends continue. Change is evolutionary, with incremental improvements in waste management and behaviour over time. Waste arisings continue to become more and more de-coupled from GDP growth.

Total Waste Arising Estimates by 2030: 229 Mt

Scenario 2 – Sustainability Turn

The scenario pictures a future in which the entire nation (society, industry and politics) opts for deep green. Sustainable demand, industries and policies co-evolve. The focus is on the principle of avoiding waste.

Total Waste Arising Estimates by 2030: 208 Mt

Scenario 3 – High-Tech / Large-Scale Approaches

The scenario pictures a future in which high-tech approaches are regarded as the key to solving waste and resource problems, rather than a shift in behaviours and a dematerialisation of society. Waste amounts rise and there is a focus on dealing with waste more smartly.

Total Waste Arising Estimates by 2030: 229 Mt

Scenario 4 – Unlimited Wastefulness

The scenario depicts an overall strong increase in waste intensity and arisings. Change is driven by a period of economic stagnation, followed by rapid growth. The focus on economic growth causes a lag in the behavioural and policy response, causing stakeholders not to address waste issues.

Total Waste Arising Estimates by 2030: 239 Mt

Scenarios – Common Assumptions and 'Givens'

The scenarios below provide a range of plausible alternatives on what our world might look like in the decades to come. While the core of each scenario is different, they share some common assumptions about the future state of the world. These so-called 'givens' provide the framework on which the differences between the various scenarios are based. Such 'givens' can be a useful tool to reduce complexity and to underline that scenarios do not assume major wild cards such as a world war or a global pandemic.

All scenarios assume the following 'givens':

- **Stable Global Economic Development**
  All scenarios assume that world GDP grows by an average of about 3% annually until 2030. Regional growth may be variable and even negative for some period of time, but overall there is no global, long-term economic depression. A 3% growth rate roughly reflects the historic development over the past 100 years[4].
- **Increase of Global Population**
  Global population growth continues, reaching 8.3 billion by 2030. Population growth is strongest in developing and emerging economies. Population aging causes an increase in average global age[5].
- **No Severe Disruptions to Global Political Stability**
  The world stays politically stable. Regional conflicts do occur, but these do not cause larger wars or severe international disruption. The world is not hit by a major pandemic or any other severe disruption which negatively affect political, societal, or economical stability. Globalisation continues, with no long-term trade wars or strong protectionism. However, cases of temporary or regional market foreclosures for certain products and resources may occur.
- **Gradual Climate Change Happens**
  Climate change happens. Until 2030, the average global temperature rises by about 0.2 °C per decade, with limited direct adverse impacts on global growth and stability. However, the need for mitigation actions grows. Temperature and impact projections are based on a range of IPCC SRES emissions scenarios, as published in the Climate Change 2007 Synthesis Report[6].

[4] United States Department of Agriculture (2010)
[5] UN (2009)
[6] IPCC (2007)

Scenario 1 – Reference Scenario

Summary

The scenario broadly assumes that current trends continue, although not necessarily at the same rate as has been recently observed. Change is evolutionary, with incremental improvements in waste management and behaviour over time. Waste arisings continue to decouple from GDP growth, though at a declining rate. In 2030, the amount of waste in the UK has increased to 229 Mt and the recycling rate for household waste has increased to 54%, while that of commercial & industrial increased to 60%.

Main Scenario Characteristics

- The economy recovers with stable long-term growth
- Everyone shows some willingness to reduce waste and increase recycling rates
- Anticipated policy changes materialise – most EU and national targets are met
- Reduced pressure to change things fundamentally – evolution rather than revolution
- Waste arisings continue to become more and more relatively de-coupled from GDP growth.[7]

Narrative Storyline

It is the year 2030 - and not all that much has changed. We may have another female prime minister and Turkey is finally expected to join the EU, but the overall situation is very similar to that of 2010. However, everything is just that little bit better: people now care more about the environment and sustainability is popular among more social groups.

Change has not been radical or rapid, but incremental, with businesses and consumers steadily improving processes and behaviours. Trends in environmental awareness did continue, yet never boomed or accelerated, and they never resulted in a major change in behaviour. Without a major crisis or turnaround in societal paradigms, there was simply neither enough pressure nor desire to change things fundamentally.

Despite this, there has been a radical re-thinking of food waste. By 2020, global food prices had increased by nearly 40% from 2010 levels, and many were concerned over the security of national food supplies. Consumers and industry simply had to cut back on wasteful behaviour, and here, price pressures effected some behavioural changes. New technologies such as intelligent shelf-life indicators that provide accurate information on the freshness and safety of perishable food items have allowed consumers and retailers to better manage their food items and have over the past years contributed strongly to the prevention of food waste.

[7] The term decoupling describes a change in the correlation of GVA and waste arisings. Thereby, two types of decoupling are possible - absolute and relative. If the growth of waste arisings slows relatively to GVA growth, i.e. decreasing positive correlation, relative decoupling takes place. Absolute decoupling is realised once GVA grows and waste arisings do not correlate, i.e. if there is any degree of negative correlation between these two factors. Here, in the Reference Scenario, we assume relative decoupling, reflecting developments of recent years.

There have also been some advances in recycling. The landfill escalator is stopped as planned beyond 2014, however the increase in landfill tax to £80 made landfill by far the most expensive mass disposal option. Separate collections for paper, metal, plastic, and glass, as required in the EU Waste Framework Directive, have significantly increased the ability of local authorities to divert waste from landfill and that of the industry to better utilise waste materials. The decision to amend the definition of Municipal Solid Waste to include waste from the commercial and industrial sector which is similar to household waste, resulted in additional impetus for the development of new waste treatment infrastructure. However, due to long-term contracts and planning system constraints, capacities in many areas still do not fully meet demand. The EU target of 50% recycled household waste was barely met in 2020. Unfortunately, success in the management of electronic waste continues to be limited, and this remains the UK's fastest-growing waste stream. The recycling rate for WEEE from commerce and industry has increased only slightly from 72% to 75%, and only about half of the old IT equipment from households is being collected and treated according to the EU's 2012 revised WEEE Directive.

Over the past decades, waste prevention, better packaging, and incremental improvements in efficiency have all helped in the steady continuation of the de-coupling of waste arisings from GDP growth, putting us on the path towards the greener and more prosperous Britain we live in today. However, things are expected to become more challenging going forward, and there are many who warn that the changes that have happened are not enough – especially in the face of ongoing climate change. The latter has somehow "come closer" to the UK with a much greater number of extreme weather events. But without radical change, it will get harder for companies to find improvements which are simple to implement or promise easy gains. Executives are already complaining that unless there is strong investment, efficiencies will begin to reach their natural limitations and that policy and behaviour change must now be the primary target for further improvements. So, most would agree that 'slow and steady' hasn't won the race, and we still appear to be facing the same old underlying problems as two decades ago.

UK Socio-Economic Development

- **Economy:** Between 2011 and 2020, the UK economy grows by an average of 2.7% annually, followed by growth of slightly above 2.0% per year until 2030. GVA per capita continues to grow.
- **Industry Share:** The trade balance remains negative as the value of imported goods exceeds that of exports. Industry's share of GVA continues to decline, accounting for 12.5% in 2020 and 11.5% in 2030, while that of services increases. Within the service sector, high-waste-intense services' share (i.e. retail, restaurants) declines to 13.5% in 2030 (14.4% in 2020), and low-waste-intense services (i.e. education and financial intermediation) gain in importance (share in 2020: 65.8%; 2030: 68.2%).
- **Population:** The population continues to grow by around 0.6% annually, reaching 70.6 million people by 2030. The age structure shifts towards a greater proportion of older people. By 2030, 24% of the UK population are 60 years or older. Continued migration leads to an increasingly mixed and diverse population.

- **Society:** Income levels continue to rise steadily. The overall number of households increases, with a strong shift to one-person households among people aged 60 and over. Income inequality remains relatively stable. The unemployment rate is slightly reduced between 2009 and 2030.
- **Energy:** Primary energy demand and demand for electricity continue to rise. Fossil fuels still dominate primary energy supply. Even though a number of new nuclear power plants go online until 2030, nuclear capacity does not grow significantly, as new plants primarily replace older ones. Renewable energy systems continue to expand, providing 15% of total primary energy supply by 2020[8]. An increasing proportion of power generation is provided by Energy from Waste (EfW) and Anaerobic Digestion (AD) solutions.
- **Commodities:** Global demand for key commodities – in particular energy resources, minerals, metals and food – continues to rise, leading to steadily increasing prices. Price increases for food are particularly high, with regular intervals of strong price volatility.

Impact on Overall Waste Arisings and Treatment

- UK's total waste arisings grow by about 16% until 2030 to a total of 229 Mt, and the recycling and composting rate from 66% to 73%.
- The energy yield from waste increases by 108% to 880 kilotonnes of oil equivalent (ktoe), of which 14% result from anaerobic digestion.

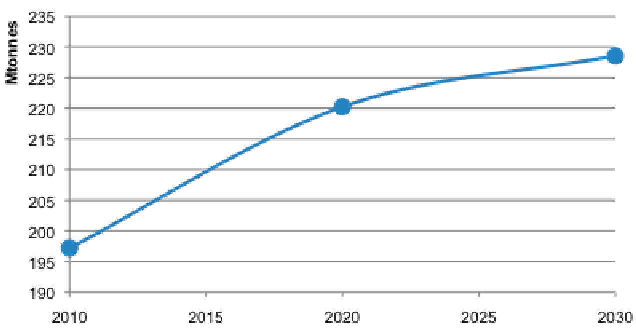

Figure 3: Reference Scenario: Total Waste Arisings

- **Waste Technology[9]:** The waste sector remains fragmented with no major breakthroughs in sorting or processing technologies. There is a trend towards more coordinated collection, but also a continued mismatch between recyclate supply and demand. The problem of the mismatch between planned and needed recycling capacity after the new definition of Municipal Solid Waste[10] could not be fully solved until 2030. Recycling infrastructure continues to be dominated by Household Waste, with limited use of co-treatment options for plants designed to accept both HH & C&I streams. Weight and quantity continue to be more important drivers for recycling than environmental aspects and the quality of material collected. EfW applications are pre-dominantly small-scale, with high regional variation in capacity and availability.

[8] No official data available for 2030.
[9] This study focussed on the exploration of possible future waste arisings in the UK. Therefore, the scenarios present technological advances in a descriptive manner rather than attempting a detailed evaluation of potential future waste technologies.
[10] Until 2010, the UK's definition of MSW included mainly just household waste, while most other EU member states also included waste which resembled household waste in composition, i.e. commercial and light industrial waste. Due to the changed definition the volume of MSW increases significantly, therefore also increasing the required treatment capacities to achieve set recycling targets.

Impact on Household Waste:

- With 29 Mt, UK's households produce slightly (3%) more waste in 2030 than they did 2010.
- On a per capita basis, the amount of waste is reduced. In 2030, each Briton produces 412 Kg of waste per year (2010: 453 Kg).

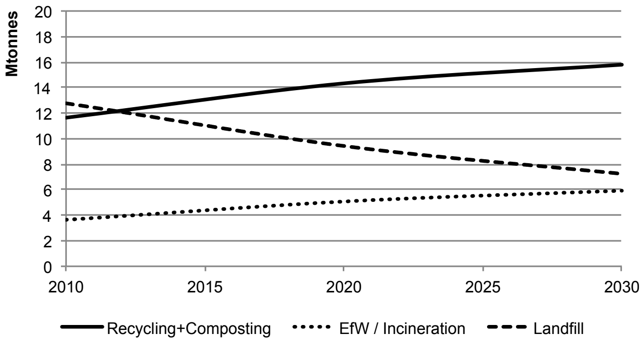

Figure 4: Reference Scenario: Household Waste, by Treatment 2010-2030

- The amount of HH waste that is sent to landfill is reduced, declining from 45% to 25% (7.2 Mt). In 2030, about half of the HH Waste (54%, or 15.8 Mt) is recycled and 20% (5.9 Mt) are incinerated for energy production.
- **Consumption / Waste Behaviour:** Disposable incomes keep increasing, as does the level of concern for the environment with more people responding to waste reduction campaigns. However, attitudes continue to be largely detached from behaviour. With more money to spend, consumption of goods and services increases, with services continuing to increase their share in the basket of goods[11]. In 2020, services account for 75% of all consumer expenditures, expanding further to 78% in 2030. The UK society continues to show a growing appetite for material possessions, with low levels of product re-use. This all results in a moderate level of annual waste intensity improvements of 0.9% per year until 2020 and 0.7% between 2021 and 2030.

[11] The basket of goods is a combination of a representative number of goods and services used to measure inflation. It is the basis for the calculation of the consumer price index. The importance of the various goods and services in the basket is weighed with the consumption shares of private households for the respective goods and services.

Impact on Commercial and Industrial Waste:

- The amount of C&I waste in the UK grows by 17% between 2010 and 2030, reaching a total of 72 Mt.
- While in 2010 about one third of C&I waste was sent to landfill, this share declines to 18% (12.6 Mt) in 2030. Recycling and composting is the mass treatment method most used in 2030 (60% or 43 Mt), up from 50% (30.6 Mt) in 2010. The amount of incinerated C&I waste grows slightly to 10.3 Mt (14%), 45% of which are used for energy production.

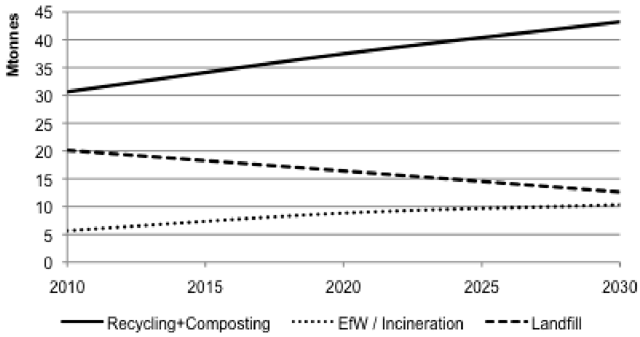

Figure 5: Reference Scenario: Commercial & Industrial Waste, by Treatment 2010-2030

- **Corporate Eco Behaviour:** Corporate eco-awareness is highly sector-specific and diverse, resulting in moderate waste reductions. Waste intensity declines by 1.0% per year until 2030. The implementation of environmental management systems is also highly sector-specific with little standardisation across industries and markets. Policy support for voluntary agreements for waste reduction continues at a stable level. Campaigns focus on information provision, education and expert support.

Impact on Construction and Demolition Waste:

- Between 2010 and 2030, the amount of C&D waste in the UK grows by 18% to 128 Mt.
- The landfill share declines from 17% in 2010 to 14% in 2030, while that of recycling increases to 84% (up from 82% in 2010).

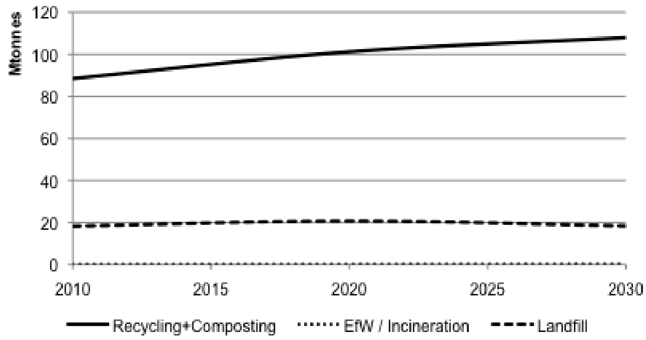

Figure 6: Reference Scenario: Construction & Demolition Waste, by Treatment 2010-2030

Demo-graphics	Socio-Economic Situation	Consump. Patterns + Environm. Behaviour	Economic Output	Economy Structure	Corporate Eco-Behaviour	Recycle & Reuse Capacities / Techn.	EfW Capacities / Techn.	Commodity Markets	Energy System	Dev. of LATS + Landfill Tax	Voluntary Improve-ments	System Support + Intervention
Stable Population Growth	Growing Affluence	Good Attitudes, Wasteful Behaviour	Steady Growth	Continued Shift to Services	Diverse Approaches	MSW Dominates Develop.	Small-Scale EfW	Steadily Increasing Prices	Slow Shift to Renew.	Gradual Tax Increases	Stable Support and Participation	Stable Legislation
Population Boom	Income Distribution	Strong Increase in Sustainable Consump.	Rapid Per Capita Growth	Resurgence of British Manuf.	Low Level of Concern and Efficiency	Coordinated Expansion	Large-Scale EfW	Open Markets and Stable Supplies	Nuclear Growth	Hammering of Landfill	Increase in Policy Driven Measures	Push for De-Regulation
Rapidly Ageing Population Stagnation	Inequality Reigns	Steady Buying Power, Conscious Choices	Bust-Boom Cycle	Centre of Excellence	Sustain-ability Drive	High-Tech, Focus on C&I Waste	De-Coupled Fuel Prod. and Consump.	High Prices and Strong Volatility	Zero Carbon Britain	Landfill Reduction and Incineration Tax	Decrease in Policy Measures / Industry Responses	More Legislation, more Standard-isation
	Poor Society	Low Consump. and Low Environm. Conscious Behaviour	Double Dip	Balancing		Low-Tech, Un-coordinated and Diverse		Closed Markets and Protec-tionism	Small-Scale Generation	Sophisti-cated, Materials-Based Approach	No Policy, but Strong Industry	
		High Consump. and Low Environm. Concious. Behaviour						Price Drop	Focus on Co-Firing and Fossil Fuels			

Figure 7: Reference Scenario: Morphological Box with Selected Projections

Morphological Box – Overview of Projections

Policy Outlook

Some progress is made in this scenario, but it is neither radical nor rapid. Existing targets for environmental protection and waste management will be met, but it is assumed that there will be no new EU nor UK targets nor significant new producer responsibility initiatives. Strategies pushing for a change in waste related behaviour have a limited impact, as attitudes continue to be detached from behaviour, apart from changes in the food waste area due to price pressure. Direct legislation is considered the most effective tool, but any measures taken are likely to be insufficient to drastically reduce waste arisings. Overall, opportunities for incremental improvements will reduce over time, as efficiency improvements hit their natural limits.

Scenario 2 – Sustainability Turn

Summary

The scenario pictures a future in which the whole country (society, industry, and politics) goes deep green. Sustainable demand, industries, and policies co-evolve. There is a focus on the principle of waste avoidance and greater resource efficiency. As a result, in 2030, the amount of waste accrued in the UK is only slightly higher than in 2010 and falling since the 2020s; totalling 208 Mt. Simultaneously, recycling and composting rates for household and commercial & industrial waste improve to 69% and 72%, respectively.

Main Scenario Characteristics

- Overall sustainability turn by society, industry, and politics
- Increasing concerns about climate change a strong driver
- Driven by a combination of political will and strict intervention, societal movement, and industry initiative
- High levels of involvement of communities and citizens at the local level
- Economic benefits cause widespread adaptation of industrial processes and foster needed investments
- Significant reduction in commercial and industrial and household waste
- UK on track to become an economy in which resources are valued and not wasted
- Focus on principle of waste avoidance and greater resource efficiency

Narrative Storyline

It is the year 2030 - and the UK is well and truly on the way to becoming an economy without what was once called waste. This does not mean that we no longer produce waste, but that most things we do produce are fully recycled or re-used. In fact, there has been a real push for manufacturers and product designers to design for waste prevention, improve product recyclability, and provide the option of refurbishment and upgrading. A major share of plastic packaging is now made of biodegradable and non-fossil materials - ready for composting. A chemical company, for instance, has just launched a new range of mushroom-based food packaging and most laptops are now made of sugar-based plastics. As a result, the opportunities for composting waste at home and at the community level have increased and the amount of industrial and household waste has been radically reduced.

Among consumers, it has now become the custom to share and swap products and not to buy new whenever the latest model is launched. The way of life has changed rather fundamentally – for example, many now share rarely used household items with their neighbours, and this is also promoted in new social housing developments by offering more shared spaces. Waste avoidance and re-use have the highest priorities. In response, many companies have adapted their business model to include much more services that focus on repairing or upgrading products.

After the financial crisis, times were relatively tough for a while. But communities grew together and there were many initiatives at the local level where central government facilitated cooperation. Today, also thanks to a tremendously improved understanding of environmental issues which came as the result of an education push in these matters, there continues to be much greater co-design of projects and involvement of local people in decision-making processes. Concerns about climate change across all classes and social settings were a major trigger. The government helped to facilitate local re-use networks and the community waste sector, by permitting third sector waste organisations to join forces. As a result, they improved their structures. Local councils offer "freecycle" initiatives and kerbside collection schemes, and community composting sites were opened in almost every council in the UK. These sites offer free compost in exchange for compostable waste.

When economic growth finally did kick off, people were already well engaged and interested in living what everyone considered to be better lives – it seems to have been the crisis that led to a fundamental and widespread re-consideration of what this might mean, and this paid off in environmental terms in most cases. Everybody appeared willing to act responsibly and think about – and change – the impact his or her lifestyle had on the environment and the long-term prospects of society. When demand for "green" or environmentally sound products grew, retailers and industry responded accordingly. Back then, corporate responsibility was big business and it still is so today, in spite of the major investments that had and have to be made. Only last week, a large supermarket chain announced their plans for further annual energy savings in the region of £27 million. Thanks to so much new insulation and other refurbishment measures, but also due to quite a bit of complete demolitions and reconstructions, our schools, hospitals and houses are now up-to-date in terms of energy efficiency. The renewal rate of the building stock has risen significantly in recent years. But our endeavour to improve the energy balance of buildings also led to an increase of waste from the construction and demolition sector, which, however, is recycled almost entirely.

But it wasn't the shift in behaviour and spending alone: Legislation played a major role. From 2015, there was a strong policy shift towards more targets, more support, and more strident rules around sustainability and waste. Because of the paradigm shift in awareness, people now fully supported and accepted this policy direction. A host of new domestic and EU targets were developed and implemented and extended producer responsibilities put into practice to a greater extent. The government introduced direct waste prevention incentives and increased the landfill tax significantly. Collection methods and the planning system were standardised to help local councils and people to manage waste better.

Britain has now entered a new era of responsibility, with a focus on local action, behavioural change, and a far-reaching concept of sustainability. This year, London is the official EU Capital of Sustainability. To mark the occasion, recyclable bicycle helmets have been introduced for the London cycle hire scheme, which now boasts over a million regular users, and the London Eye is run by solar power. But again, it is the people who really lead the way, with more than half of all London households pledging to significantly further reduce their household waste over the coming year. We are on track to becoming a prosperous low-waste economy.

UK Socio-Economic Development

- **Economy:** Between 2011 and 2020, we assume the UK economy to grow by an average of almost 3.3% per year, followed by a period of robust growth of 2.4% on average per year towards 2030. GVA growth significantly outpaces population growth, leaving the UK population much better off. Government spending is reduced.
- **Industry Structure:** By 2030, the UK has developed into a centre of excellence for high value R&D and niche products and services in sustainability and clean-tech. The shift towards more services in value creation accelerates. Industry's share of GVA is declining to 12% in 2020 and 10% in 2030. By contrast, services and especially low-waste-intense services (i.e. education and financial intermediation) gain in importance. Their share grows to 66.7% in 2020 and 69.5% in 2030, while that of high-waste intense services (i.e. restaurants and retail) declines to 13.9% in 2020 and 13.5% in 2030.
- **Population:** The population continues to grow by around 0.6% annually, reaching 70.6 million people by 2030. The age structure shifts towards a greater proportion of older people. By 2030, 24% of the UK population are 60 years or older. Continued migration leads to an increasingly mixed and diverse population.
- **Society:** Income inequality is significantly reduced. Unemployment is relatively low. The overall number of households continues to increase, with more households with people aged 60 and above. Although households continue to be smaller on average, there is a parallel development of more communal ways of living, some trends towards larger households (e.g. an increase of flat and house sharing out of choice rather than necessity alone) and more social housing designed to support connections and sharing between neighbours.
- **Energy:** The highest priority is on achieving strong carbon reductions. Efficiency improvements cause energy demand to stagnate. Fossil fuel use is minimised, there is a widespread deployment of carbon capture and storage technologies, and a rapid expansion of renewable power solutions, including Energy from Waste (EfW) and Anaerobic Digestion (AD)
- **Commodities:** Global demand for key commodities continues to rise. This, coupled with a limited expansion of supplies, leads to steadily increasing prices on world markets. Due to strong efficiency gains and a focus on renewable materials and energy, Britain is largely independent from globally rising prices.

Impact on Overall Waste Arisings and Treatment

- UK's total waste arisings grow significantly slower than in the reference scenario and even start declining in the 2020s, peaking somewhere around 210 Mt per year in the early 2020s.
- By 2030, waste arisings (208 Mt) are the lowest of the scenario portfolio, and overall recycling and composting rates have increased to 84%, the highest rate of all scenarios.

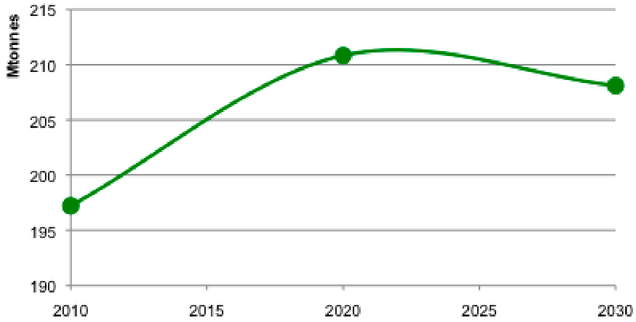

Figure 8: Sustainability Turn: Total Waste Arising 2010-2030

- The energy yield from waste increases by 60% to 670 kilotonnes of oil equivalent (ktoe), of which 25% result from anaerobic digestion.
- **Waste Technology:** Treatment infrastructure increasingly focuses on local requirements and is developed on a smaller scale. The waste sector consolidates, leading to a standardisation of collection methods and greater consideration of the specific requirements of C&I waste. The environmental aspects and quality of material collected are increasingly important and more widely understood by the general public, industry, and policy makers alike. Energy from waste (EfW) shows a strong increase in Anaerobic Digestion, but with high regional variation in capacity and availability.

Impact on Household Waste:

- With about 22 Mt, households produce significantly less waste in 2030 than they did in 2010 (-22%).
- On a per capita basis, amounts also show a decline. In 2030, each Briton produces 310 Kg of waste per year, compared to 453 Kg in 2010.
- The amount of HH waste that is sent to landfill is drastically reduced, dropping from 45% to 12%, or about 2.6 Mt in 2030. The lion's share (69% or 15.2 Mt) is recycled/composted, and 18% (4.0 Mt) are incinerated for energy production.

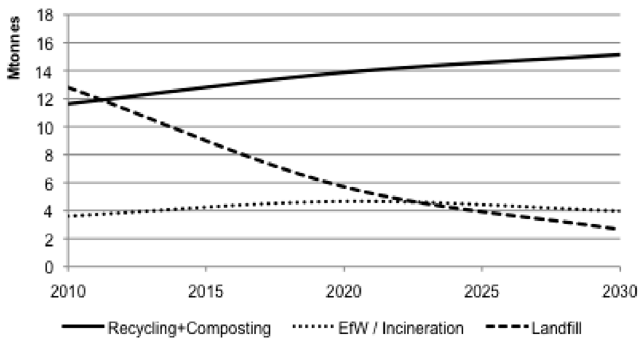

Figure 9: Sustainability Turn: Household Waste, by Treatment 2010-2030

- **Consumption / Waste Behaviour:** Peoples' buying patterns shift strongly to a consumption of more services and there is a trend towards dematerialisation, with more people trying to reduce the impact of their purchases. Renting instead of owning things becomes en vogue. The share of services in the basket of goods increases to 76% in 2020 and 79% in 2030. Households are actively committed to reducing waste, e.g. by boycotting packaging-intense products. Consumers show a real change in purchasing and consumption patterns, including high participation in recycling and high awareness of waste issues. The level of concern for the environment increases substantially. This all results in a high level of annual waste intensity improvements of 2.8% until 2020 and 2.1% between 2021 and 2030.

Impact on Commercial and Industrial Waste:

- Between 2010 and 2030, the amount of C&I waste in the UK declines significantly by 7%, totalling 57 Mt in 2030.
- Whereas in 2010, about a third of C&I waste was sent to landfill (33%), this share declines to only 8% (4.7 Mt) in 2030. On the other hand, more C&I waste is recycled and composted in 2030 (72% or 40.7 Mt). The amount of C&I waste that goes through incineration or EfW technologies grows slightly to ca. 7.1 Mt or 12%, 44% of which are used for energy production.

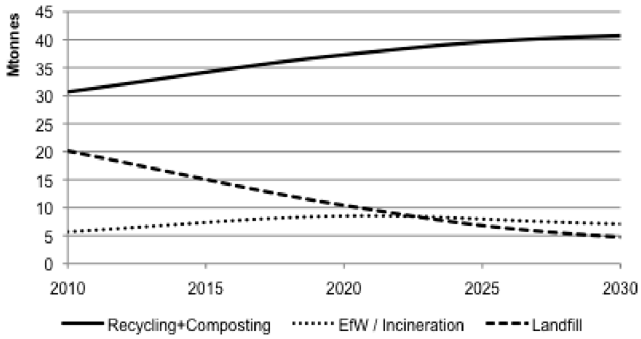

Figure 10: Sustainability Turn: Commercial & Industrial Waste, by Treatment 2010-2030

- **Corporate Eco Behaviour:** The UK economy develops a high level of corporate eco-awareness. This leads to widespread resource productivity gains and improvements in efficiency. Waste intensity declines by 2.4% annually between 2010 and 2020 and 2.2% per year afterwards. Use of sustainable and renewable materials increases significantly, while consumption of finite materials decreases.

Impact on Construction and Demolition Waste:

- The amount of C&D waste in the UK grows by 20% until 2030, to 129 Mt, with 92% being recycled (up from 82% in 2010), and 7% landfilled. The incineration/EfW share remains at less than 1%.

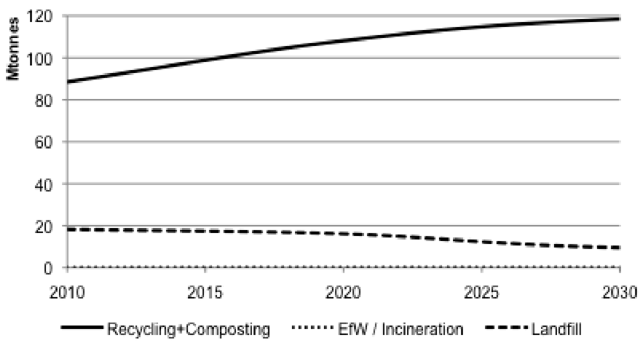

Figure 11: Sustainability Turn: Construction & Demolition Waste, by Treatment 2010-2030

Morphological Box – Overview of Projections

Demo-graphics	Socio-Economic Situation	Consump. Patterns + Environm. Behaviour	Economic Output	Economy Structure	Corporate Eco-Behaviour	Recycle & Reuse Capacities / Techn.	EfW Capacities / Techn.	Commodity Markets	Energy System	Dev. of LATS + Landfill Tax	Voluntary Improve-ments	System Support + Intervention
Stable Population Growth	Growing Affluence	Good Attitudes, Wasteful Behaviour	Steady Growth	Continued Shift to Services	Diverse Approaches	MSW Dominates Develop.	**Small-Scale EfW**	**Steadily Increasing Prices**	Slow Shift to Renew.	Gradual Tax Increases	Stable Support and Participation	Stable Legislation
Population Boom	**Income Distribution**	**Strong Increase in Sustainable Consump.**	**Rapid Per Capita Growth**	Resurgence of British Manuf.	Low Level of Concern and Efficiency	**Coordinated Expansion**	Large-Scale EfW	Open Markets and Stable Supplies	Nuclear Growth	**Hammering of Landfill**	**Increase in Policy Driven Measures**	Push for De-Regulation
Rapidly Ageing Population Stagnation	Inequality Reigns	Steady Buying Power, Conscious Choices	Bust-Boom Cycle	**Centre of Excellence**	**Sustain-ability Drive**	High-Tech, Focus on C&I Waste	De-Coupled Fuel Prod. and Consump.	High Prices and Strong Volatility	**Zero Carbon Britain**	Landfill Reduction and Incineration Tax	Decrease in Policy Measures / Industry Responses	**More Legislation, more Standard-isation**
	Poor Society	Low Consump. and Low Environm. Conscious Behaviour	Double Dip	Balancing		Low-Tech, Un-coordinated and Diverse		Closed Markets and Protec-tionism	Small-Scale Generation	Sophisti-cated, Materials-Based Approach	No Policy, but Strong Industry	
		High Consump. and Low Environm. Concious. Behaviour						Price Drop	Focus on Co-Firing and Fossil Fuels			

Figure 12: Sustainability Turn: Morphological Box with Selected Projections

Policy Outlook

Significant advances are achieved in this scenario with a strong drop in waste arisings and a push towards an economic system without waste. Policy focuses on more support for civil society, initiatives to increase social inclusion at the local level, and an overall strong shift in behaviour towards greater re-use and recycling. However, supported by societal awareness, strict and direct policy interventions remain the key to driving this radical change. Behaviour change is facilitated by targeted pressure on industry to improve resource efficiency and to shift use towards more biodegradable and recyclable materials. Landfill tax is accelerated beyond 2015 and there are strict environmental regulations. Waste policy focuses strongly (and with strict interventions) on avoidance and recycling, while existing environmental, waste, and climate change targets are met.

Scenario 3 – High-Tech / Large-Scale Approaches

Summary

The scenario pictures a future in which high-tech approaches are regarded as the key to solving waste and resource problems, rather than a shift in behaviours. Capacity development is highly coordinated, with a close relationship between (local) government and industry. In 2030, the UK produces about 229 Mt waste; household recycling and composting rates have been improved to 63%, for commercial and industrial waste to 71%.

Main Scenario Characteristics

- High commodity prices, business-case for recycling
- Remodelling of waste planning system (centralisation and standardisation)
- Close relationship between (local) government and industry
- Relaxation of planning procedures and increased investment security
- Rapid progress in waste sorting and processing technologies
- Expansion of (large-scale) high-tech recycling facilities
- The share of Energy from Waste (EfW) in the total primary energy supply increases
- Waste is a resource, landfill mining becoming profitable
- No push for behavioural change
- Rising waste amounts, with a focus on dealing with waste in a smarter way

Narrative Storyline

It is the year 2030 and waste is not really an obvious issue – at least not for the general public. In fact, for consumers, dealing with waste has never been easier. Today, household waste is collected frequently and the number of bins has been reduced to a minimum. Thanks to new sorting technologies, mixed collection of kitchen waste and all other types of waste, excepting paper and textiles, is no longer an issue for further processing.

The idea was simple: create more stringent targets and standards; compel industry to reduce the amounts of materials allowed for use in manufacturing processes; make sure that these materials and products are fully recyclable and can be easily disassembled; and build the infrastructure to sort and treat this waste as efficiently and effectively as possible.

In 2012, pressure from both the public and businesses against multiple bin collection was increasing considerably. Resistance by waste disposal companies and the general public interfered with the practical implementation of separate collections involving multiple bins. Some people even deliberately threw their rubbish into the wrong collection bins to protest against separation. Also, there was a central government policy preference for "fewer bin solutions" and Local Authorities – concerned about public pressure and re-electability – tendered only for waste management contracts that demonstrated ease of use for consumers and business and quality of service. Others, especially in industry, implemented collection systems with less bins out of the conviction that it was the better solution.

The biggest challenges were getting industry to invest into better recycling technologies and capacities and getting different local authorities to work together. In 2014, the government facilitated partnership working to foster a much closer relationship and better coordination between industry, local government, and municipalities. In a wholesale reform, institutional arrangements and responsibilities for waste streams were redefined and a centralised scheme for trading of waste was established. The proximity principle was softened to enable economies of scale. Along with this, measures were taken to harmonise household and commercial waste streams to increase and optimise the treatment streams and recovery rates and to provide further disincentives for landfill. A material-based landfill tax was introduced along with new landfill restrictions for valuable materials. This really opened up the market for recycling.

From here on, there was a much better and much more effective connection and cooperation between those who produce waste and the companies which know how to use it. Most importantly, there was investment security. Loans for new facilities were underwritten by the government, red tape was reduced, and guarantees were given that enabled longer-term contracts between waste producers and the waste treatment industry. These drivers pushed waste management companies to invest in high tech sorting facilities and to move back to fewer bin solutions with minimal to no requirements for householders or businesses to sort materials into different recycling streams.

In the 2020s, the push for a technology solution got its final boost. Energy and commodity prices skyrocketed, peak oil had been reached in 2017, and price levels for recyclates exploded. Large-scale, high-tech waste treatment facilities shot up all over the country. High energy prices also increased demand for EfW capacity, utilising types of waste not yet or entirely unsuitable for recycling, while providing the UK with greater energy security and independence. Initial concerns by residents and environmental groups over the large numbers of new treatment infrastructures were assuaged by improved and intense communication.

Today, more waste travels. Throw away a drinks can in London and it may end up in a treatment facility in Glasgow. There are small, regional pre-treatment facilities everywhere. Waste, especially waste containing higher value materials, is sorted, transported, and sorted again, until it reaches its final point of treatment. Large-scale applications are now much more effective than letting the consumer do all the work. Calls for behaviour change have become a thing of the past and no one worries about household recycling rates close to zero. While at the beginning, organic waste still had to be strictly sorted separately, households now put it in the same bin as cans, bottles, or plastic packaging. All they have to do is collect paper and textiles separately. Thanks to new sorting technologies, for instance based on micro-bacteria, organic waste has almost ceased to be an issue and contamination levels of recyclates are low.

Back in 2014, a plastic bottle was manufactured using three different types of plastic, which increased the necessary recycling efforts. Other plastic items, such as trays for ready meals, could not be recycled at all as they consisted of more than 30 polymer types. Today, plastic containers are composed of one type of plastic only, can be thrown into any bin, and are simply sorted out in one of the waste filtering processes that take place in pre-treatment and sorting facilities all over the country. A computer manufacturer recently marketed a 'designed for recycling/ disassembly' laptop that can be dismantled in under two minutes, with no tools necessary at the recycling facility. Some companies have even begun to consider landfill mining. With rare earth metals in great demand, landfills could suddenly turn into gold mines. Some technical issues remain, but the engineers are expected to find a solution.

However, a growing number of critics state that the troubles we've already had with volatile recyclates markets, leaving us with a bulk of partly unneeded secondary paper and plastic, are going to get worse as foreign buyers increasingly recycle domestically, leaving us unable to grow our own market. Furthermore, growing waste arisings will require a continuously increasing waste infrastructure level, which will eventually produce even more recyclates in the future.

UK Socio-Economic Development

- **Economy:** Between 2011 and 2020, the UK economy (GVA) grows by an average of 2.7% per year, followed by a growth of slightly above 2.0% per year until 2030.
- **Industry Structure:** The trade balance remains negative as the value of imported goods exceeds that of exports. Industry's share of GDP continues to decline, accounting for 12.0% of GVA in 2020 and 11.5% in 2030, while that of services increases to 81.7% in 2030 (2020: 80.8%). Thereby especially low-waste-intensive services (e.g. education and financial intermediation) gain in importance.
- **Population:** The population continues to grow by around 0.6% annually, reaching 70.6 million people by 2030. The age structure shifts towards a greater proportion of older people. By 2030, 24% of the UK population are 60 years or older. Continued migration leads to an increasingly mixed and diverse population.
- **Society:** Income levels continue to rise steadily and income inequality remains relatively stable. Overall, the number of households has increased, with a strong shift to one-person households among the middle-aged and households with people aged 60 and over.
- **Energy:** Primary energy demand and demand for electricity continue to rise. Concerns over energy security foster a strong increase in EfW. The UK experiences strong nuclear growth coupled with an expansion of renewables. Requirements for other fossil fuels in electricity generation are significantly reduced.
- **Commodities:** Global demand for key commodities increases rapidly. This, coupled with a limited expansion of supplies, leads to a strong increase in prices on world commodity markets. Markets are increasingly restricted. Price increases for energy and food are particularly strong and highly volatile. Demand for and prices of recyclates increase substantially, but remain coupled to overall commodity prices.

Impact on Overall Waste Arisings and Treatment

- UK's total waste arisings grow more or less in line with the reference scenario to about 229 Mt in 2030 (+16%).
- Overall recycling and composting rates are second highest in this scenario, with 81% in 2030.

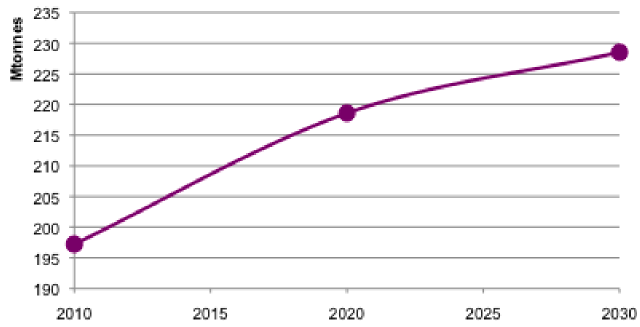

Figure 13: High-Tech / Large-Scale Approaches: Total Waste Arising 2010-2030

- The amount of energy yielded from waste treatment more than triples to over 1.300 kilotonnes of oil equivalent (ktoe) in 2030, of which 21% results from anaerobic digestion and the remaining 79% from incineration.
- **Waste Technology:** Major improvements in pre-treatment and waste sorting increase the quality and quantity of recyclates, in spite of co-mingled collection. The composition of waste changes, with fewer types of plastics and less variation in materials, which collectively enable more effective treatment. Over time, the growth of incineration/EfW slows, as more waste goes into recycling. The waste sector is increasingly consolidated. New recycling infrastructure is both high-tech and large-scale and balanced for household and C&I waste requirements. The development of energy from waste (EfW) capacity and infrastructure focuses on large-scale applications. Regional capacity and availability is coordinated. Where feasible, waste producers engage in large, long-term contracts with EfW capacity providers.

Impact on Household Waste:

- With about 31 Mt, UK's households in total produce significantly more waste in 2030 than they did back in 2010 (+11%).
- On a per capita basis, however, the amount has slightly declined. In 2030, each Briton produces 442 Kg of waste per year (2010: 453 Kg).

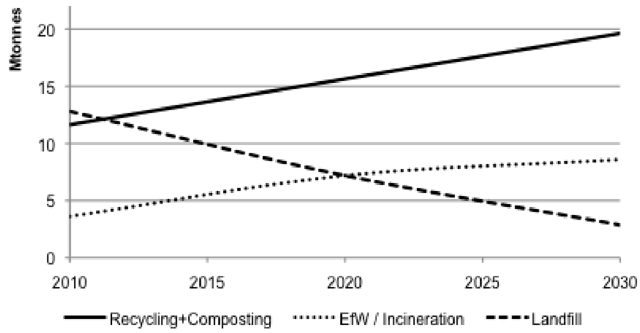

Figure 14: High-Tech / Large-Scale Approaches: Household Waste, by Treatment 2010-2030

- The amount of HH waste that is sent to landfill is dramatically reduced, declining from 45% in 2010 to only 9% or about 2.8 Mt. In 2030, a large majority (63%, 19.8 Mt) is recycled/composted, while 28% (8.5 Mt) are incinerated for energy production, the highest share and volume of all scenarios.
- **Consumption / Waste Behaviour:** Consumer behavioural changes are extremely limited, as people see no necessity for change and waste companies focus on post-collection sorting. Overall, society continues to show a growing appetite for material possessions, with low levels of product re-use. The share of goods in the basket of goods continues to decline moderately to 25% in 2020 and 22% in 2030. Overall, household waste intensity declines only marginally by 0.5% per year until 2020 and 0.4% per year between 2021 and 2030.

Impact on Commercial and Industrial Waste:

- Between 2010 and 2030, the amount of C&I waste in the UK grows by 22%, totalling 75 Mt in 2030.
- Whereas in 2010, about a third of C&I waste was sent to landfill (33%), the share declines strongly to only 5% (3.9 Mt) in 2030, the lowest share and volume of all scenarios. On the other hand, significantly more C&I waste is recycled and composted in 2030 (71% or 53.3 Mt). The amount of C&I waste that goes towards incineration or EfW technologies doubles to about 11.7 Mt or 16%, of which 45% are used for energy production.

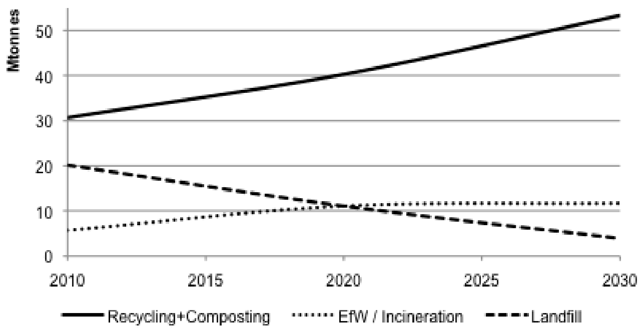

Figure 15: High-Tech / Large-Scale Approaches: Commercial & Industrial Waste, by Treatment 2010-2030

- **Corporate Eco Behaviour:** Corporate eco-awareness in the UK is highly sector specific and diverse. Industry-driven campaigns and voluntary agreements are highly influential in changing corporate waste behaviour. Some sectors show strong shifts in corporate culture and technological change to accommodate the new requirements in designing products suitable for recycling and easy disassembly. However, with economical incentives low, UK C&I waste intensity declines only slightly by 0.8% per year until 2030.

Impact on Construction & Demolition Waste:

- The amount of C&D waste in the UK grows by 14% until 2030 to a total of 123 Mt, with 91% recycled/composted in 2030 (112 Mt), and 7% landfilled (9.0 Mt). The share of incineration/EfW remains at less than 1%.

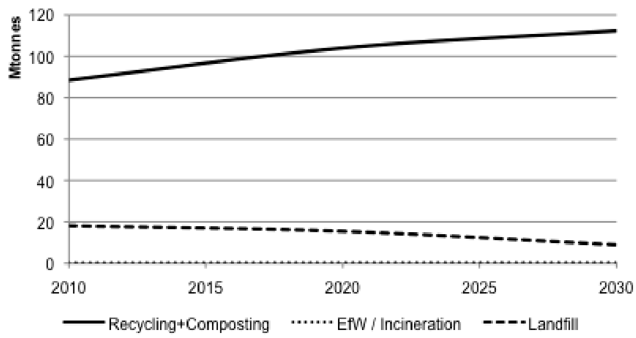

Figure 16: High-Tech / Large-Scale Approaches: Construction & Demolition Waste, by Treatment 2010-2030

Morphological Box – Overview of Projections

Demo-graphics	Socio-Economic Situation	Consump. Patterns + Environm. Behaviour	Economic Output	Economy Structure	Corporate Eco-Behaviour	Recycle & Reuse Capacities / Techn.	EfW Capacities / Techn.	Commodity Markets	Energy System	Dev. of LATS + Landfill Tax	Voluntary Improve-ments	System Support + Intervention
Stable Population Growth	**Growing Affluence**	**Good Attitudes, Wasteful Behaviour**	**Steady Growth**	Continued Shift to Services	**Diverse Approaches**	MSW Dominates Develop.	Small-Scale EfW	Steadily Increasing Prices	Slow Shift to Renew.	Gradual Tax Increases	Stable Support and Participation	Stable Legislation
Population Boom	Income Distribution	Strong Increase in Sustainable Consump.	Rapid Per Capita Growth	Resurgence of British Manuf.	Low Level of Concern and Efficiency	Coordinated Expansion	**Large-Scale EfW**	Open Markets and Stable Supplies	**Nuclear Growth**	Hammering of Landfill	Increase in Policy Driven Measures	Push for De-Regulation
Rapidly Ageing Population Stagnation	Inequality Reigns	Steady Buying Power, Conscious Choices	Bust-Boom Cycle	Centre of Excellence	Sustain-ability Drive	**High-Tech, Focus on C&I Waste**	De-Coupled Fuel Prod. and Consump.	**High Prices and Strong Volatility**	Zero Carbon Britain	Landfill Reduction and Incineration Tax	Decrease in Policy Measures / Industry Responses	**More Legislation, more Standard-isation**
	Poor Society	Low Consump. and Low Environm. Conscious Behaviour	Double Dip	**Balancing**		Low-Tech, Un-coordinated and Diverse		Closed Markets and Protec-tionism	Small-Scale Generation	**Sophisti-cated, Materials-Based Approach**	**No Policy, but Strong Industry**	
		High Consump. and Low Environm. Concious. Behaviour						Price Drop	Focus on Co-Firing and Fossil Fuels			

Figure 17: High-Tech / Large-Scale Approaches: Morphological Box with Selected Projections

Policy Outlook

The scenario is characterised by a policy and industry focus solely on developing high-tech, large-scale technology approaches to waste management. Initiatives concerning consumer behaviour change are reduced as resources are channelled into facilitating greater communication and dialogue between industry and local government. There is a policy push for de-regulation with a focus on streamlining planning applications and a reduction in red tape. At the same time, policy makers create more stringent targets and standards and introduce measures aimed at reducing material consumption in manufacturing processes. Remodelling the planning system also includes incentives for EfW and recycling, and a more centralised approach to planning, to ensure that arisings and treatment facilities are more closely matched. Higher waste materials in the waste stream travel much further across Britain and there is an increased focus on filtering and sorting waste post-collection. Bin and collection systems are simplified, with little or no need for consumers and industry to manage their own waste. So far, concerns over waste arisings are low as waste is increasingly considered a resource. However, this could easily return to the agenda due to increased pressure from unsolved problems within the recyclates markets and probably unmet climate change targets.

Scenario 4 – Unlimited Wastefulness

Summary

The scenario depicts an overall strong increase in waste intensity and arisings. Change is driven by a period of economic stagnation, followed by rapid growth. The focus on economic growth causes a lag in behavioural and policy response, leading stakeholders to not address waste issues and storing up long-term problems. As a result, the amount of waste in the UK grows significantly to a total of 239 Mt in 2030. With 44%, and 52% respectively, HH and C&I recycling rates are the lowest of all scenarios.

Main Scenario Characteristics

- Economic stagnation until 2017 with rapid economic growth afterwards
- Policy focus on economic growth – limited focus on waste reduction and sustainability
- Reduction of landfill tax rate even for active waste materials
- EU caught up in internal struggles, no push for strong policies
- Reduction in environmental concerns – expansion of status-driven, throw-away society
- High income inequality, but strong consumption at both high and low ends
- Significant increase in waste arisings and intensity

Narrative Storyline

It's 2030 – and waste is everywhere, but not on peoples' minds. Recycling rates are low, manufacturing processes are inefficient and waste treatment capacities have severely fallen behind the rapid increase in waste arisings. The UK society is extremely wasteful, but very few people are actually concerned about the amount of waste they produce. Having the latest mobile communicator is all that matters. Once a product is out of fashion, it's readily discarded - fashion moves on and so do consumers.

The roots of this development go back to 2011, when the economy really started to stagnate. People were a lot worse off than today. Incomes dropped and nearly four million people were unemployed. In some regions, average property values fell by more than one third. Back then, waste arisings actually went down. People had less money to spend and took much greater care of the things they owned.

In the 2015 election campaign, there was only one topic: which party had the better concepts to kick-start economic growth? The government then decided to focus on growth only. Out went the idea of a green economy. Corporate taxes were lowered to attract investment; even the Landfill tax rate was lowered to ease the burden on industry. With stable prices for commodities, nothing would now stop growth. In those days, wherever you looked, measures to foster growth replaced environmental and sustainability concerns.

The boom that followed reminded everyone of the economically prosperous mid- to late 80s and late 90s of the previous century – as the "growth-at-any-price" policies showed effect from 2017 on, UK's GVA grew by around 3% per year on average. In 2025, the prime minister stated that the UK was on track to once more compete with the world's biggest economies. Everything from waste management to construction was de-regulated. There were no more pushes for corporate responsibility, and climate change was low on the agenda. Manufacturing returned to the UK and exports grew. There could be no doubt that "Made in UK" and UK PLC were on the rise again.

But the sudden boom had its drawbacks. Income levels grew rapidly, but so did inequality. Many people have more money and consumption is high, but there is also a greater proportion of the population that are either very well off or near the poverty line. We truly live in a divided, wasteful, throw-away society. A far cry from the sustainable utopia people envisioned at the turn of the millennium.

So today, status is more important than looking after the environment or your neighbour. A push for sustainability would have been possible, but the sudden boom took industry, consumers, and even policy-makers by surprise. During the years of economic hardship efforts to improve environmental awareness had been severely neglected. Very few people cared about climate change or waste. With the initial reduction in waste arisings there was no incentive to invest in waste treatment capacities or draw up new waste policies in the 2010s. And with the landfill tax reduced, any remaining incentives died off completely. A massive acceleration in extractive industries operating in the UK created a plentiful supply of holes in the ground that could "easily" be filled with waste. All this laid the foundations for an economy, government, and society that was unprepared to manage the massive increase in waste arisings that came with the boom. Low levels of environmentally conscious behaviour and low waste treatment capacities set the stage for the wasteful society we live in today. We now scramble to improve sustainability and tackle the increasing mountains of waste, but for those who opposed this wasteful growth in the first place, it is too little, too late. Many sceptics now say: Only a crisis will end this mess.

UK Socio-Economic Development

- **Economy:** In the early 2010s, the UK economy experiences a period of recession. Post-2016, the economy recovers. However, economic growth (GVA) until 2020 reaches only 0.7% per year on average; even though growth rapidly accelerates from 2016 onwards. Between 2021 and 2030 an annual average growth rate of 2.8% per year is achieved. During this period, GVA per capita increases significantly, leaving the UK population generally better off in the long run.
- **Industry Structure:** Over the coming two decades, the UK economy experiences a period of rebalancing, both in terms of GVA by sector, export/import balance and geographic dominance. Industry's share of GVA grows to 15.5% in 2020 and 14% in 2030 through an increase in British manufacturing and investment incentives. The share of high-waste-intense services (e.g. retail and restaurants) remains stable at around 14%, while low-waste-intense services (e.g. education and financial intermediation) increase their shares slightly to 62.8% in 2020 and 64.9% in 2030.
- **Population:** During the economic stagnation, fewer people are born in the UK and migrate to the country than projected. Once the economy recovers, the country experiences an unexpected population boom. By 2030, 72.5 million people live in the UK. Growing migration, a slight increase in birth rates and a small drop in death rates then drive population growth. The age structure continues its upwards shift, with the trend slowing slightly by 2030.
- **Society:** Overall, average income levels rise considerably with more people in employment. However, the middle class continues to erode and income inequality increases substantially, with an ever wider divide between those at the top and those living near or below the poverty line. The shift towards older and one-person households continues.
- **Energy:** Primary energy demand and demand for electricity continue to rise. Fossil fuels still dominate primary energy supply and electricity generation. CCS equipped coal-fired power plants, gas-fired capacity and co-firing show particularly strong growth, while nuclear power capacity also increases.
- **Commodities:** Global demand for key commodities increases only slightly in the period until 2020. This, coupled with a strong expansion of supplies, leads to stable and in some cases decreased prices on world commodity markets. During this time, markets are increasingly open, with better integration of developing and emerging markets. As the economy in many countries booms in the 2020s, demand increases and the resources situation begins to worsen towards the end of the decade.

Impact on Overall Waste Arisings and Treatment

- In 2030, the UK's waste arisings total 239 Mt, making the scenario the most waste-intense of all scenarios. Compared to 2010, the amount of waste increases by 21%.
- At 67%, the overall recycling and composting rate is the lowest of all scenarios.

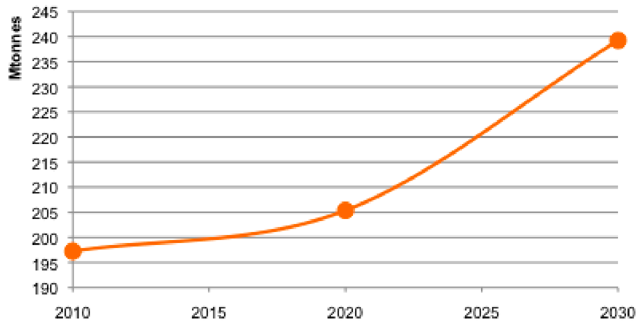

Figure 18: Unlimited Wastefulness: Total Waste Arising 2010-2030

- The energy yield from waste increases by 71% to about 720 kilotonnes of oil equivalent (ktoe), of which 93% result from incineration and only 7% from anaerobic digestion.
- **Waste Technology:** With a focus on growth and limited concerns about waste, less advanced, easy and cheap technology solutions are favoured. High-tech waste treatment is only applied where economically attractive. Limited incentives for treatment cause an increase in paper and plastics sent to landfill or being re-used as fuel. AD capacity is not expanded past 2015, as there are no incentives for investment. As a consequence, treatment infrastructure and technology for recycling and re-use in the UK develops in an uncoordinated manner. The waste sector is increasingly fragmented, leading to a further diversification of collection methods. EfW capacity is pre-dominantly small-scale, with high regional variation in capacity and availability.

Impact on Household Waste:

- With about 33 Mt, UK households produce significantly more waste in 2030 than they did in 2010 (+16%).
- On a per capita basis, the amount of waste remains fairly stable. In 2030, each Briton produces 450 Kg of waste per year (2010: 453 Kg).

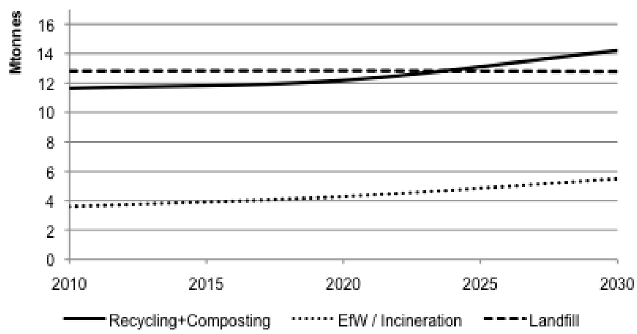

Figure 19: Unlimited Wastefulness: Household Waste, by Treatment 2010-2030

- The amount of HH waste landfilled remains comparably high, declining from 45% in 2010 to only 39% or 12.8 Mt, which is the highest share and amount of all scenarios. In 2030, less than half of the HH waste (44%, 14.2 Mt) is recycled/composted and the remaining 17% (5.5 Mt) are incinerated for energy production.
- **Consumption / Waste Behaviour:** A general lack of concern over waste leads to higher levels of WEEE, textile waste, and food waste as the economy recovers. Those able to afford

to do so take some purchasing decisions based on sustainability factors; "green status consumption" also exists to some degree. Over time, levels of sustainability-oriented behaviours and consumption increase with higher income levels. But with not many people really caring about the amount of waste they produce, waste intensity declines only marginally by 0.6% until 2020 and by even less afterwards (0.3% between 2020 and 2030).

Impact on Commercial and Industrial Waste:

- Between 2010 and 2030, the amount of C&I waste in the UK grows by 26%, reaching 77 Mt in 2030.
- Even though a major portion of C&I waste in 2030 is recycled (52%, 40 Mt), about one third (28%, 22 Mt) is still sent to landfill. Post-2020, in particular, the amount of waste that is incinerated grows significantly, reaching 9.4 Mt (or 12%) in 2030, 47% of which are used for energy production.

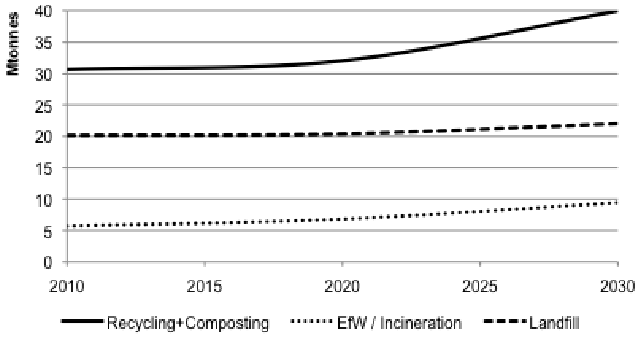

Figure 20: Unlimited Wastefulness: Commercial & Industrial Waste, by Treatment 2010-2030

- **Corporate Eco Behaviour:** During the recession, companies implement some efficiency gains in order to save money. However, only cheap and easy savings are realised. Overall, the UK economy is characterised by a low level of corporate eco-awareness, with low-level resource productivity gains only. The total amount of materials consumed by the UK economy grows significantly. C&I waste intensity declines only slightly by 0.6 % per year until 2020 and 0.4% per year afterwards. Policy support and funding for voluntary agreements for waste reduction decrease substantially. Industry does not fill the void and many campaigns and voluntary agreements eventually disappear or lose influence.

Impact on Construction and Demolition Waste:

- The amount of C&D waste in the UK grows by 20% until 2030, reaching a total of 129 Mt. The recycling share remains stable at 82% (106 Mt), while 17% are still landfilled (21.8 Mt). The share of incineration remains at less than 1%.

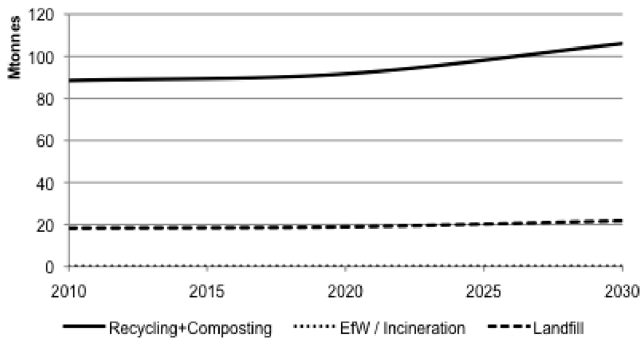

Figure 21: Unlimited Wastefulness: Construction & Demolition Waste, by Treatment 2010-2030

Morphological Box – Overview of Projections

Demo-graphics	Socio-Economic Situation	Consump. Patterns + Environm. Behaviour	Economic Output	Economy Structure	Corporate Eco-Behaviour	Recycle & Reuse Capacities / Techn.	EfW Capacities / Techn.	Commodity Markets	Energy System	Dev. of LATS + Landfill Tax	Voluntary Improve-ments	System Support + Intervention
Stable Population Growth	Growing Affluence	Good Attitudes, Wasteful Behaviour	Steady Growth	Continued Shift to Services	Diverse Approaches	MSW Dominates Develop.	**Small-Scale EfW**	Steadily Increasing Prices	Slow Shift to Renew.	**Gradual Tax Increases**	Stable Support and Participation	Stable Legislation
Population Boom	Income Distribution	Strong Increase in Sustainable Consump.	Rapid Per Capita Growth	**Resurgence of British Manuf.**	**Low Level of Concern and Efficiency**	Coordinated Expansion	Large-Scale EfW	**Open Markets and Stable Supplies**	Nuclear Growth	Hammering of Landfill	Increase in Policy Driven Measures	**Push for De-Regulation**
Rapidly Ageing Population Stagnation	**Inequality Reigns**	Steady Buying Power, Conscious Choices	**Bust-Boom Cycle**	Centre of Excellence	Sustain-ability Drive	High-Tech, Focus on C&I Waste	De-Coupled Fuel Prod. and Consump.	High Prices and Strong Volatility	Zero Carbon Britain	Landfill Reduction and Incineration Tax	**Decrease in Policy Measures / Industry Responses**	More Legislation, more Standard-isation
	Poor Society	Low Consump. and Low Environm. Conscious Behaviour	Double Dip	Balancing		**Low-Tech, Un-coordinated and Diverse**		Closed Markets and Protec-tionism	Small-Scale Generation	Sophisti-cated, Materials-Based Approach	No Policy, but Strong Industry	
		High Consump. and Low Environm. Concious. Behaviour						Price Drop	**Focus on Co-Firing and Fossil Fuels**			

Figure 21: Unlimited Wastefulness: Morphological Box with Selected Projections

Policy Outlook

In this scenario, there is no policy push for stricter legislation and waste arisings rise substantially. Even though, as a result of low economic growth, there was little waste increase, existing environmental and waste targets for 2020 are not met. For 2030 and beyond, the direction of development does not match the desired direction of most National Performance Indicators.

Support for waste policy is reduced as governments focus on enabling economic growth. Measures include a reduction in landfill tax for high cost materials and in some regions relaxed planning systems lead to the expansion of landfill capacity. Waste policy takes a secondary role to economic targets. As a result, environmental and waste policy remains dormant, resulting in a policy scramble and emergency measures once waste arisings and inefficiencies reach probelmatic levels. Addressing consumer behaviour continues to be a challenge as a reduction in investments in campaigns and voluntary agreements leaves society wholly unprepared for the impacts people's actions are having. The deregulation of the waste sector and the failure of an "end-of-pipe" pollution regulation result in higher cost at a later point. Especially, with regard to landfill, leachate and methane cause problems. Large clean-up programmes might have to be set up.

A View to 2050 – the Extended Reference Scenario

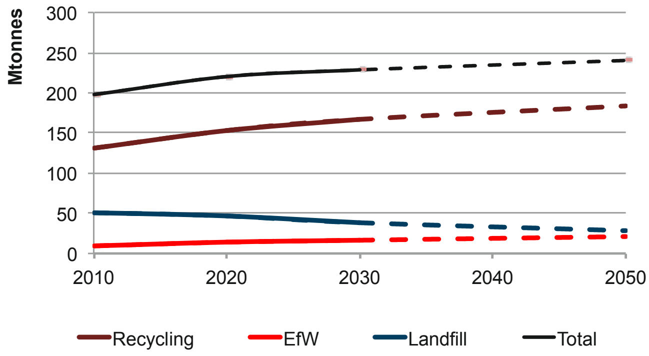

Figure 22: Extended Reference Scenario, Waste Arisings by Waste Area, 2010-2050

When considering this view to 2050, we have to take into account that the longer the time horizon, the more speculative assumptions about technological, social, and economical developments become. However, the current long-term orientation, e.g. in climate change mitigation and adaptation policy, makes reflections on 2050 necessary for many policy arenas, including waste. Thus, we opted for a conservative approach when covering this time horizon. The data provided here comes from an extrapolation of data based on the reference case assumptions of moderate economic growth and rather stable population growth, showing the likely outcomes if developments are extended to 2050. No new policies are assumed for this rough view to 2050, and waste intensities are set to continue to increase at a rate of 0.6% per year for households, and 1.0% for both C&I and C&D.

Economy and Society

- For the time period between 2031 and 2050, the extended reference scenario expects the UK's solid economic performance to continue. GVA is estimated to grow at 1.8% per year on average.
- At the same time, population growth in the UK will continue at a rate of 0.48% per year (slightly less than 2010-2030). As a result, Britain will have some 77.6 million inhabitants by 2050. Large migration inflows and slightly increasing birth rates will lead to a slow decline in the share of people aged 60 years and older to less than 24%.

Waste Arisings and Treatment

- Overall, waste arisings continue to increase, totalling 240 Mt in 2050. However, while waste arisings grow by 16% between 2011 and 2030, their growth is significant slower between 2031 and 2050 (+5%).
- Britons produce less household waste on a per capita basis towards 2050. The amount per capita and year drops below 400 kg to 388 kg. Overall, the amount of household waste continues to grow at a very moderate rate (+3.7% between 2031 and 2050).
- The share and amount of waste destined for landfill continues to decline. For household waste, the landfill share in 2050 is 14%, for waste from the commercial and industrial sector 9%, and 13% for construction and demolition waste.
- On the other hand, the trend towards more recycling persists. In 2050, 60% of all household waste is recycled, 66% of that from commerce and industry, and 86% of that resulting from construction and demolition activities.

- In 2050, slightly more household (+6% points to 26% of total HH) and commercial and industrial waste (+3%points to 17% of C&I) is incinerated than in 2030, while the share for C&D remains at less than 1%.

Overview of Key Scenario Characteristics and Data

	Data Today[12]	Reference Scenario	Sustainability Turn	High-Tech / Large-Scale Approaches	Unlimited Wastefulness
Scenario Core	n.a.	The scenario assumes current trends to continue.	The entire nation (society, industry, and politics) opts for deep green.	High-tech approaches are regarded as the key to solving waste and resource problems, rather than a shift in behaviours.	Overall waste intensity and arisings increase strongly due to an early period of economic stagnation.
Key Characteristics	n.a.	- The economy recovers with stable long-term growth - Everyone shows some willingness to reduce waste and increase recycling rates - Anticipated policy changes materialise – most EU and national targets are met - Reduced pressure to change things fundamentally – evolution rather than revolution - Waste arisings continue to become more and more relatively de-coupled from GDP growth.	- Overall sustainability turn by society, industry, politics - Driven by a combination of political will, societal movement, and industry initiative - High levels of involvement of communities and citizens at the local level - Economic benefits cause widespread adaptation of industrial processes and foster needed investments - Significant reduction in commercial and industrial, as well as household waste - UK on track to become a wasteless economy - Focus on principle of waste avoidance and greater resource efficiency.	- High commodity prices, business-case for recycling, waste is considered a resource - Remodelling of waste planning system; increased investment security - Close relationship between (local) government & industry - Changed EU Waste Framework Directive; source-separation not mandatory - Rapid progress in sorting and processing technologies - Expansion of (large-scale), high-tech recycling facilities - The share of Energy from Waste (EfW) increases - No push for behavioural changes - Rising waste amounts with a focus on smarter ways of dealing with waste.	- Economic stagnation until 2017, with rapid economic growth onwards - Policy focus on economic growth – limited focus on waste reduction and sustainability - Reduction of landfill tax rate for active waste materials - EU caught up in internal struggles, no push for strong policies - Reduction in environmental concerns – expansion of status-driven, throw-away society - High income inequality, but strong consumption at both high and low ends of society - Significant increase in waste arisings and intensity.

[12] Extrapolated data, based on latest available data (for further information on data availability, please refer to the detailed model approach description in Section 5.2)

	Data Today[13]	Reference Scenario		Sustainability Turn		High-Tech / Large-Scale Approaches		Unlimited Wastefulness	
Main Driver / Trigger / Turning Points	n.a.	- Current waste policies remain stable (at EU and national level) - Moderate levels of environmental behaviour and climate change concerns (in society & industry) - No major breakthroughs in sorting and processing technologies.		- Increasing environmental concerns (society & industry as well as government) - Very strict environmental / waste legislation, with main focus on avoidance - Greater producer responsibility and investments into sustainable processes - Strengthening of local communities.		- High public and business pressure against sorting into multiple bins drives changes in waste management & investment in facilities for high-tech solutions - Growing commodity prices, which create a business case for recyclates - Reform of planning system - Major advances in recycling technologies - Investment security.		- A period of economic stagnation which initially causes a slower growth of waste arisings - A policy focus on reinvigorating economic growth, also at the cost of environmental issues - Lacking sense of responsibility in society, industry, and policy-making in terms of environmental footprints, driven by a short-term fixation.	
Overall Waste Arisings	**2010**: 197 Mt	**2020**: 220 Mt (+12%, Rank 4) **2030**: 229 Mt (+16% Rank 3)		**2020**: 211 Mt (+7%, Rank 2) **2030**: 208 Mt (+6% Rank 1)		**2020**: 219 Mt (+11%, Rank 3) **2030**: 229 Mt (+16% Rank 2)		**2020:** 205 Mt (+4%, Rank 1) **2030**: 239 Mt (+21%, Rank 4)	
HH Waste Arisings	**2010:** 28.2 Mt	**2020**: 29.0 Mt (+2.8%) **2030**: 29.1 Mt (+3.3%)		**2020**: 24.3 Mt (-13.5%) **2030**: 21.9 Mt (-22.4%)		**2020**: 30.1 Mt (+7%) **2030**: 31.2 Mt (+10.8%)		**2020**: 29.4 Mt (+4.5%) **2030**: 32.6 Mt (+15.8%)	
HH Treatment Shares	**2010**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**
Recycling	41%	50%	54%	57%	69%	52%	63%	41%	44%
Landfill	45%	33%	25%	23%	12%	24%	09%	44%	39%
EfW/Incin.	13%	18%	20%	19%	18%	24%	27%	15%	17%
HH Waste Arisings per Capita[14]	**1996:** 465 Kg **2000**: 509 Kg **2005**: 504 Kg **2010**: 453 Kg	**2020:** 435 Kg	**2030:** 412 Kg	**2020:** 366 Kg	**2030:** 310 Kg	**2020:** 453 Kg	**2030:** 442 Kg	**2020:** 453 Kg	**2030:** 450 Kg

[13] Extrapolated data, based on latest available data (for further information on data availability, please refer to the detailed model approach description in Section 5.2)

[14] Data for 1996, 2000, 2005 for England, for 2010 UK

	Data Today[15]	**Reference Scenario**		**Sustainability Turn**		**High-Tech / Large-Scale Approaches**		**Unlimited Wastefulness**	
HH Waste Intensity Improvement p.a.	n.a.	**2010-20:** 0.9%	**2021-30:** 0.7%	**2010-20:** 2.8%	**2021-30:** 2.1%	**2010-20:** 0.5%	**2021-30:** 0.4%	**2010-20:** 0.6%	**2021-30:** 0.3%
C&I Waste Arisings	**2010:** 61.1 Mt	**2020:** 67.9 Mt (+11%) **2030:** 71.6 Mt (+17%)		**2020:** 60.9 Mt (-0.4%) **2030:** 56.9 Mt (-7%)		**2020:** 67.5 Mt (+10%) **2030:** 74.6 Mt (+22%)		**2020:** 64.1 Mt (+5%) **2030:** 77.3 Mt (+26%)	
C&I Treatment Shares **Recycling** **Landfill** **EfW/Incin.**	**2010** 50% 33% 09%	**2020** 55% 24% 13%	**2030** 60% 18% 14%	**2020** 61% 17% 15%	**2030** 72% 08% 12%	**2020** 60% 16% 16%	**2030** 71% 05% 16%	**2020** 50% 32% 11%	**2030** 52% 28% 12%
C&I Waste Intensity Improvement p.a.	n.a.	**2010-20:** 1.0%	**2021-30:** 1.0%	**2010-20:** 2.4%	**2021-30:** 2.2%	**2010-20:** 0.8%	**2021-30:** 0.8%	**2010-20:** 0.6%	**2021-30:** 0.4%
C&D Waste Arisings	**2010:** 108 Mt	**2020:** 123 Mt (+14%) **2030:** 128 Mt (+18%)		**2020:** 126 Mt (+16%) **2030:** 129 Mt (+20%)		**2020:** 121 Mt (+12%) **2030:** 123 Mt (+14%)		**2020:** 112 Mt (+04%) **2030:** 129 Mt (+20%)	
C&D Treatment Shares **Recycling** **Landfill** **EfW/Incin.**	**2010** 82% 17% <1%	**2020** 82% 17% <1%	**2030** 84% 14% <1%	**2020** 86% 13% <1%	**2030** 92% 07% <1%	**2020** 86% 13% <1%	**2030** 91% 07% <1%	**2020** 82% 17% <1%	**2030** 82% 17% <1%

[15] Extrapolated data, based on latest available data (for further information on data availability, please refer to the detailed model approach description in Section 5.2)

	Data Today[16]	Reference Scenario		Sustainability Turn		High-Tech / Large-Scale Approaches		Unlimited Wastefulness	
C&D Waste Intensity Improvement p.a.	n.a.	**2010-20:** 1.0%	**2021-30:** 1.0%	**2010-20:** 1.4%	**2021-30:** 1.4%	**2010-20:** 1.2%	**2021-30:** 1.2%	**2010-20:** 0.5%	**2021-30:** 0.5%
GVA, Annual Growth Rates	n.a.	**2010-20**: 2.7% **2021-30**: 2.0%		**2010-20:** 3.3% **2021-30:** 2.4%		**2010-20:** 2.7% **2021-30:** 2.0%		**2010-20:** 0.7% **2021-30**: 2.8%	
Sectoral GVA Shares: **Industry:** **Low-waste-intense services:** **High-waste-intense services:**	**1991:** 24.2% 52.9% 14.2% **2000:** 19.7% 58.1% 15.3% **2010:** 14.2% 63.5% 14.5%	**2020** 12.5% 65.8% 14.4%	**2030** 11.5% 68.2% 13.5%	**2020** 12.0% 66.7% 13.9%	**2030** 10.0% 69.5% 13.5%	**2020** 12.0% 66.9% 13.9%	**2030** 11.5% 68.2% 13.5%	**2020** 15.5% 62.8% 14.0%	**2030** 14.0% 64.9% 14.0%
Population Estimates	**1990:** 57.2 **2000:** 58.9 **2010:** 62.2	**2020:** 66.5 mil. **2030:** 70.6 mil.		**As in Reference Scenario**		**As in Reference Scenario**		**2020**: 64.9 mil. **2030:** 72.5 mil.	
CPI Shares **Goods / Services**	**1996:** 39 % / 61% **2000:** 34 % / 66 % **2005:** 30 % / 70 % **2010:** 29 % / 71 %	**2020** 25% / 75%	**2030** 22% / 78%	**2020** 24% / 76%	**2030** 21% / 79%	**2020** 25% / 75%	**2030** 22% / 78%	**2020** 30% / 70%	**2030** 26% / 74%

[16] Extrapolated data, based on latest available data (for further information on data availability, please refer to the detailed model approach description in Section 5.3)

Overview of Targets and Desired Directions of Developments per Scenario

EU Targets	Origin	Reference Scenario	Sustainability Turn	High-Tech / Large-Scale Approaches	Unlimited Wastefulness
Increase recycling rate for household waste to 50% by 2020	**EU Waste Framework Directive**	**□ 50%**	**□57%**	**□52%**	**□ 41%**
Increase recycling rate for construction & demolition waste to 70% by 2020	**EU Waste Framework Directive**	**□82%**	**□86%**	**□86%**	**□82%**
Collect 4kg WEEE per capita from households by 2012[17]	**EU WEEE Directive**	**(2020: 4.77 kg p. c.)**	**(2020: 4.81 kg p. c.)**	**(2020: 5.46 kg p.c.)**	**(2020: 4.07 kg p.c.)**
Reduction of biodegradable municipal waste (BMW) landfilled by 65% until 2020 compared to 1995[18]	**EU Landfill Directive (1999)**	□(4,760 kt biodegradable household waste landfilled in 2020)	□ (2,620 kt biodegradable household waste landfilled in 2020)	□ (3,390 kt biodegradable household waste landfilled in 2020)	□ (6,370 kt biodegradable household waste landfilled in 2020)
Waste generation stabilised by 2012 (vs. 2008 level)/ declining after 2020	**EU Waste Framework Directive**	□	□	□	□

[17] Scenario assessment in brackets because of its very limited informative value (comparing 2020 data with a 2012 target). The other elements of directive 2002/96/EC are not covered here as there is no match in our model data. Furthermore, a proposal for a revised directive on WEEE has been submitted to the European Parliament to alter the collection target from 4 kg per annum per inhabitant to a 65% collection rate, calculated according to the average weight of electrical and electronic equipment placed on the market over the two previous years in each Member State. This proposed target cannot be assessed on the basis of the quantitative estimates calculated for this project, as there are no assumptions on the average weight of electrical and electronic equipment placed on the market in any year in the UK.

[18] The model projects household waste arisings which are only one part of MSW. Thus, actual MSW arisings would be higher. Under the former definition of MSW, the 2020 target for BMW (in the model context: food, other biodegradable, paper+card, wood) to landfill was 6,390 kt. At a rough estimate, the BMW target would be missed clearly in the Unlimited Wastefulness scenario, while target achievement appears plausible in the Reference scenario and definite in the Sustainability and High-Tech scenarios.

Illustrative performance indicators	Desired Direction of Travel	Reference Scenario	Sustainability Turn	High-Tech / Large-Scale Approaches	Unlimited Wastefulness
Household waste per capita after re-use, recycling and composting (kg)	↓	↓↓	↓↓↓	↓	←→
Household re-use, recycling and composting (%)	↑	↑↑	↑↑↑	↑↑↑	↑
Waste arisings – (by key sectors – municipal, commercial and industrial) (tonnes)	↓	↑↑	↓↓	↑↑	↑↑↑
Municipal waste recovery (%)	↑	↑↑↑	↑↑↑	↑↑↑	↑↑↑
Waste re-used, recycled or composted – (by key sectors – municipal, commercial and industrial) (%)	↑	↑↑	↑↑↑	↑↑↑	↑
Energy recovered from waste (tonnes of oil equivalent)	↑	↑↑↑	↑↑↑	↑↑↑	↑↑↑
Waste landfilled – (total and by key sectors – municipal, commercial and industrial, construction and demolition)	↓	↓↓	↓↓↓	↓↓↓	↓
Total non-municipal/non-inert waste landfilled (tonnes)	↓	↓↓	↓↓↓	↓↓↓	↓
Biodegradable municipal waste landfilled (tonnes) Target	↓	↓↓↓	↓↓↓	↓↓↓	↓↓

Illustrative performance indicators	Desired Direction of Travel	Reference Scenario	Sustainability Turn	High-Tech / Large-Scale Approaches	Unlimited Wastefulness
Public awareness of recycling (% – committed recyclers)	↑	↑↑	↑↑↑	←→	↓

Colour Codes						
target achieved/strong development in desired direction	target achieved/clear development in desired direction	target achieved/some development in desired direction	situation remains unchanged	target not achieved/some development contrary to desired direction	target not achieved/clear development contrary to desired direction	target not achieved/ strong development contrary to desired direction

4. Synthesis & Conclusion

The futures described in the scenarios above are all radically different. Each stems from a different set of determining factors, highlighting the multitude of factors that play a role in shaping the future of the UK waste system as well as the option space for change going forward. They differ markedly in terms of their socio-economic profile, their future waste arisings and treatment, the behavioural profile of both society and industry, as well as in waste legislation. The Reference Scenario assumes that current trends continue with incremental improvements going forward. Here, much is the same as today, with some small improvements. In contrast, Sustainability Turn envisions a future in which the country as a whole (society, industry, and politics) goes deep green, driven by changes in behaviour on all levels and a widely accepted stricter waste policy. This differs from High-Tech / Large-Scale Approaches, where high-tech approaches are regarded as the key to solving waste problems and efficient consumer behaviour is much less of an issue. Finally, Unlimited Wastefulness is driven by a bust-and-boom economic cycle leading to a lag of societal, industrial, and policy responses to many waste problems. Here, the main outcome is a mismatch between economic development and the industry/policy response.

Socio-Economic Development

For all scenarios, the economic development of the UK is considered a key determinant for overall waste arisings and management. On a macroeconomic level, the Reference Scenario and High-Tech / Large-Scale Approaches both assume steady economic growth of on average 2.7% annually between now and 2020, and 2.0% between 2020 and 2030[19]. Sustainability Turn is characterised by a higher initial growth rate of on average 3.3% p.a., followed by 2.4% p.a. between 2020 and 2030. In the latter scenario, strong economic growth is coupled with an expansion in green investments and behaviour change which result in a strong decoupling of GVA growth and overall waste arisings. By contrast, Unlimited Wastefulness describes an economic development characterised by an initial period of economic stagnation followed by rapid growth. This bust-boom-cycle translates into an average growth rate of only 0.7% p.a. until 2020, followed by much higher growth of 2.8% p.a. Here, the initial period of economic recession is considered a bottleneck for investments in waste infrastructure and improvements in waste behaviour, leaving the UK wholly unprepared for higher waste arisings from 2017 onwards.

The Reference Scenario, Sustainability Turn, and High-Tech / Large-Scale Approaches all assume that the UK population will grow to 66.5 million by 2020 and reach 70.6 million by 2030[20]. In contrast, population growth in Unlimited Wastefulness closely follows the characteristics of the bust-boom-cycle, reaching a comparatively low 64.9 million people by 2020, but rapidly growing to 72.5 million by 2030, surpassing all other scenarios. The lower population growth to 2020 is caused by a less attractive UK labour market and consequently lower levels of immigration rates during periods of economic stagnation.

[19] Existing projection from: Oxford Economics 2010 – Baseline Forecast
[20] Existing projection from: ONS 2010 - principal (main) projection

Waste Arisings

None of the scenarios assumes an absolute reduction in waste arisings by 2030. Sustainability Turn shows a strong reduction in household waste (-22.4% by 2030) as well as commercial and industrial waste (-7% by 2030), but this is offset by a 20% increase in construction and demolition waste to 2030 due to a rise in refurbishments and reconstruction, leading to an overall increase in total waste arisings of 5.5%, the lowest of all scenarios. With an increase of 21%, overall growth in waste arisings is strongest in Unlimited Wastefulness. Fuelled by strong economic growth, household waste increases by 16% until 2030 – the highest growth rate of all scenarios – while commercial and industrial waste grows to 77 Mt (+26%), or 36% higher than Sustainability Turn. The Reference Scenario and High-Tech / Large-Scale Approaches also show significant growth in total waste arisings, with an increase of 16% in each case. However, in the Reference Scenario household and commercial and industrial waste are slightly lower, due to a greater focus on industry and household waste avoidance, albeit with limited success.

Recycling and Landfill Rates

All scenarios assume some improvement in recycling rates and overall reductions in the amount of waste sent to landfill, due to the increased economic attractiveness of other solutions compared to landfill. Reductions in waste sent to landfill are particular large for Sustainability Turn and High-Tech / Large-Scale Approaches (-69%/-67% to 2030), as a result of improvements in the areas of household and commercial and industrial waste.[21] In Sustainability Turn, this is primarily due to progress in waste prevention, while in High-Tech / Large-Scale Approaches it is driven by economic incentives for other treatment options. Therefore, almost 5 Mt more household recycling capacity is needed in the latter scenario compared to Sustainability Turn, although this achieves a slightly lower recycling rate of 63%, compared to 69% in Sustainability Turn. Furthermore, reductions in biodegradable waste sent to landfill are achieved in all scenarios except Unlimited Wastefulness, where landfill continues to be an important treatment route for all types of waste.

In the Reference Scenario, the amount of household waste sent to landfill is reduced from 45% to 26% by 2030. Reductions are even stronger in Sustainability Turn, where only 12% continues to be sent to landfill. Even though landfill rates for household waste are lowest in High-Tech / Large-Scale Approaches (9%), slightly more household waste is sent to landfill in absolute numbers. In contrast, the scenario Unlimited Wastefulness shows household waste recycling rates of only 44% in 2030, leaving 39% to be landfilled with 17% incinerated.

While in all other scenarios, the landfill share for commercial and industrial waste declines to less than 18% (Reference Scenario) or 10%, respectively (Sustainability Turn & High-Tech / Large-Scale Approaches), in Unlimited Wastefulness 28% is still landfilled. Here, landfill remains economically competitive with other treatment options, mainly due to a lack of competitive recycling and incineration capacity, caused by political inaction in the early 2010s. For Unlimited Wastefulness in 2030, almost 5 times more landfill capacity for household and commercial and industrial waste is needed than in the Sustainability Turn and almost twice as much as in the Reference Scenario's.

[21] The recycling rate for Construction and Demolition Waste is already 82% in 2010.

Energy from Waste

All scenarios assume an increase in the amount of energy generated from waste. The increase is highest in High-Tech / Large-Scale Approach, in which the amount of energy generated from waste in 2030 more than triples over 2010: the energy yield increases from 420 kilotonnes of oil equivalent (ktoe) in 2010 to about 1,300 ktoe in 2030, enabled by investment security and a focus on R&D and technological progress. 79% of the energy results from the incineration of waste, while 21% results from anaerobic digestion. The second largest increase comes in the Reference Scenario: as energy yield doubles to some 880 ktoe (14% from AD), followed by a 70% increase in Unlimited Wastefulness (AD share: 7%). Incinerating waste in general has low priority in Sustainability Turn; furthermore, the volume of combustible waste declines. The energy yield from waste increases only by 60% to 670 ktoe in 2030, of which 25% is provided by AD.

Policy Outlook

Political approaches to and priorities for waste differ considerably between scenarios. The Reference Scenario assumes that there are no significant changes to existing waste legislation and that no new legislation is passed into law, both domestically and by the EU. There are also no significant new producer responsibility initiatives. Instead, efforts focus on ensuring that existing goals are met, including targets from the EU Waste Framework Directive, EU Landfill Directive, and for UK Landfill Tax. In the Reference Scenario, the planning system around waste remains largely untouched, while (moderate and limited) improvements in behaviour are achieved through a mix of soft and hard measures, including both campaigns for voluntary improvement and direct legislation.

In Sustainably Turn, significant improvements in waste management are achieved by a combination of societal, political, and industrial engagement. Here, people are actively engaging in more sustainable behaviour and are supportive of stricter waste policy. In response, there is a policy focus on waste avoidance by supporting local community actions around recycling, enforcing stricter recycling rates and landfill bans, and creating higher standards for industry and businesses in terms of resource efficiency, product design, and recyclability. Sustainability Turn is the scenario with the greatest focus on enabling behaviour change. In contrast to all other scenarios, landfill tax is accelerated beyond 2015 and there are very strict environmental regulations.

The scenario High-Tech / Large-Scale Approaches takes an entirely different approach. Crucially, the overall priority of waste policy shifts from waste avoidance towards smarter waste treatment, with a complete policy and industry focus on developing high-tech, large-scale technology approaches to waste management. The waste planning system is significantly reformed, enabling to a greater extent than now a closer relationship between both industry and local authorities and between the waste management entities of local authorities themselves, creating regional clusters governed by patterns of waste arisings and treatment options and not political responsibility. Policies focus on expanding treatment infrastructure, creating economies of scale around waste recycling, and providing investment and planning security for industry to expand capacity. EU requirements around the source-separation of waste are relaxed, enabling greater opportunities in post-collection sorting. In contrast to Sustainability Turn and the

Reference Scenario, societal changes plays almost no role in the realisation of this scenario. Bin and collection systems are simplified, with little or no need for consumers and industry to take responsibility for their own waste.

Unlimited Wastefulness is characterised by a complete lack of initiatives by both government and industry, in particular at the early stages of the scenario. Difficult economic conditions reduce concerns about waste and sustainability and create an unfavourable climate for strong policy or investments in new treatment infrastructure and capacity. Even though there is not much more waste due to low economic growth in the beginning of the scenario, existing environmental and waste targets for the year 2020 are not met. For 2030 (and we would expect even more so beyond), the direction of developments does not match at all with the desired direction of most National Performance Indicators. This is due to a waste system wholly unprepared for a rapid growth in waste arisings that accompanies the economic boom this scenario envisions from 2017 onwards. In the following years, capacities lag behind rapid waste arisings and the government fails to stimulate adequate changes in behaviour in a society desensitized towards issues of waste and sustainability.

Greenhouse Gas Emission Effects from Waste

The global warming potential of emissions is becoming an ever more important indicator and driver in policy-making and business. Following the scenario development and model creation, the results of the waste arisings estimates served as a basis for calculating indicative estimates for greenhouse gas (GHG) emission effects from waste arisings and waste management in each of the four scenarios, looking at the time horizon 2050. To calculate the GHG emission effects, material specific GHG emission factors were combined with the waste material categories used in the waste model, thus revealing the emission effects caused by the waste treatment of each material category. The GHG factors were provided by WRAP (Waste & Resources Action Programme[22]) and are based on assumptions for the 2008 waste management and technology, i.e. not taking account of future efficiencies in technologies.

It is important to note that the aim of the indicative estimation was not to specify the total volume of GHG emissions from the waste sector but rather the relative effects of arisings & different treatment options in the scenarios. The analysis includes the treatment options recycling (incl. AD), composting, energy recovery using combustion, and landfill, as well as transport where possible. Furthermore, the effects of substituting virgin raw materials with recyclates are contained, but CO_2 emissions of preparing materials for reuse could not be considered. Applying the GHG factors to the estimated waste arisings causes some inconsistencies and, due to adapting the factors to the model structure, the resulting indicative GHG emission effects are subject to considerable uncertainties.[23]

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[22] WRAP, 2010 http://www.wrap.org.uk/downloads/Carbon_Factor_headline_figures.d528f042.10579.xls

[23] The connection and adjustment of the GHG factors to the waste model required a series of assumptions and approximations. The modes of waste treatment under consideration differed only slightly. In allocating the GHG factors to the material classes used in the model, we encountered the problem of partially missing data on the actual composition of these classes and a limited number of available CO_2-factors. Combined with the high degree of aggregation within each material class, this leads to considerable uncertainties in the estimation. Furthermore, the available data reflects the situation in 2008, while estimates are made for emission effects in 2030 and 2050. By then, there will have been, in all likelihood, ample changes in the material and treatment

The estimation results follow the general intuition:

- For landfill, emissions from transportation and methane emitted by biodegradable material in landfills increases GHG emissions;
- for recycling, emissions from transportation and the material recovery processes are more than offset by the savings generated from using recyclates in production processes instead of virgin raw materials, whose extraction and production has a higher GHG impact than the recycling process;
- for energy from waste, the recovered energy lowers GHG emissions because it reduces the need to generate energy from fossil fuels. The GHG emission effects correlate with the volume of waste arisings.

Thus, simply adding up the effects for each scenario into a single number would paint a potentially misleading picture. For example, waste arisings are considerably higher in the Reference scenario than in the Sustainability Turn scenario and so are the GHG emission reduction effects from recycling. This, however, does not imply that the development of GHG emissions fares in any way better in the Reference scenario, because higher waste arisings do not equal lower GHG emissions. Therefore, we do not add up the treatment specific effects into one representative number.

We nevertheless attempted a comparison of the scenarios using the waste prevention component of the GHG factors. This specific component represents the amount of GHG emissions, which can be saved by preventing a tonne of waste of the respective material. This can also be interpreted as the GHG emissions attributed to a tonne of the respective material or, in other words, the GHG emissions "content" of waste arisings (i.e. embedded emissions which do not take different types of treatment into account). Looking at the scenarios from this angle, the indicative estimates show: Due to the high level of waste prevention in the Sustainability Turn scenario, the total GHG emissions "content" is considerably lower than in the other three scenarios. Compared to the Sustainability Turn scenario, the GHG emissions "content" is about 50% higher in the Baseline scenario, 67% higher in the High-Tech / Large-Scale Solutions Scenario and 84% higher in the Unlimited Wastefulness scenario for the year 2050.[24]

Conclusion and Outlook

The four scenarios highlight that there are markedly different pathways for how the UK waste system could evolve over time. Change will be most certainly driven by a multitude of interdependent factors rather than a single driver. Key issues will continue to be the development of the UK economy, global commodity prices, developments in product and treatment technology, consumer attitudes and behaviour, as well as the design of EU waste policy. The diversity of these external drivers is matched by a broad range of plausible UK policy options for how to deal with long-term changes in future waste arisings. One crucial topic strongly debated within the project consists of how to bring about a fundamental societal and

specific emission effects due to process innovation and technological development. The degree and direction of these developments, which differ between the scenarios, were not taken into account.

[24] For 2030, the GHG emissions „content" (compared to the Sustainability Turn scenario) is about 27% higher in the Baseline scenario, 33% higher in the High-Tech / Large-Scale Solutions scenario and 38% higher in the Unlimited Wastefulness scenario.

industrial recycling and waste avoidance behaviour. Strict legislation and investment security emerged as being regarded as the main lever, with industry taking over greater responsibility. Both aspects call for a clear long-term direction setting of the desired future that is to be shaped.

Opportunities for a follow-up to this project revolve around deepening the reflection of foresight perspectives on waste. This includes a possible continuation of the stakeholder dialogue that was established in the course of the project. The 40 experts that contributed to this project are sensitized towards long-term challenges and perspectives around future waste and should therefore be well equipped to contribute to any similar projects and policy questions in the future; considerable interest to do so has been voiced throughout the process.

In terms of a deeper implementation of foresight within Defra waste policy, the scenarios as well as the model offer the possibility of a continuous monitoring so that they can be regularly updated according to new insights and developments. This can help identify whether either of the scenarios has become more or less likely over time or whether any of the scenarios should be adapted in its key contents and assumptions to better reflect new knowledge. This is particularly true for the model element of the project. Any new data should be regularly integrated to ensure the model takes into account the latest statistics on UK waste arisings; composition and treatment structure; also assumptions and parameters could be adapted according to new insights.

Several topics that were only touched upon in the project may also be regarded as deserving closer attention and more research: The influence of external factors such as different climate change development paths, a life-cycle-perspective on global footprints of waste, a comparative analysis of different countries' future waste perspectives and policy conclusions, exports of waste or a closer examination of more extreme economic developments.

One particularly important aspect that would deserve more attention in the context of mapping potential futures of UK waste is an in-depth systems analysis. A provisional analysis suggests that that there would appear to be three key relationships between the various actors in the waste system[25]. These relationships are characterised in different ways and play key roles in determining the overall behaviour of the system. They constitute the 'critical determinants' of the future path of change in the UK waste system; and in turn offer both the opportunities for intervention and the means of monitoring change:

- **Citizen/service –** in general, the relationship between citizens/householders and the waste management companies that provide their waste services is a behavioural relationship. That is to say, the scope for change lies within the domain of 'behaviour change' – the pattern and quality of service provision, the role of nudges and shoves, the nature of information provision and incentives, these will determine both the willingness and the ability of the general public to reduce their waste volumes and/or increase their re-use and/or increase their recycling rate. The scope for intervention (in the absence of enforced participation) is thus the burgeoning array of behaviour change techniques; while the monitoring opportunity comes from assessing public attitudes and perceptions about waste and the environment. Sustained shifts towards heightened environmental concern would signal a shift in the direction of the 'Sustainability Turn'

[25] For more details on critical determinants please refer to Section 5.1 provided by David Fell.

scenario; while a maintained commitment towards consumerism could signal either the Reference Scenario or Unlimited Wastefulness.

- **Waste company/local authority** – the relationship between waste companies (including both commercial and third sector entities) and local authorities is a contractual relationship. The parties enter into binding legal agreements, with particular fee structures, with respect to the provision of waste management services. These contracts are thus the principal means by which the provision of (municipal) waste services is determined and, by extension, everything from the pattern of waste processing technologies, to the relative significance of social and environmental factors within the delivery of waste services, the costs of waste services and the degree of effort committed to achieve 'behaviour change'. The scale and manner of possible interventions – through higher-level contract negotiations, through the dissemination of best practice, through the diffusion of standard clauses, through the development of negotiating capacity and so forth – will determine the overall calibre of contract and, by extension, the pattern of development of the waste system as a whole; whilst monitoring these contracts will provide a means of assessing the direction of travel. (Given the length of some of these contracts, close monitoring of contracts could provide a means of developing 'leading indicators' of future change.)
- **Government/enterprise –** the third key relationship is that between central government and those entities involved in delivering waste services (i.e. local authorities and waste management companies) and enterprises responsible for the production of waste. This relationship is largely a regulatory relationship. In modern mixed economies, governments have to make choices about where on a spectrum between extreme regulation and extreme laissez-faire they wish to be in terms of their relationship with such entities. Regulation may be perceived (by both government and enterprise) as intrusive and stifling red-tape; or as a means of ensuring a level playing field. Laissez faire may be interpreted as facilitating the emergence of lowest-common denominator behaviours, or as the means by which the most efficient solutions are found by the market. The broad direction of travel for the past half century – at least in terms of environmental issues – has been for an increase in the use of regulatory mechanisms; and there is a great deal of research to suggest that this has not, at the macro-level, compromised economic performance or the creation of jobs. Nevertheless, future decisions on the balance between regulation and other devices could have a significant effect on the direction of travel of the UK waste system; and monitoring the response of enterprises to any such changes will be vital in understanding how the system as a whole is evolving.

As has been said, these propositions have been derived from a provisional systems analysis of the UK waste system; and a recommendation for further work would be the development of a full and detailed systems map, with particular attention being paid to the causal loops that thread through the system. This would by no means be a straightforward task, but it could reveal with much greater precision where, within these relationships, the optimal intervention points lie.

As a next step, the results from this project will support policy development through the current waste policy review and generally flow into long-term oriented policy development. As such scenarios can be used to test the resilience of different policy measures in each of the four scenarios, one can e.g. identify so-called no regret options that “work” in all scenarios, and explore where specific risk and opportunities for current policy targets or those in development may stem from. As stressed before, which route is chosen will not be a question of opting for one of the scenarios alone as the direction of policy, but of developing resilient long-term strategies that answer to challenges occurring across the set of scenarios.

5. Annex

5.1 A Remark on Critical Determinants and Possible Implications for Policy[26]

The scenarios presented in this report set out an array of possible future paths for the development of the UK waste system. This brief section presents a discussion of the factors that might affect which path or paths are more likely, and what scope there is, or might be, for influencing those factors and, by extension, the direction of travel.

The starting point for the discussion is the notion that the UK waste system – like the UK economy as a whole – is a complex, adaptive system. That is to say, it consists of a wide variety of component parts – people and businesses, products and materials, processes and rules – linked together in a complex web. Both the component parts and the web as a whole change over time, and adapt with respect to one another. The relationships between components are frequently non-linear and can be characterised by complex feedback and feed-forward loops.

The relatively novel and rapidly evolving discipline of 'systems thinking' offers a useful mechanism for analysing such situations; and provides, in particular, an approach for identifying the 'critical determinants' of the system's behaviour. Identifying and understanding these 'critical determinants' can help to identify effective intervention points.

Although this study has not provided an opportunity for the development of a full 'systems map' of the UK waste system, we have nevertheless taken the opportunity to consider some of the broad parameters of the system. Such consideration has enabled us to identify particular aspects of the system that are likely to prove significant in shaping the direction of travel over the coming years and which, as a result, represent, on the one hand, possible opportunities for policy intervention and, on the other, realms of behaviour that could usefully be monitored in order to assess the direction of travel.

An important feature of systems thinking is that, unlike, say, traditional economic analysis, it acknowledges the importance of history. The UK waste system does not exist in isolation, operating according to abstract principles or the rules of supply and demand, and it does not head towards some notional equilibrium. It is, rather, characterised by a fabric of rules and conventions – collectively, 'institutions' – that have developed over a long period of time and which to a significant extent shape both the current operation of the system and the near-future realm of possibilities.

Two examples, of particular relevance to scenario planning, illustrate the point.

Firstly, it would not be unreasonable to describe the provision of 'waste services' as a basic utility, a service that is needed by all. In principle, there would appear to be little difference between – say – a householder's need for energy, water and waste services. In practice, however, the evolution of institutions in the UK has led to a situation in which energy and water services are provided directly to householders by a small number of commercial organisations

[26] The following text (5.1) was provided by David Fell of Brook Lyndhurst, a key advisor to this project.

that operate under a regulatory regime specified by national government; while household waste services are delivered by a mix of commercial, third-sector and publicly-funded organisations under the auspices of literally hundreds of individual contracts administered at local level. These different solutions have evolved, over a long period of time, for a mix of operational, organisational and political reasons, and they significantly determine the possible 'what next?' in each case.

In the case of this study, we have been looking from 2010 towards 2030; we might therefore usefully try to imagine what 2010 might have looked like from 1990. By way of a second example, then, it is interesting to consider the case of the Greater London Authority. In 1990, there was no (mainstream) political dialogue concerning the devolution of government; yet within a decade the GLA Act had established the office of the Mayor and the GLA family. It is only in the context of a Mayor and the GLA that there could have been – as there was – a fierce debate on whether or not there should have been a Single Waste Authority for London; and it is only in the context of the mixed fabric of waste collection and waste disposal contracts that these days characterise the waste system in London that it is possible fully to explain the capital's landfill patterns, recycling rates and so forth.

This is not to infer that, for instance, recycling rates would necessarily have been higher or lower had there been no GLA, or if there had been a Single Waste Authority; and neither is it meant to imply that only a fully-developed view of political institutional arrangements would enable us to take a view on how the waste system might function in 2030. Rather, it is intended to highlight the fact that the cumulative effect of interdependent factors is an inevitable feature of a complex system such as the UK waste system, and an appreciation of these processes is a useful part of any scenario planning exercise.

Many of the most important features of the operation of the UK waste system, then, must be seen in a historic-political context. The post-war consensus, the statism of the 60s, the stagflation of the 70s, the liberalisation of the 80s, the drift through much of the 1990s and attempts over the last fifteen years to achieve a balance between neo-liberalised economic growth and socio-environmental progress (embodied, perhaps, in the notion of PPP and PFI) have all left their mark.

Current forces of change with the potential to have a similar impact on the waste system in the future – and which are therefore of interest in the current case – would appear to be:

- **The nature of economic growth** – as highlighted and discussed throughout this report, the pattern and pace of economic recovery in the next few years will significantly determine both the scale and mix of wastes arising within the economy. The way in which UK government finances are managed and the way in which the economy as a whole responds will be hugely important. However, the question is deeper still: an economic transformation commensurate with the 'Sustainability Turn' scenario, for example, could presage entirely different patterns of behaviour throughout the economy (among businesses, consumers, agencies of the State and so forth) compared to a future in which, for example, a neo-liberal model of globalised growth persists throughout the next two decades. In either case, the entire 'waste system' would have a very different character by 2030.

- **Investment & market structure** – there has been considerable consolidation within the private waste management sector in recent years, as well as a fluctuating set of relationships between commercial, third and government sectors. Clearly, an oligopolistic, commercially-dominated waste system by 2030 would have a very different character from a pluralist, localised, community-owned waste system. As well as political factors (see below) a key driver of evolution in this context will be the availability and nature of investment funds, as well as the tensions that will be inherent to investment decisions. Investment in 'waste management solutions' will be a function of the rates of return on those investments in comparison with alternatives; which will in part be a function of relative risk and uncertainty. Longer contracts may give greater certainty, thus attracting investment – but may mitigate against innovation at a time when new waste management technologies are in considerable flux. Large waste management contractors may be better able to deliver against large and complex contracts – but they may be less flexible or sensitive to local needs; or they may be more likely to become subsidiaries of energy companies (as 'waste' comes increasingly seen as a feedstock suitable for achieving renewable energy targets etc). All this matters not only because different market structures are likely to have different social and economic impacts, but also because different tools will be required to intervene in the system (or even to not intervene).
- **Big Society and 'localism' –** these two policy narratives have the potential to shape the UK waste system in ways that will persist throughout the period to 2030. If individuals and communities truly accept the mantle of responsibility for their waste, for example, and choose their own, localised solutions, then an intensely variegated pattern could have emerged by 2030, with both a wide variety of waste management solutions and a wide range in performance. Conversely, waste may remain a 'low salience' issue for most people and most communities, enabling a small number of waste contractors to deliver homogenised solutions in most locations. Either solution would be consistent with either high-waste or low-waste worlds: but, again, would have potentially radically different social, environmental and economic footprints, and would imply very different intervention and management models.

Although the UK waste system comprises, as noted above, "people and businesses, products and materials, processes and rules", a systems approach makes it clear that it is the 'people and businesses' whose reaction and responses to the forces just described that will most significantly determine 'what happens'. The various 'players' are:

- Individuals – in their role as citizens, voters, consumers and householders
- Communities – at a variety of spatial levels, across a wide range of interests and in both formal and informal settings
- Enterprises – both commercial and non-commercial; waste-sector specific and more general; local/indigenous and transnational/global; and ranging from micro-enterprises to large-scale corporations
- Non-governmental institutions – including universities, trades unions, media companies, charitable trusts and so forth

- Governmental institutions – including local, regional, national and international government, as well as agencies of the State such as regulatory bodies, quangos etc.

This multiplicity of actors, and the relationships between them, comprises the main body of the complex adaptive system under consideration. How citizens respond to the 'Big Society'; how non-governmental institutions respond to economic conditions; how communities adapt to the localism agenda; how commercial enterprises respond to investment conditions; how governments react to the mix of successes and failures of policy: these are the critical determinants of 'what happens next'.

The provisional systems analysis suggests that that there would appear to be three key relationships between the various actors in the waste system. These relationships are characterised in different ways and – against the broad historic-political background just referred to - play key roles in determining the overall behaviour of the system. They constitute the 'critical determinants' of the future path of change in the UK waste system; and in turn offer both the opportunities for intervention and the means of monitoring change:

- **Citizen/service –** in general, the relationship between citizens/householders and the waste management companies that provide their waste services is a behavioural relationship. That is to say, the scope for change lies within the domain of 'behaviour change' – the pattern and quality of service provision, the role of nudges and shoves, the nature of information provision and incentives, these will determine both the willingness and the ability of the general public to reduce their waste volumes and/or increase their re-use and/or increase their recycling rate. The scope for intervention (in the absence of enforced participation) is thus the burgeoning array of behaviour change techniques; while the monitoring opportunity comes from assessing public attitudes and perceptions about waste and the environment. Sustained shifts towards heightened environmental concern would signal a shift in the direction of the 'Sustainability Turn' scenario; while a maintained commitment towards consumerism could signal either the Reference Scenario or Unlimited Wastefulness.
- **Waste company/local authority** – the relationship between waste companies (including both commercial and third sector entities) and local authorities is a contractual relationship. The parties enter into binding legal agreements, with particular fee structures, with respect to the provision of waste management services. These contracts are thus the principal means by which the provision of (municipal) waste services is determined and, by extension, everything from the pattern of waste processing technologies, to the relative significance of social and environmental factors within the delivery of waste services, the costs of waste services and the degree of effort committed to achieve 'behaviour change'. The scale and manner of possible interventions – through higher-level contract negotiations, through the dissemination of best practice, through the diffusion of standard clauses, through the development of negotiating capacity and so forth – will determine the overall calibre of contract and, by extension, the pattern of development of the waste system as a whole; whilst monitoring these contracts will provide a means of assessing the direction of travel. (Given the

length of some of these contracts, close monitoring of contracts could provide a means of developing 'leading indicators' of future change.)

- **Government/enterprise** – the third key relationship is that between central government and those entities involved in delivering waste services (i.e. local authorities and waste management companies) and enterprises responsible for the production of waste. This relationship is a regulatory relationship. In modern mixed economies, governments have to make choices about where on a spectrum between extreme regulation and extreme laissez-faire they wish to be in terms of their relationship with such entities. Regulation may be perceived (by both government and enterprise) as intrusive and stifling red-tape; or as a means of ensuring a level playing field. Laissez faire may be interpreted as facilitating the emergence of lowest-common denominator behaviours, or as the means by which the most efficient solutions are found by the market. The broad direction of travel for the past half century – at least in terms of environmental issues – has been for an increase in the use of regulatory mechanisms; and there is a great deal of research to suggest that this has not, at the macro-level, compromised economic performance or the creation of jobs. Nevertheless, future decisions on the balance between regulation and other devices could have a significant effect on the direction of travel of the UK waste system; and monitoring the response of enterprises to any such changes will be vital in understanding how the system as a whole is evolving.

As has been said, these propositions have been derived from a provisional systems analysis of the UK waste system; and a recommendation for further work would be the development of a full and detailed systems map, with particular attention being paid to the causal loops that thread through the system. This would by no means be a straightforward task, but it could reveal with much greater precision where, within these relationships, the optimal intervention points lie.

The foregoing discussion has also paid little attention to the role of the price mechanism. Although this sub-section began by suggesting that traditional supply and demand analysis would be an inadequate method for analysing the UK waste system as a whole, there is no doubt that 'price' has a key role to play in both explaining how the system works at present, and how it will evolve in the future.

Price effects permeate the entire system: the relative cost of basic commodities, for example, determines the relative price of recyclates, which in turn shapes the rate of return on investment in waste treatment technologies, which in turn – and in the context of the relative price of land and labour – shapes the price that companies will wish to charge to run waste services. The cost of waste contracts affects the size of the bills that local authorities have to charge rates payers. In the case of other utilities, such as energy and telecommunications, there is a direct relationship between consumption by households and the cost they incur, such that (other things being equal) higher prices cause demand to fall. The costs of waste disposal for businesses, relative to their other operating costs, influence their resource efficiency. Increasing the cost of landfill, via a tax, increases prices throughout the system, acting as a disincentive to use landfill, as an incentive to use alternative routes, and as an incentive to innovation in new treatment routes. Factoring in the carbon-price associated with different treatment routes could produce different 'optimal' profiles compared to calculations based solely on market prices.

By way of further work, then, the relative costs and benefits of any given 'solution' could usefully be calculated: each of the scenarios presented in this study implies not only a different 'waste system', but also a different distribution of prices and incomes, costs and benefits. We would recommend that such an analysis could be conducted, better to inform which direction of travel might be 'best'. In the end, and as with any economic sector, the costs are borne by the consumer: how much they are willing to pay, and what – in terms of service, in terms of environmental performance, in terms of 'opportunity cost' – they expect in return, will be a critical determinant of the path to 2030.

5.2 The Process in Detail

Overall, the project consisted of 4 phases (plus a set up phase), which will be outlined in the following.

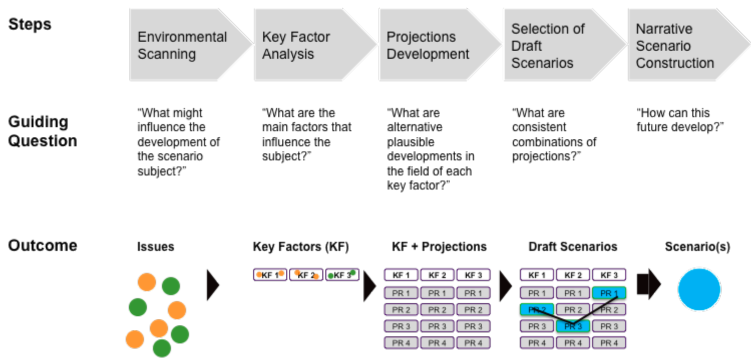

Figure 23: Morphological Scenario Approach: From Issues to Scenarios

The project started in late July with a start-off-meeting at Defra on July 29, 2010, discussing the project approach, milestones, and expectations. No significant changes to the proposal were debated, but the meeting highlighted, e.g., the necessity to label results as a think piece, to work with narrative scenarios, and to include developments up to 2050 where possible.

Furthermore, as per the project proposal, it was agreed at this meeting to involve both Julian Parfitt from Resourcefutures and David Fell from Brook Lyndhurst very closely, as key advisors who would contribute to the crucial steps of the process on a day-to-day basis. Both have contributed to all project phases by commenting on the projection's draft list, identifying "business-as-usual" projections, reviewing draft scenarios as well as the model draft, and helping in the finalisation of the scenarios and the model.

Phase 1 – Environmental Scanning and Key Factor Analysis

UK's Demographics	
Definition	Status and development of UK's demographics, expressed in total population, population growth (net migration, births, deaths) and age structure
Summary	The UK population is growing and the population growth has even accelerated during the last decades. One reason is a growing birth rate at simultaneously stable death rates another is increasing immigration. Additionally, the population is getting older (especially the number of the oldest old grow strongly) and more multi-cultural.
Parameter for Quantification	- Annual population growth and total population - Age structure (development of median age)

Impact on Waste Streams & Treatment

Hypotheses (+Evidence)

More people lead to more consumption of durable and non-durable goods, which leads to more household waste.

- It is apparent that population growth is coupled with growth in household waste arising. However, where there is marginal population growth there are a number of cases where this is coupled with a decrease in household waste arising (Resourcefutures 2009)
- According to Lee / Chung/ Koo (2005) a higher population density leads to less waste and a higher degree of environmental sustainability. "Reducing Waste and Consumption Pressures, has a statistically meaningful negative relation with land area per capita".
- Volumes of waste are likely to increase (Forum for the Future 2010).

Older people produce less waste than younger

- According to Chen 2010, in developing countries, there is a "significant negative coefficient of the age variable", "each percent increase in age composition leads to a decrease in MSW (municipal solid waste) disposed". Named reasons are: older people stay more often at home, consume less and some incur sickness and require care. The German federal association for waste, water and resources management also states that "older people generate less waste than younger" (Die Zeit 2010).

Differentiated Impacts

	Impact	Comments
Municipal / HH Waste	indirect	- More people lead to more consumption of durable and non-durable goods, which leads to more household waste - The older a society, the less waste (assuming a stable total population).
C+I Waste	indirect	- A higher population leads to a higher demand for products. If those products are produced domestically that leads to more industrial waste from production.
C+D Waste	indirect	- A growing population will increase demands for housing and infrastructure – ranging from roads and utilities to hospitals, schools and shops (Forum for the future 2010).
Re-use	indirect	- The rising pressure on scarce resources will increase the demand for re-use and recycling solutions.
Recyc. / Comp.	indirect	- See re-use; and: Participation in food collection higher amongst households over 35 yrs. (Defra 2008)
Inciner. / EfW	indirect	- As the number of people living in the UK increases, the demand for energy will also increase. Therefore, EfW solutions could become more attractive.
Landfill / Disp.	indirect	- A growing population increases the demand for land and therefore landfill sites will increasingly compete with other land uses (housing, agriculture, recreation)

Figure 24: Example of a Described Shaping Factor

The first phase included a comprehensive desk study on the factors shaping the future of waste, as well as a causal analysis and impact evaluation to develop an understanding of their impact on waste arisings and treatment. The search field encompassed a wide range of global and national interconnected topics, both direct and indirect factors. Direct factors include actors producing or treating wastes in the UK, indirect factors include issues such commodity prices and attitudes to the environment. This work led to a draft list of shaping factors, among them a description of their historical development from the 1980's to today, and where possible evidence on their impacts on waste arisings and management. During a workshop on the September 1, 2010, a number of external experts coming from the field of policy as well as from academia and the industry side refined the draft list and developed a common deeper understanding of potential impacts of these factors on future waste arisings and treatment. Additionally, data sheets were compiled for each factor, bringing together the available information from a wide number of research reports and statistical databases in order to develop the quantitative model.

Phase 2 – Key Factors' Projections

The aim of the second phase was to understand trend developments and their impacts on the factors identified in Phase 1, and based on that analysis, to agree on the final set of key factors used for the scenario construction.

Demo-graphics	Socio-Economic Situation	Consump. Patterns + Environm. Behaviour	Economic Output	Economy Structure	Corporate Eco-Behaviour	Recycle & Reuse Capacities / Techn.	EfW Capacities / Techn.	Commodity Markets	Energy System	Dev. of LATS + Landfill Tax	Voluntary Improve-ments	System Support + Intervention
Stable Population Growth	Growing Affluence	Good Attitudes, Wasteful Behaviour	Steady Growth	Continued Shift to Services	Diverse Approaches	MSW Dominates Develop.	Small-Scale EfW	Steadily Increasing Prices	Slow Shift to Renew.	Gradual Tax Increases	Stable Support and Participation	Stable Legislation
Population Boom	Income Distribution	Strong Increase in Sustainable Consump.	Rapid Per Capita Growth	Resurgence of British Manuf.	Low Level of Concern and Efficiency	Coordinated Expansion	Large-Scale EfW	Open Markets and Stable Supplies	Nuclear Growth	Hammering of Landfill	Increase in Policy Driven Measures	Push for De-Regulation
Rapidly Ageing Population Stagnation	Inequality Reigns	Steady Buying Power, Conscious Choices	Bust-Boom Cycle	Centre of Excellence	Sustain-ability Drive	High-Tech Focus on C&I Waste	De-Coupled Fuel Prod. and Consump.	High Prices and Strong Volatility	Zero Carbon Britain	Landfill Reduction and Incineration Tax	Decrease in Policy Measures / Industry Responses	More Legislation, more Standardisati on
	Poor Society	Low Consump. and Low Environm. Conscious Behaviour	Double Dip	Balancing		Low-Tech, Un-coordinated and Diverse		Closed Markets and Protec-tionism	Small-Scale Generation	Sophisti-cated, Materials-Based Approach	No Policy, but Strong Industry	
		High Consump. and Low Environm. Concious. Behaviour						Price Drop	Focus on Co-Firing and Fossil Fuels			

Figure 25: Final Morphological Box (grey row: key factors, white boxes= projections)

After debating a draft list with external stakeholders at the second workshop, a final set of 13 key factors was agreed on. Following the finalisation of the list, a first set of draft projections (projections are alternative and plausible developments in the area of a key factor) was identified for each of the key factors. Comprehensive desk research, data evaluation, as well as trend and evidence analysis were used to create the draft projections. One objective during this process was to understand which factors have a relatively low level of uncertainty and could therefore be classified as so-called "givens". In this context, "givens" means that the future development of a specific key factor remains constant in all scenarios, or in practical terms: there is only one projection for this key factor.

After a broad range of existing futures-related studies had been compiled and analysed for the topics covered by the identified factors, it became clear that there were no "givens" among the selected set of key factors. For each factor, we found evidence that there might be at least two alternative and plausible futures. A standard template was used to describe each key factor and its projections.

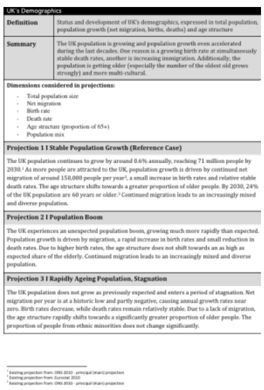

Figure 26: Example of a Described Key Factor and Projections

For each factor, one projection was designated as the so-called reference (or "business-as-usual" (BaU)) projection, i.e. one which assumed that there would be no major trend breaks and that current trends would continue[27]. The projections determined as reference projections were selected based on valid existing assumptions and data, for instance from the Department of Climate Change and Energy. As a result, the projections set is based on "general expectations" captured via key advisors' input, trend studies, and specific evidence and focuses on the time horizon 2030.

Furthermore, the quantitative model was further developed and the qualitative (scenarios) and quantitative (model) working streams were refined iteratively for consistency and coherence.

Phase 3 – Scenario Development

[27] This refers to trends that have lasted for some time, roughly a decade, with the reasoning to exclude rather current, possibly short-term volatility in developments.

During the third phase, a set of four scenarios was developed. Here, the aim was to identify one reference scenario, i.e. a high-probability scenario which represents a surprise-free future that is based on extending current developments and on existing policy frameworks. This was to be accompanied by a number of disruption scenarios, which are by definition less probable but still reasonably imaginable and rather probable. The second aim was to give a first assessment of the scenarios' impacts on future waste arisings and treatment, both qualitative as well as, where possible, in concrete numbers.

The final scenario set in this report is the result of a combined issue- and consistency-based selection approach. On the one hand, the choice is based on content- or issue-wise criteria and on the other hand, it is supported by software usage supporting the selection of the most consistent scenarios.

As the scenario development process is designed as a participative process, the third phase consisted of two major steps – first the development of draft scenarios and in a subsequent step, following a debate with key stakeholders during a workshop, the elaboration of the final scenarios.

Applied Basic Scenario Selection Rules

For the selection of the scenarios, several "basic scenario selection rules" were applied. Taking into account that the scenarios are developed in order to support policy development, the set does not cover extreme, low probability wild card scenarios such as the complete collapse of the British or global economy. While these scenarios may be a very helpful tool for expanding one's mental horizon, they remain unsuited to highlighting where waste policy makers' most pressing future needs for action would be. In total, the aim was to develop a set of four to five scenarios, one of which would be a reference case scenario ("what if things don't change all that much"), whereas the other three or four would be alternative, more disruptive scenarios ("what if things change a lot?"). The scenarios should also be very distinct from each other, in order for the scenario set not to feature several variations of one kind of future development or direction. Rather, the scenarios all start from different drivers, so that the overall set covers a broad range of the possible opportunity space.

Selection of the Reference Scenario

During the previous phase, a shared assessment on the most probable projection (the "expected future") of each key factor had been debated and selections for the reference scenario had been made. The following projections were identified as reference case projections:

Key Factor	Reference Case Projection
Demographics	Stable Population Growth
Socio-Economic Situation	Growing Affluence
Economic Output	Steady Growth
Economy Structure	Continued Shift to Services
Consumption Patterns + Environmental Behaviour	Good Attitudes, Wasteful Behaviour
Corporate Eco Behaviour	Diverse Approaches
Energy System	Slow Shift to Renewables
Commodity Markets	Steadily Increasing Prices
EfW Capacities / Technology	Small-Scale EfW
Recycling and Reuse Capacities / Technology	MSW Dominates Development
Voluntary Improvements	Stable Support and Participation
Dev. of Landfill Tax + LATS	Gradual Tax Increase
System Support + Intervention	Stable Legislation

Software Supported Consistency Analysis

Starting from this suggestion, the project team determined the consistency of these projections, i.e. whether they could form one consistent, plausible scenario together.

Figure 27: Consistency Analysis Matrix

A consistency analysis was carried out with, due to the immense complexity of this task, a software-tool used to support the analysis.[28] The objective was not only to check how consistent the 13 reference case projections were with each other, but also to check the consistency of each of the 51 projections with each other for the construction of the

[28] Eidos, for further information on the software please go to http://www.parmenides-foundation.org/application/parmenides-eidos/

alternative scenarios.

For each possible combination of two projections, the project team checked whether this combination could – or could not - consistently happen in a given scenario. If, e.g. the UK's energy system was transformed towards zero carbon, as featured in one of the projections in the key factor "UK's energy system", this is highly consistent with a growing environmental awareness in both society and industry, but slightly inconsistent with an economic crisis (assuming that the transformation requires high investments and results in extra short-term costs for companies). Consistencies were evaluated from -3 (highly inconsistent, combination not imaginable in one scenario) to +3 (highly consistent, very imaginable in one scenario).

Construction of the Alternative Scenarios

The selection of alternative scenarios was also based on the content-based criteria sketched out above and supported by software. Without considering any content-based selection criteria, an impressive but unmanageable number of 49,766,400 possible scenario combinations would – theoretically- result from the set of 13 key factors and 51 projections. Even after consistency analysis, there were still several million consistent scenario candidates.

Using a so-called cluster analysis, Eidos (see Footnote 28) identified the existing clusters of consistent scenarios amongst the most consistent combinations. Scenarios within such a cluster differ only marginally from each other, often in only one selected projection. Two scenarios within a cluster may, e.g., share the same waste policy projections, but one may feature high population growth, whereas the other assumes only moderate population growth. Clusters thus consist of very similar scenarios that differ only in minor details in individual projections. A multi-step process was used to deal with the remaining large number of consistent scenarios and select those which would eventually be featured. During an internal initial workshop, the project team developed ideas for potential alternative scenarios which were based on major ideas from the previous process. Using the issue-wise criteria described above, the team checked consistency with Eidos and agreed on the following set of three draft alternative disruption scenarios:

- Sustainability Turn
- High Tech / Large-Scale Approaches
- Unlimited Wastefulness

Selection of the scenario ideas was supported by a cross-impact-analysis, which had been conducted beforehand. The cross-impact-analysis highlights drivers and factors that have the highest influence on the future of waste and therefore are good candidates as starting point for the alternative scenarios. Different drivers, such as societal actors, technologies, or policy, drive all three scenarios.

Finally, the selected scenarios were discussed with Defra and Key Stakeholders at the third project workshop. The first working session focused on the question of how the scenarios might evolve until 2020/2030, and what would make the scenarios more probable. In the second session, participants worked on the impact side of the scenarios. Assuming a scenario materialised, what would be the consequences for waste arisings and treatment? The third task was to indicate which projections (from the other key factors that were not already part of the scenario core) would best fit the scenario. Finally, all groups reflected on the overall scenario set and suggested changes where needed. The discussions at the workshop resulted in a scenario set that was more or less in line with the drafts presented, but added many storyline elements, drivers, and impacts details[29].

During this phase, the quantitative model was also developed further, up to the point that numbers were calculated for future waste arisings in the UK for the reference case up to 2030.

Phase 4 – Impact Assessment of Future Waste Policy

This report marks the conclusion of Phase 4. The main objective of our work during this phase was to further elaborate on the scenarios according to stakeholder feedback and discuss the policy outlook of each scenario with Defra. A policy-briefing workshop took place in London on December 10, 2010, during which the project team presented the scenarios to key addressees from Defra. Their comments were already considered for the updated version of the scenarios and models within the scope of this report.

Furthermore, the model was finalised, streamlined with the scenario narratives, and a combined qualitative-quantitative scenario description was developed. Following the submittal of the preliminary final report on December 22, 2010, further comments on the report from Defra and external experts were integrated, and the final results were presented on January 20, 2011.

[29] One group in the workshop which worked on the "Unlimited Wastefulness" scenario proposed an additional scenario – a low-growth scenario that features very low waste arisings due to a persistent economic crisis. The changes the group made to the original scenario, describing a boom-bust-development, are included, as discussed in this report in the updated scenario. However, the proposed scenario of low growth with an economic crisis persisting until 2030 was not realised as a fully-fledged scenario. One reason is that a 20-year economic crisis was considered rather improbable and is hence outside our scenario scope of rather probable, not too radical future developments. Secondly, imagining a world where economic hardship leads to waste reductions, lead to problematic and little helpful policy implications in devising future waste policy measures.

5.3 The Model Approach

Model Logic Mirrors the Results of the Key Factor Analysis

The aim of the model is to estimate waste arisings for the UK and its constituent countries for the time horizons 2020 and 2030, with a very rough outlook to 2050 for the UK under the conditions of an extended reference case scenario. The model differentiates three main areas of waste production – household waste, commercial and industrial waste (C&I), and waste from construction and demolition (C&D). In addition to waste arisings, the future waste treatment mix is integrated. Here, the model shows whether and to which extent waste is sent to landfill, composted, recycled, or incinerated (with energy recovery). Furthermore, the model is designed to estimate waste arisings and treatment under a varying set of future conditions to support the qualitative scenarios with quantitative estimations. The amount of energy recovered from waste (incineration with EfW and anaerobic digestion) is estimated based on how the waste is treated.

The waste model consists of a core model, which explains waste arisings and the different treatment streams. Waste policy and a set of various parameters influence the elements of the core model.

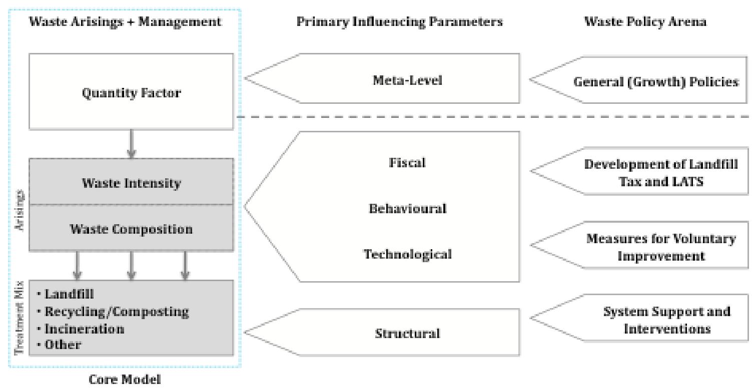

Figure 28: Overall Model Logic

In the core model, a quantity factor in combination with an area-specific waste intensity (the amount of waste per unit of quantity factor) defines waste arisings. Depending on the composition of waste, waste arisings are then sent to landfill, recycling, composting, incineration, or others. The so-called primary parameters and waste policy influence the elements of the core model.

The influencing parameters drive the quantity factor, the level of waste intensity, waste composition, and the treatment mix applied in the waste management process. The quantity factor is primarily influenced by meta-level parameters such as economic structure or population size.

Waste intensity, waste composition, and the treatment mix are in turn influenced by fiscal, behavioural, technological, and structural parameters. For example, the employed production technology and rising commodity prices influence the manufacturing waste intensity. Additionally, rising commodity prices also make recycling more profitable, but the structural parameter of recycling facilities' capacity might limit further increases in recycling rates. Waste policies have indirect effects by altering sets of primary influencing parameters.

The development of the model was based on the results of the first project phase, in which the key factors for waste arisings in the UK where identified and described. Thus, the overall model logic mirrors the findings of the desk research into key factors of the UK waste system and in this way the overall structure and general content orientation of the qualitative side of the project. During the quantification process, however, the structure of the model had to remain manageable and the number of parameters integrated in the model had to be adapted according to the availability of data.

Detailed Model Structure

Household Waste Arisings

The development of household waste arisings is modelled using the parameters GVA, population size, consumption patterns approximated by the CPI (Consumer Price Index) weights for goods and services, and the waste intensity of household consumption activities (kg household waste/GBP of GVA). GVA p.c. is determined by the development of GVA and population size. GVA p.c. multiplied with the household area specific waste intensity equals household waste arisings. Households consume goods and services. The model assumes a waste intensity of zero for the consumption of services, i.e. no household waste is generated by consuming services. The waste “saved” by switching to services arises on the other end, i.e. the service sector. Household consumption patterns as represented by CPI weights are a major influence on household waste arisings.

Another driving factor for the development of household waste arisings is the development of household waste intensity. We assume that intensity changes over time according to the development of household waste-related behaviour which can be influenced by educational campaigns or waste-related incentives. Secondly, the amount and weight of product packaging influences household waste intensity.

Commercial and Industrial Waste Arisings

The development of commercial and industrial waste arisings is modelled using the parameters GVA, economic structure, and the waste intensity of C&I activities (kg/GBP of sectoral GVA). The model simplifies the sectoral structure of the UK economy by assuming that only three sectors exist: the industrial sector, including all of manufacturing and utilities; the high-waste intense service sector, comprising wholesale, retail, and hotels and restaurants; the low-waste intense sector, which includes all other services. The decision to divide the service sector in this fashion is based on the observation that these businesses have a threefold higher waste intensity (kg/GBP of sectoral GVA). Additionally, high-waste intense services are not subject to over-proportional growth as are low-waste intense services; it is especially activities in the financial sector or immaterial goods that show high growth.

All three sectors exhibit sector-specific waste intensities. Sectoral shares of GVA multiplied with the respective waste intensity then equal sectoral waste arisings. The waste intensity is assumed to change over time, as improvements in resource efficiency are realised.

Construction and Demolition Waste Arisings

The development of construction and demolition waste arisings is modelled using the parameters GVA, the size of the construction sector, and the waste intensity of C&D activities (kg/GBP of the construction sector's GVA). Waste arisings are calculated by multiplying the construction sector's GVA with its waste intensity. There are only few data points available on past waste arisings (as C&D waste was never reported), and they vary widely over the constituent countries. This will mainly be due to different reporting methodologies. Here, we decided to use an average for the UK and benchmark with the most recent estimations for total C&D waste. The waste intensity is assumed to change over time, as improvements in the resource efficiency of construction activities are realised.

Waste Composition

In the model, waste composition functions as the link between waste arisings and waste treatment. Waste materials are allocated to the various treatment options, i.e. recycling and composting, energy recovery/incineration, landfill and special treatment for hazardous waste. Not every material can be used for every treatment option of course, e.g. metal is not composted. Also, a certain share of each material stream constitutes hazardous waste.

When statistical data on waste composition is collected, the European waste catalogue (EWC) is normally used to classify the different material types. The EWC represents a detailed classification system of waste types according to the origin of waste. Since the EWC classification is rather complex, many studies on waste composition use simplified lists of materials. To keep the model manageable, we break down the different waste types to a set of fourteen material classes: food, other biodegradable, paper+card, glass, metal, plastic, textiles, wood, chemical, WEEE, other combustibles, other non combustible, aggregate mineral, soil/silt. In this way, biodegradable materials, all main recyclates, as well as inert materials and two categories for other materials are covered.

There are two types of sources for data on waste composition: government waste reports based on survey data on the one hand and studies on waste composition on the other. A Resource Futures study[30] provides recent data on the composition of municipal waste in England. We used the results of this compositional analysis as an approximation for the composition of household waste in the UK (see Table 01). These shares were modified for paper and card as it is clear from industry surveys that about 14.1 Mt of these materials arise, either produced in the UK or imported to the UK. Furthermore, food waste was corrected downwards to account for more recent findings (J. Parfitt of Resource Futures). Various government reports provide information on C&I and C&D waste composition. However, as explained above, the statistical data in these reports differ widely in methodology, making comparisons extremely complex. In 2006, Environment Resource Management[31] conducted a meta-study of available information on waste arisings in the UK. Gathering and combining the information from over a hundred different sources, this study still represents the most comprehensive source for data on UK waste composition. Hence, we used it as an approximation for the composition of C&D waste.

[30] Resource Futures (2009)
[31] ERM (2006)

The shares for wood and metal appeared to be underestimated in the ERM study. Using recent information on C&D waste arisings[32], we adjusted the shares accordingly, while retaining the total volume of C&D waste reported in the ERM study stable (see Table 01). During this project, DEFRA published a survey of the 2009 figures on C&I waste which substantially differs from the 2003 survey. These data vary from the ERM study but are used for C&I waste composition and arising. The shares of mixed ordinary waste were allocated according to the assumed MSW shares, which resulted in an overestimation of e.g. paper+card compared to the Resource Futures study.

Table 01: Composition of Waste Arisings Based on ERM (2006), Resource Futures (2009) and Defra (2010)

Waste materials used in the model	Share of waste material in %				
	Household waste	Industry waste	High waste intense services	Low waste intense services	C&D waste
Food	17.8	10.2	9.6	8.5	-
Other biodegradable	15.8	8.6	8.2	9.2	-
Paper and card	22.7	10.8	38.2	30.6	-
Glass	6.6	1.2	8.2	4.5	0.1
Metal	4.3	9.0	3.3	4.8	0.4
Plastic	10.0	2.8	8.7	5.6	-
Textiles	2.8	0.6	1.3	1.2	-
Wood	3.7	2.3	4.3	3.8	0.5
Chemicals	0.5	10.7	2.9	3.3	-
WEEE	2.2	0.5	2.5	2.7	-
Other combustibles	6.5	1.3	10.7	14.7	-
Other non-combustibles	6.8	39.5	3.5	8.5	0.5
Aggregate mineral	-	2.4	0.5	2.6	49.3
Soil/silt	0.2	0	0.1	0.1	49.2

Sources: ERM (2006), Resource Futures (2009). Own calculations based on Capita Symonds (2010).

Due to the structure of available data, we had to make strong assumptions to estimate the share of hazardous waste for each waste material. We assumed that a fixed share of each waste material in the model is hazardous. The Environment Agency publishes data on the arisings of hazardous waste in England and Wales[33]. We used these to approximate hazardous waste shares for household and C&D waste arisings. In order to allocate the hazardous share of waste materials to the three economic sector aggregates in the C&I module of the model, we relied on the data in the latest SEPA Waste Data Digest as an approximation (see Table 02).

[32] WRAP (2010)
[33] EA (2009)

Table 02: Composition of Hazardous Waste Material Share in Percent

Waste materials used in the model	Hazardous waste material share in %				
	Household waste	Industry waste	High waste-intense services	Low waste-intense services	C&D waste
Food	-	-	-	-	-
Other biodegradable	-	-	-	-	-
Paper and card	-	-	-	-	-
Glass	-	-	-	-	-
Metal	-	0.2	-	0.2	0.1
Plastic	-	-	-	-	-
Textiles	-	-	-	-	-
Wood	-	-	-	-	-
Chemicals	50.0*	40.9	99.5	30.3	-
WEEE	-	1.6	1.0*	1.0*	-
Other combustibles	-	-	-	31.5	-
Other non-combustibles	3.0*	8.9	98.2	27.9	80.0
Aggregate mineral	-	0.5	19.6	0.1	0.3
Soil/silt	-	-	-	-	1.0

Source: SEPA (2009), *Modified as original data are inconsistent

The future development of waste composition remains an open question. The composition of waste arisings is directly linked to consumption patterns which will most likely change in the future (e.g. more electronic devices and less paper). So far, no research has been done which attempted a comprehensive projection of waste composition development. We discussed this issue at the project workshops and in our series of expert interviews, but were unable to obtain an information basis for the projection of future waste composition. Therefore, we assumed that the composition of waste arisings would remain stable over the entire time frame of the projection.

Treatment

We distinguished five treatment streams: recycling (including reuse), composting, energy from waste (EfW, including incineration), landfill, and treatment (i.e. hazardous waste). Anaerobic digestion (AD) is explicitly captured as and declared as recycling of organic material. Treatment volumes are realised in a backwards, i.e. we first estimated total waste arisings based on intensity improvements (as described above), and in a second step divided the waste into the respective treatment streams.

The material flow is organised hierarchically and separately for each material. Firstly, recycling/re-use and composting is deduced from the total, based on the recycling rate as well as the hazardous waste part. The residual is either subject to incineration/EfW or landfill. Not all material from the incineration feedstock is combustible, resulting in a share of 22% as ash. This ash will have to be landfilled but we decided not to list it thus to avoid double-counting. Recycling rates are based on a Prognos[34] study that presents an overview of recycling rates in Europe in 2004 and prospective rates for 2020. There are no UK recycling rates per material available in statistics or surveys, so the rates have been adapted according to our knowledge to reflect the known 2008 overall rate and the known composting rates.

For the scenarios, three levels of recycling rates were considered that serve as cornerstones: The EU target for 2020, best practice today (see Table 03) and maximum attainable recovery rate (see Table 04). It has to be noted that the EU targets refer to a recycling rate for the total MSW and not to each material individually. We chose the Prognos assumption for 2020 which reflects the 50% overall target for recyclates well. For comparison, the global recycling rate was derived as the recovery share (recycling/composting) from the total MSW.

Waste collection and separation differ fundamentally between sectors; generally, separation is much higher for industry than for household waste. As a consequence, the recovery rates (recycling/composting) for each material are generally higher in industry. This is accounted for by higher recycling rates for the key recyclates to match the available global industry recycling rate. Treatment rates were taken from the 2009 C&I survey. The recycling rates for aggregate and mineral come from correspondence with DEFRA C&D experts. These are generally quite high and already exceed EU targets.

In all scenarios, recycling rates improve in general. The dynamics of improvement was set on the basis of whether individual targets were met. The Reference Scenario only just meets the EU targets for 2020; for 2030, the rates move towards best practice for the materials. The Unlimited Wastefulness Scenario falls short of fulfilling the 2020 targets and shows incremental improvement by 2030. Both Sustainability and High-tech exceed the EU 2020 targets. Here, High-tech surpasses these targets in C&I recycling as these materials are more readily accessible. The Sustainability Scenario in turn is higher in the organic share in households, as people realise that home composting and presorting generally increases recyclate quality.

[34] Prognos(2008)

Table 03: Recyclable Materials Recycling Rates

Key Recyclable Material	2004 Rate	Assumed 2020	Best Practice Country (2004)
Glass	50%	70%	Denmark (78%)
Paper	56%	70%	Denmark (68%)
Plastics	17%	50%	Denmark (38%)
Iron and Steel	76%	85%	Denmark (85%)
Aluminium	66%	85%	Luxembourg (85%)
Wood	31%	65%	Denmark (65%)
Textiles	23%	60%	Germany (40%)
Biowaste	33%	65%	Luxembourg (63%)
Total Key Recyclables	48%	70%	

Source: Based on Prognos 2008

Table 04: Different Materials' Resource and Energy Recovery Upper Fractions

Material Fraction	Resource Recovery (Recycling/ Composting) Upper Limit	Energy Recovery Upper Limit
Paper & Card	85%	90%
Kitchen/Food Waste (non-agriculture)	75%	90%
Agricultural Manure/Slurry	50%	50%
Other Organic Waste (predominantly sewage sludge)	55%	90%
Garden/ Plant Waste (non-agriculture)	90%	90%
Agricultural Crop Waste	50%	50%
Wood	50%	90%
Textiles	50%	90%
Plastic (dense)	60%	90%
Plastic (film)	60%	90%
Ferrous Metal	95%	n/a
Non-ferrous Metal	95%	n/a
Aggregate/Mineral Materials	95%	n/a
Silt/Soil	95%	n/a

Sources: CRN (2002), Danish EPA (2006), EEA (2005), Eurostat (2005)

Downstream, residual waste goes to either landfill or EfW. We assume that the total residual waste is treated in a lumped fashion. It is assumed that total combustible residual waste is treated in the shares similar as if thrown into one large bin. This share is split up in EfW and landfill (see Table 05). This holds true for all waste, both for the recyclates and uncategorised other waste and chemicals. This reflects the reality that even non-combustible materials are sent to incineration, yielding a high volume of ash. Recycling of metals benefits from incineration as these can be easily extracted from the residues. At the time of writing, a share of 22% of the residual waste MSW is incinerated, the remaining 78% is landfilled. In the scenarios, we raise this share in favour of incineration/EfW with varying dynamics until 2030.

Table 05: Share of EfW in Residual Waste in the Different Scenarios

	Current	***Reference***		***Sustainability***		***High-Tech***		***Wastefulness***	
		2020	***2030***	***2020***	***2030***	***2020***	***2030***	***2020***	***2030***
EfW / Residual Waste	22%	35%	45%	45%	60%	50%	75%	25%	30%

There are no comprehensive data available on the composition of hazardous waste for all constituting countries or the UK in general. The hazardous waste shares from individual surveys reveal manifold differences in hazardous waste arisings for all waste areas between the constituting countries, which seems counter-intuitive. Consequently, we chose the very detailed EA Scotland survey to best represent the hazardous waste composition in the UK and used this as the basis in the model. This extensive and recent survey presents each hazardous waste category by sector origin for 2008. On this basis, we were able to extract hazardous waste compositions for industry, high waste-intense services, and low waste-intense services. Over the time period, we assumed a constant hazardous waste share of each material. This is obviously a simplification as a change in hazardous waste composition is to be expected. However, this change so far remains absolutely speculative. With the shares of industry sectors changing, the model sets a respective change in hazardous waste.

Energy from Waste

MSW is mainly incinerated with energy recovery today and only a negligible share will be incinerated without energy recovery in the future. C&I is still partly incinerated without energy recovery, the share also varies by industry sector. The EfW shares of incineration are extracted from the 2009 C&I survey for England and are assumed to be good approximations for the UK. As there is no information available on the future development of these shares, we assumed them to be constant (see Table 06).

Table 06: 2009 shares EfW / total incineration for calculating the energy yield

Sector	EfW/total incineration
Industry	58.7%
High waste-intense services	46.6%
Low waste-intense services	19.4%
Household	100%

Sources: Own calculations based on Defra (2010a).

From the treatment data, it is possible to estimate the energy output from EfW. Here, we integrated the two methods incineration with energy recovery and anaerobic digestion (AD) in the model. The specific energy content in each material is a constant, which can be applied as a factor to the volume. The energy content is realised per material, with individual energy yields assumed for each combustible material and, in the case of AD, for biodegradables. The factors for the energy generated per material were supplied by DEFRA (see Table 07).

Table 07: Energy content of the Materials (toe/ktonne)

Material Fraction	Incineration (with EfW) / toe/ktonnes	Anaerobic Digestion/ toe/ktonnes
Food	45	49
Other biodegradable	61	40
Paper & card	146	-
Plastic	111	-
Textiles	111	-
Wood	210	-
Other combustibles	111	-

Sources: Own calculations based on Defra (2010b).

It is to be expected that both the share of EfW will increase as will the specific energy yield per material, so the estimated energy yield is a lower bound for the generated energy. Also, these yields only account for electricity generation, including heat and electricity. Technological progress will further increase yields. On the other hand, more energy will be necessary to transport the material to AD plants, which reduces the overall energy balance. This is especially relevant for the carbon balance.

Data Availability Sets Limits to Parameter Implementation

The model requires data input on different levels and in different dimensions. In order to estimate future waste arisings and treatment streams, a picture of the present situation of waste management in the UK is necessary in order to establish a baseline. This requires current data for the UK and its constituent countries on waste arisings, waste composition, and treatment streams. Furthermore, not only are current data for the various parameters required, e.g. GVA, population size, structure of the economy, and policy actions, but also data on the respective impacts of these parameters on the waste streams in the waste areas under consideration. Once the model baseline is established, projections for the future development of the parameters are necessary to calculate future waste arisings.

Initially, we planned to use time-series or cross-sectional data to estimate parameter influences via the appropriate forms of regression. The statistical data on waste arisings used to be fully based on surveys. Time-series data for all constituent countries is only available for household waste arisings, and even here starts only in 1996/97 (for England). With the introduction of the Waste Data Flow system in 2004, reporting of household waste data was unified, representing a great improvement. Less data are available for C&I waste and the data situation appears to be even worse for C&D waste. In the case of C&I and C&D waste, comparability between the waste statistics of the constituent countries is greatly impaired due to a series of changes in methodology of data collection and also changes in reporting[35]. Efforts have been made to improve statistics; however, the very limited availability of data on waste arisings and composition renders the sound use of statistical estimation methods impossible in this case. Due to the scarcity of data, we resorted to case studies, expert opinions, and international reference values to estimate the influence of parameters and policies on waste arisings, composition, and treatment.

Baseline Waste Data

To establish a baseline for the model projections on waste arisings, we combined data from the official waste statistics. Based on the data available, 2007 was chosen as the model's base year. Where data for 2007 was unavailable, waste arisings from adjacent years were used as approximation. For data on the household waste baseline, the respective reports issued by Defra, SEPA, NIEA, and StatsWales were consulted.[36]

Data on C&I waste arisings were more difficult to obtain. At the time of writing, data from the 2009 survey of C&I waste arisings in England had just been published,[37] The former survey on C&I waste arisings in England was conducted by the EA in 2002/03.[38] More recent reports for the other constituent countries were available from SEPA, NIEA, and StatsWales.[39] Compared to the data from 2002, C&I waste arisings appear to be significantly lower in 2009. This is partly due to the economic crisis, but this does not fully explain the extent of the downward trend. In the model, we assume a decoupling of waste elasticity from GDP growth and integrated the 2009 survey.

Data on C&D waste arisings were also published by respective organisations[40], but the quality of the data are inconsistent. A recent report on C&D waste arisings in England in 2008 provided the most robust input so far.[41]

In order to align waste statistics with the broader EU definition of municipal solid waste, a new definition for municipal solid waste was recently adapted in the UK. Starting in 2010, household similar wastes from commercial and industrial sources will be balanced as municipal solid

[35] A 2008 report on waste statistics by Defra to the European Commission explains these challenges (Defra 2008).
[36] Defra (2009), NIEA (2009), SEPA (2009), StatsWales (2010a)
[37] Defra (2010)
[38] Defra (2006)
[39] NIEA (2009b), SEPA (2008), StatsWales (2010b)
[40] EA (2007), NIEA (2009c), SEPA (2009)
[41] Capita Symonds (2010)

waste. This implies a statistical shift of waste arisings from the C&I area to the municipal area. As of now, it is unclear how just large this shift will be. For this reason, the new definition is not incorporated into the model structure.

Primary Parameter Data

Ample official statistical information is available to establish the model's baseline for the primary parameters. Regional accounts published by the Office for National Statistics (ONS) provided information on GVA, the regional structure of the UK economy, and the shares of the economic sectors.[42] Also, data on population size and consumption patterns were obtained from ONS[43] (see Table 08).

Primary parameter development was projected based on the following studies and assumptions:

- GVA: Oxford Economics projected UK GVA growth until 2030[44], with a low, central, and high growth projection path. The Reference and High-Tech scenarios use the central projection; economic growth in the Sustainability scenario is based on the high projection; while the Unlimited Wastefulness scenario uses the low projection in the bust phase and the high projection in the following boom phase.
- Population size: The Reference, High-Tech, and Sustainability scenarios use the standard ONS population projection. The Wastefulness scenario uses a combination of the low and high population growth projections.[45]
- CPI weights: Future CPI weights were non-linearly extrapolated from the historical trend in the Reference and High-Tech scenario.[46] In the Sustainability scenario, we assume a shift of consumption patterns to a lower share of goods in the 2010s. In the Wastefulness scenario, we implicitly assume decreasing disposable household incomes in the 2010s, which lead to a relative increase in spending allocation on goods in the 2010s.
- Sectoral shares: A recent study by Oxford Economics explored possible future sectoral developments for the UK economy until 2030.[47] Sectoral development in both the Reference and the High-Tech scenario are based on the study's reference scenario, while the Sustainability scenario assumes an expansion of the low-carbon sectors and the Wastefulness scenario uses the rebalancing scenario sectoral development. Sectoral shares are assumed to continue developing along the respective growth paths until 2030.

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[42] ONS (2009a). The regional accounts are published at nominal values only. GVA values were adjusted to 2005 prices using inflation data published by ONS. At the time of model creation, regional accounts were only available to 2007. The recently published data for 2008 could not be integrated in the model by the time this report had to be finalised.
[43] ONS (2009b), ONS (2010)
[44] Oxford Economics (2009)
[45] ONS (2009b)
[46] Z_punkt extrapolation based on historic development of CPI weights.
[47] Oxford Economics (2010)

Table 08: Primary Parameter Projections

Parameters	*Reference*		*Sustainability*		*High-Tech*		*Wastefulness*	
	2020	***2030***	***2020***	***2030***	***2020***	***2030***	***2020***	***2030***
GVA growth p.a.	2.7	2.0	3.3	2.4	2.7	2.0	0.7	2.8
Population growth p.a.	0.67	0.59	0.67	0.59	0.67	0.59	0.42	0.86
CPI weights								
Exp. on goods in %	25	22	24	21	25	22	30	26
Exp. on services in %	75	78	76	79	75	78	70	74
Regional GVA shares	const.	const.	const.	const.	const.	const.	const.	const.
Sectoral GVA shares in %								
Construction	6.2	5.8	6.2	5.8	6.2	5.8	6.5	6.0
Industry	12.5	11.5	12.0	10.0	12.5	11.5	15.5	14.0
High-waste intense services	14.4	13.5	13.9	13.5	14.4	13.5	14.0	14.0
Low-waste intense services	65.8	68.2	66.7	69.5	65.8	68.2	62.8	64.9

Sources: Oxford Economics (2009), Oxford Economics (2010), ONS (2009a), ONS (2009b), ONS (2010)

Waste Intensity Development

The waste intensity improvement factor is one of the key levers in the model. Initially, the factor was designed to capture the waste intensity impacts of most of the primary influencing parameters that were identified in the first phase of the project. However, empirical evidence on the actual impact on waste arisings of these parameters is scarce, at best. As was expected, information is more abundant when it comes to household waste arisings and less so for commercial and industrial waste or construction and demolition waste. The lack of empirical data forced a reduction of the number of parameters that could be considered in the model context (for a list of the implemented parameters, see the Table 09 below). This reductionist approach is crude and owed to the practical constraints in impact assessment, which can only be resolved once more adequate data becomes available. In order to estimate the influence of waste related parameters more accurately, further research into waste intensity development will be essential.

Table 09: Parameter Impact on Waste Intensity

Parameters	***Average annual parameter development in %***							
	Reference		*Sustainability*		*High-Tech*		*Wastefulness*	
	2020	***2030***	***2020***	***2030***	***2020***	***2030***	***2020***	***2030***
Household	**0.9**	**0.7**	**2.8**	**2.1**	**0.5**	**0.4**	**0.6**	**0.3**
Campaigning	*0.4*	*0.4*	*0.8*	*0.6*	*0.1*	*0.1*	*0.2*	*0.1*
Direct waste incentives	*0.3*	*0.2*	*1.0*	*0.8*	*0.2*	*0.1*	*0.2*	*0.1*
Lighter + less packaging	*0.2*	*0.1*	*1.0*	*0.7*	*0.2*	*0.2*	*0.2*	*0.1*
C&I	**1.0**	**1.0**	**2.4**	**2.2**	**0.8**	**0.8**	**0.6**	**0.4**
Resource efficiency	*0.2*	*0.2*	*0.4*	*0.4*	*0.0*	*0.1*	*0.2*	*0.2*
General improvement factor	*0.8*	*0.8*	*2.0*	*1.8*	*0.8*	*0.7*	*0.4*	*0.2*
C&D	**1.0**	**1.0**	**1.4**	**1.4**	**1.2**	**1.2**	**0.5**	**0.5**
General improvement factor	*1.0*	*1.0*	*1.4*	*1.4*	*1.2*	*1.2*	*0.5*	*0.5*

Sources: BUWAL (2003), Institute for Environmental Studies (2009), SERI (2010), WRAP (2009), WRAP (2010)

The following studies were used as reference for estimating waste intensity development:

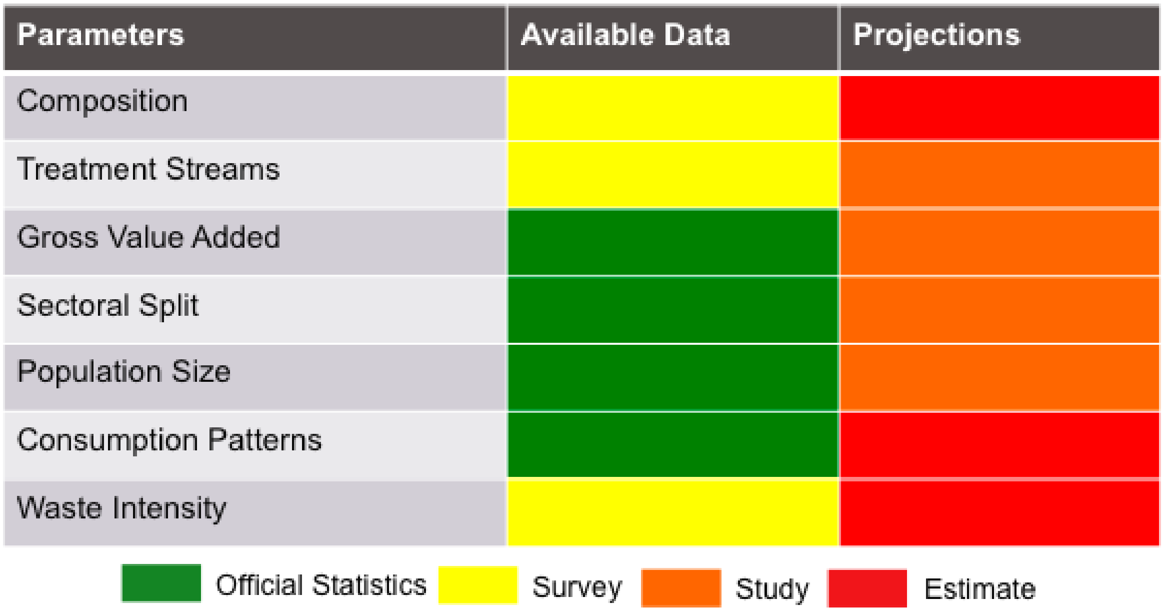
- Campaigning: WRAP's 'Love Food, Hate Waste' campaign seems to be the only large-scale campaign on waste prevention that generated data to measure its impact. In 2008, about 137,000 tonnes of food waste (equalling 1.6% of household food waste arisings or about 0.5% of household waste arisings) were avoided due to the campaign. We assume that similar campaigns achieve a comparable impact in the Reference Scenario. In comparison, campaigns are assumed to be highly effective in the Sustainability Scenario, but not in the High-Tech and Wastefulness scenarios.[48]
- Direct waste incentives: Swiss and Dutch studies[49] have shown that charging households directly for the collection of household waste leads to a significant reduction of household waste arisings. In the case of Switzerland, reductions amounted to an average 30% of residual household waste, the Netherlands reported a 11.6% reduction of household residual waste arisings and a 3% reduction of total household waste arisings. For certain reasons, direct household charging is regarded as unfeasible in the UK. However, according to waste experts the optimisation of other direct waste incentives such as bin sizes, collection intervals, and the design of collection schemes could result in effects mirroring those of direct household charging.
- Lighter and less packaging: The weight of packaging materials has been significantly reduced over the past several decades.[50] Given the lightweight packaging of today's products, this development might soon reach its limits. There is, however, potential for introducing more reusable packaging for transporting goods from producers to markets and also for a variety of fast-moving consumer goods. Here, impact assumptions on waste intensity development represent a rough estimate.
- Resource efficiency: WRAP published scenarios on the development of resource efficiency. The assumptions in Table 09 are to some extent based on the possible efficiency gains identified in the WRAP 2010 report.[51]
- General improvement factor: Recently, the Swedish Environmental Research Institute (SERI) published a model on future waste generation, which estimates future Swedish waste generation until 2030 along a line of scenarios. The model incorporates assumptions on the development of waste intensity concerning household waste generation and input-, staff-, depreciation-, and output-related wastes from industry and services. It assumes average annual improvement rates between 0% and 3%, depending on waste generating area and scenario. Unfortunately, the report does not provide significant detail on the empirical basis of these assumptions. However, SERI's study provides some orientation regarding the possible range of intensity improvement rates.[52]

[48] WRAP (2009)
[49] BUWAL (2003), Institute for Environmental Studies (2009)
[50] Incpen (2010)
[51] WRAP (2010)
[52] SERI (2010)

Robustness of Baseline and Projection Data

The data which establishes the model's baseline and facilitate the projection calculation shows different levels of robustness. Official statistics on population size and the economy can be considered to be highly robust, due to the broad collection base and long-established statistical processes. The waste data collected in surveys show a considerable margin of deviation. The studies venturing to project economic growth use well-established methods, yet the margin for error is considerably high. Finally, the model's assumptions for the development of waste composition, waste intensity, and consumption patterns of private households are quite strong, also leaving a potential margin for error. Table 10 shows an overview of the robustness of the available data and the projections that were used in the model. Robustness decreases as the colour changes from green to red.

Table 10: Robustness of Baseline and Projection Data



Parameters	Available Data	Projections
Composition		
Treatment Streams		
Gross Value Added		
Sectoral Split		
Population Size		
Consumption Patterns		
Waste Intensity		

Official Statistics Survey Study Estimate

Source: Z_punkt

5.4 Key Factors' Projections

On the following pages, we introduce the set of projections for each key factor. The material provides information on the alternative and plausible developments for each factor identified during the analysis. Each factor has one evidence-based "Reference Case" projection and several other possible ones, using an accepted source outlining what can be regarded as "business as usual" or trend continuation projections for the specific subject. Every key factor is concisely defined and summarised (for details on the key factors as such, please see the key factor report provided to Defra at an earlier stage of the project – please also be aware that because this step was finalized quite early on in the project, it may not reflect the final project reasoning in all details). The time horizon for each of these projections is 2030.

UK's Demographics	
Definition	Status and development of UK's demographics, expressed in total population, population growth (net migration, births, deaths) and age structure
Summary	The UK population is growing and population growth even accelerated during the past decades. One reason is a growing birth rate at simultaneously stable death rates, another is increasing immigration. Additionally, the population is getting older (especially the number of the oldest old grows strongly) and more multi-cultural.

Dimensions considered in projections:

- Total population size
- Net migration
- Birth rate
- Death rate
- Age structure (proportion of 65+)
- Population mix

Projection 1 I Stable Population Growth (Reference Case)

The UK population continues to grow by around 0.6% annually, reaching 70.6 million people by 2030.[53] As more people are attracted to the UK, population growth is driven by continued net migration of around 150,000 people per year[54], a small increase in birth rates and relative stable death rates. The age structure shifts towards a greater proportion of older people. By 2030, 24% of the UK population are 60 years or older.[55] Continued migration leads to an increasingly mixed and diverse population.

Projection 2 I Population Boom

The UK experiences an unexpected population boom, growing much more rapidly than expected. Population growth is driven by migration, a rapid increase in birth rates, and small reduction in death rates. Due to higher birth rates, the age structure does not shift towards an as high as expected share of the elderly. Continued migration leads to an increasingly mixed and diverse

[53] Existing projection from: ONS 2010 - principal (main) projection
[54] Existing projection from: Eurostat 2010
[55] Existing projection from: ONS 2010 - principal (main) projection

population.

Projection 3 I Rapidly Ageing Population, Stagnation

The UK population does not grow as previously expected and enters a period of stagnation. Net migration per year is at a historic low and partly negative, causing annual growth rates near zero. Birth rates decrease, while death rates remain relatively stable. Due to a lack of migration, the age structure rapidly shifts towards a significantly greater proportion of older people. The proportion of people from ethnic minorities does not change significantly.

UK's Socio-Economic Situation	
Definition	Status and development of UK's socio-economic structure, expressed in household size, proportion of foreigners, income distribution, people living below the 60% low-income threshold, education levels, degree of urbanisation, and unemployment rates.
Summary	The UK's household structure is characterised by a permanent increase in the total number of households and a simultaneous trend toward smaller households. Furthermore, society is becoming more multi-cultural as the number and share of people born outside the UK is growing. While it was mainly people from India and Pakistan who immigrated to the UK in the 1980s and 1990s, it is now first and foremost people from Eastern Europe. Compared to the 1980s, income inequality and relative poverty have increased significantly, but have remained relatively stable over the past 8-10 years. There is a clear upward trend in A-levels and higher education amongst younger Britons. The share of people living in urban areas is inching towards the 80% mark.

Dimensions considered in projections:

- Income levels (real median income)
- Household number
- Proportion of single person households
- Proportion of households 65+
- Income distribution / inequality
- Poverty levels (households below the 60% of median income threshold)[56]
- Education levels / social grade
- Unemployment levels

Projection 1 I Growing Affluence (Reference Case)

UK income levels continue to rise steadily. Overall, the number of households has increased, with a strong shift to one-person households among the middle-aged and households with people aged 60 and over. Income inequality remains relatively stable[57], while overall education levels are improving. The unemployment rate does not change significantly between 2009 and 2030.

Projection 2 I Income Distribution

UK income levels continue to rise. Income inequality is significantly reduced, with greater earnings for poorer and rural households and significantly higher taxes for high and medium earners. Education is booming, even among low-income households, causing a steep rise in overall education levels. Unemployment is relatively low. Overall the number of households has increased, with a shift to one-person households and households with people aged 60 and over.

Projection 3 I Inequality Reigns

UK income levels rise slightly. The middle class continues to erode and income inequality increases substantially, with an ever-wider divide between those that are very well off and those

[56] This refers to a household income that is 60% or less of median British household income in that year.
[57] In this case, "relatively stable" means that the Gini coefficient value ranges between 32 and 37, which has been roughly the range since the first half of the 1990s, according to statistics from ONS 2010b

living near or below the poverty line. Education levels do not improve and fewer people participate in higher education. In 2030, the unemployment rate is much higher than today. The shift towards older and one-person households continues.

Projection 4 I Poor Society

UK income levels do not grow, hovering at a real median income of around GDP 17,800 by 2030[58]. Income inequality is reduced, but the UK population is generally a lot less well off. In 2030, there is high unemployment, with a large proportion of the total population living below the 60% median-income threshold. Competition for jobs increases, leading to a rise in education levels. As people aim to reduce living costs, average household size increases, while the trend towards older households continues.

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[58] Estimate based on 2009 data by IFS 2010

Consumption Patterns and Environmental Behaviour

Definition	The aggregate amount and streams of money that households spend on consumption in the UK, as well as the underlying motives for the individual consumption decisions and resource use.
Summary	Consumption expenditure has grown rapidly in the past, with average incomes lagging slightly behind. Non-durable goods attracted the largest share of consumption expenditure three decades ago, now services have taken their place. In the coming years, expenditure growth is likely to slow down, as private and public households will have to reduce their levels of debt. Britons' buying decisions and everyday behaviours are increasingly determined by a growing concern over environmental issues. However, a considerable gap remains between attitudes and behaviour. Environmentally conscious behaviour is likely to increase once the impacts of climate change and other environmental problems become more apparent.

Dimensions considered in projections:

- Consumption expenditure (real consumption expenditure)
- Disposable income
- Consumption of non-durable goods
- Consumption of semi-durable and durable goods
- Consumption of tangible and intangible services
- Level of public concern for the environment
- Proportion of the population that have adopted the LOHAS lifestyle
- Influence of sustainability in buying decisions
- Influence of price in buying decisions
- Volume of material intensive products purchased
- Level of recycling, composting, and reuse

Remarks:

- **Non-Durable Goods**: have a lifespan of less than one year, typical examples are: food, fuel, cosmetics, drugs, shoes, and services.
- **Semi-Durable Goods:** typical lifespan between one and three years (neither perishable nor long-lasting), typical examples are: clothing, some types of furniture
- **Durable Goods:** items which should continue to be serviceable for at least three years and that are not consumed or destroyed in a single usage, typical examples: cars, refrigerators, appliances, business equipment, electronic equipment, home furnishings and fixtures, household goods and accessories, photographic equipment, recreational goods, sporting goods, toys and games.

Projection 1 I Good Attitudes, Wasteful Behaviour (Reference Case)

In the UK, both the level of concern for the environment and the amount of disposable income continue to increase. In surveys, more than half of respondents regularly express concern for the environment. However, only a small proportion of the population has fully adopted the LOHAS[59] lifestyle, as attitudes continue to remain detached from behaviour. With more money to spend, consumption of non-durable goods increases. Demand for semi-durable and durable goods show a proportionate decline, while demand for tangible and intangible services increases. People are evidently aware of the environmental impact their lifestyles are having, but are unable to translate this concern into tangible actions. Individual consumption decisions continue to be driven by price, brand, or quality, while recycling and composting rates remain largely stable.

[59] LOHAS: Lifestyles of Health and Sustainability

Overall, the UK society's appetite for material possessions continues to grow, with low levels of product re-use.

Projection 2 I Strong Increase in Sustainable Consumption

In the UK, both the level of concern for the environment and income levels increase substantially. In surveys, most respondents regularly express concern for the environment and more than half of the population have adopted the LOHAS lifestyle. Consumers increasingly make conscious choices about which products and services they consume and how they consume these. The level of consumption of non-durable goods continues to fall. Consumption of semi-durable and durable goods remains relatively stable, but consumers favour high quality products with low environmental impacts (in terms of materials used and lifespan). Use of reusable and refillable products and services increases substantially as more people try to reduce the impact of their purchases. The volume of material intensive products purchased is significantly reduced. With more money to spend, consumption expenditure increases significantly, but with a strong focus on sustainable products and tangible services that reduce waste.

Projection 3 I Steady Buying Power, Conscious Choices

UK disposable income remains relatively stable. However, consumers increasingly make conscious choices about which products and services they consume and how they consume these. The level of concern over the environment increases substantially. In surveys, most respondents regularly express concern for the environment, and around one resident in five has adopted the LOHAS lifestyle. People are fully aware of the environmental impact their lifestyles are having. The level of consumption of non-durable goods continues to fall. Consumption of semi-durable and durable goods remains relatively stable, but consumers prefer products of high quality and low environmental impact (in terms of materials used and lifespan). The same is true for non-habitual consumption, such as holidays. Use of reusable and refillable products and tangible services increases substantially as more people try to reduce the impact of their purchases. Households recycling and composting rates are at a historic high. The volume of material-intensive products purchased is significantly reduced.

Projection 4 I Low Consumption and Low Environmentally Conscious Behaviour

UK disposable income and real consumption expenditure are in decline. Limited buying power causes a proportionate increase in the consumption of non-durable goods and services. Consumer choices are pre-dominantly driven by price and cost, not quality. Recycling and composting rates are high in cases where this offers a financial return. The level of concern over the environment does not increase. In surveys, only a minority regularly expresses concern about the environment as one of their main worries, and only a fraction of the population are living the LOHAS lifestyle. Durable goods sold are more waste-intensive as suppliers aim to provide lost-cost products. The volume of material intensive products purchased is dominated by demand for low-cost, low-quality products.

Projection 5 I High Consumption and Low Environmentally Conscious Behaviour

After a short period of stagnation, UK disposable income increases rapidly. As incomes grow, the gap between rich and poor widens, but overall people are somewhat better off. The level of concern over the environment and sustainability decreases. Waste-reducing behaviours are limited to where this is fashionable and provides status. With more money to spend, consumption of consumer goods increases rapidly, both at the high end and the low end of the market. Demand for non-durable, semi-durable and durable goods show strong increases. Tangible and intangible services also expand. In this consumption driven, throw-away society, recycling, re-use, and composting rates are low.

UK's Economic Output	
Definition	Size and future development of UK's economic output, expressed in real GDP, total and per capita, average annual growth, and origin (expenditure approach).
Summary	UK's economic output exceeds £1 trillion, and the UK is one of the top 10 economies in the world in real GDP (ranking 34th in terms of GDP p.c.). Since emerging from recession in 1992/93, Britain's economy enjoyed the longest period of expansion on record, outpacing many other countries of Western Europe. Most of the economic output results from consumer expenditures. However, the country was hit hard by the global financial crisis in 2008.

Dimensions considered in projections:

- Size of UK economy
- Development of UK's economic output (real total GDP; GDP per capita)
- Export/import balance
- Proportion of consumption by households/government

Projection 1 I Steady Growth (Reference Case)

Between 2011 and 2020, the UK economy grows by an average of 2.7% per year.[60] From 2020 to 2030, the UK grows by around 2.0% a year.[61] GDP per capita continues to grow at a rate similar to real GDP. The UK trade balance remains negative as the value of imported goods exceeds that of exports. The proportion of GDP resulting from final consumption by households rises slightly, while government spending is proportionally reduced. In 2020, the UK is the eighth largest economy of the world (losing one rank to Brazil), accounting for 3% of the world economy.[62]

Projection 2 I Rapid Per Capita Growth

Between 2011 and 2020, the UK economy grows by an average of almost 3.3% per year[63], followed by a period of robust growth of 2.4% on average per year towards 2030. GDP growth significantly outpaces population growth, leaving the UK population generally better off. The UK trade balance improves significantly, mainly driven by strong exports of manufactured goods and services. The proportion of GDP resulting from final consumption by households continues to rise, while government spending is proportionally reduced.

Projection 3 I Bust-Boom Cycle

The UK economy experiences an initial period of stagnation. Between 2011 and 2017, UK economic growth does not exceed 0.7%.[64] After 2017, growth rapidly accelerates, with an annual average growth rate of 3% per year.[65] The economic boom years continue well into 2030s. GDP per capita increases significantly, leaving the UK population generally much better off. The UK trade balance improves slightly, but overall remains negative, as UK consumers significantly increase the consumption of goods and services produced outside of the UK. The proportion of GDP resulting from final consumption by households increases significantly, while government

[60] Existing projection from: Oxford Economics 2010 – Baseline Forecast
[61] Existing projection from: Oxford Economics 2010 – Baseline Forecast
[62] Existing projection from: Euromonitor 2010
[63] Existing projection from: Oxford Economics 2010 – Upper Scenario
[64] Z_punkt estimate
[65] Z_punkt estimate

spending is proportionally reduced.

Projection 4 I Double Dip

The UK experiences a double dip recession. Between 2011 and 2019, UK economic growth is initially negative and after 2014 does not exceed 1% per year.[66] The double dip recession is followed by a relatively stable recovery. From 2020 to 2030, the UK economy grows by around 2.0% a year.[67] The UK trade balance remains negative as the value of imported goods exceeds that of exports. The proportion of GDP resulting from final consumption by households remains stable, while government spending is proportionally increased due to a new wave of stimulus packages.

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[66] Z_punkt estimate
[67] Existing projection from: Oxford Economics 2010 – Not related to double dip recession scenario

UK's Economic Structure	
Definition	Composition and value of GDP by economic sector (agriculture, industry & services), as well as structure and value creation within the secondary sector of UK's economy. Total number of enterprises by size of employment.
Summary	Services, particularly banking, insurance, and business services, account by far for the largest proportion of GDP, while industry continues to decline in relative importance. Although industry output grows, it grows slower than total GDP. Within the industrial sector, manufacturing is responsible for the lion's share of the industrial value creation (62.5% in 2008). However, since the 1980s, its relative importance compared to the other industrial sectors is declining. Especially construction and utilities become more important. The fourth major branch, mining and quarrying, is rapidly declining, both in absolute terms and relative shares. Within manufacturing, machinery and equipment manufacturing account for the largest share, with chemical, rubber, plastics, and fuel products growing strongest since 1980. UK's enterprise structure is characterised by SMEs. The majority of UK's enterprises has 0-4 employees (68%), and only about 0.5% of all enterprises are larger than 250 employees. SMEs (up to 249 employees) contribute about half of UK's economic output.

Dimensions considered in projections:

- GDP by economic sector
- Development of service sub-sector growth
- Development of industry growth
- Number of enterprises by size
- Structure and value creation within the secondary sector of UK's economy
- Real growth of the industrial branches in the second economic sector: real value creation of mining & quarrying, manufacturing (and its sub-branches), electricity, gas, water supply and construction

Projection 1 I Continued Shift to Services (Reference Case)

Over the coming two decades, industry's share of GDP continues to decline, while that of services (in particular finance, insurance, real estate, and business services) continues to increase. The economy continues to be dominated by Small and Medium Sized Enterprises. The industrial sector shows a slight increase in the proportion of food manufacturing. Overall, most manufacturing sectors show stable, slow growth in real terms. Utilities and the construction sector also expand in real terms. The South-East of England continues to dominate as the UK's leading economic region.

Projection 2 I Resurgence of British Manufacturing

Over the coming two decades, industry's share of GDP grows significantly. Services increase in real terms, but show a proportionate decline. Growth in the industrial sector is driven by a rapid expansion of the construction sector, a resurgence of British manufacturing, and a much stronger agricultural sector. Food manufacturing, chemicals, rubber, plastics, and fuel products show the strongest growth along with machinery and equipment. The proportionate industry share and real GDP output of mining and quarrying increases. Medium to Large Enterprises increasingly dominate, but SMEs still make up the largest share. The economy is slightly rebalanced away from the South East of England.

Projection 3 I Centre of Excellence

By 2030, the UK has outsourced most resource and energy-intensive manufacturing activities and has instead developed into a centre of excellence for high value R&D and niche products and services. The trend is driven by a successful shift towards developing strong intellectual property and specialised niche production. While R&D and value creation remain in the UK, more commoditised manufacturing is re-located to low-cost and low-tax jurisdictions off-shore. Specialised chemical, rubber, plastics, and fuel products show the strongest growth along with machinery and equipment. As a result, industry's share of GDP has increased slightly, while that of services has also increased. Small and Medium Sized Enterprises and so-called hidden champions dominate the economy. The South-East of England continues to dominate as the UK's leading economic region, but other parts of the UK have developed strong market positions in niche industries. The construction sector and utilities show strong growth, while mining and quarrying continue to decline.

Projection 4 I Balancing

Over the coming two decades the UK economy experience a period of rebalancing, both in terms of GDP by sector, export/import balance, and geographic dominance. Industry and agricultural shares of GDP increase, while that of services declines. Volumes of exports increase, which leads to a near balance of exports and imports. Small and Medium Sized Enterprises dominate the economy. However, the South-East of England is no longer so disproportionately important an economic region, as other key regions around the UK, in particular the north of the UK, increase their relative economic importance.

UK's Energy System	
Definition	UK's energy system, described by total energy demand, energy supply by source (energy mix), electricity mix, and energy price.
Summary	UK's total energy demand increased by about 20% between 1982 and 2005. The vast majority is provided by fossil sources (nearly 90%). Compared to 1980, fossil fuel dependency declined only marginally, by 5%. Since 1980, natural gas has become Britain's most important energy source. In 2009, NG accounted for 41% of all energy consumed. Renewables and waste contribute less than 3%, growing by 11.5% in absolute numbers (mt) per year on average. After having been an energy net exporter for decades, UK's energy imports outnumber exports since 2004, with growth tendencies. Expenditures for energy are growing in absolute terms, having more or less developed in line with GDP. However, fuel poverty for households due to rising energy prices is a growing concern in recent years. Electricity's share in final consumption increases. The electricity fuel mix is also dominated by fossil fuels (92% in 2009), but the renewables' contribution, including energy from waste, has grown in double digits during the last decades.

Dimensions considered in projections:

- Total energy demand
- Energy supply by source (energy mix)
- Proportion of Energy from Waste (EfW) and Anaerobic Digestion (A.D.)
- Electricity supply by source (electricity mix = proportion of coal/gas-fired power plants, nuclear power, and renewables)
- Energy prices

Projection 1 I Slow Shift to Renewables (Reference Case)

In the UK, primary energy demand and demand for electricity continue to rise. Fossil fuels still dominate primary energy supply and electricity generation, with natural gas showing a proportionate increase over coal-fired power generation. Even though a couple of new nuclear power plants go online until 2030, nuclear capacity does not grow significantly, as new plants primarily replace older ones. Renewable energy systems continue to expand, providing 15% of the total primary energy supply by 2020.[68] Both globally and in the UK, energy prices rise. By 2015, oil prices average USD 86 per barrel, an increase of 13% from 2010 levels.[69] As prices for energy resources remain high, an increasing proportion of renewables generation is provided by Energy from Waste (EfW) and Anaerobic Digestion (A.D.) solutions.

Projection 2 I Nuclear Growth

In the UK, primary energy demand and demand for electricity continue to rise. The UK experiences strong nuclear growth with a rapid and extensive expansion of nuclear power, coupled with an expansion of renewables. Requirements for other fossil fuels in electricity generation are significantly reduced. Both globally and in the UK, energy prices remain volatile and high. The impact of Energy from Waste (EfW) solutions remains limited, while Anaerobic Digestion (AD) solutions continue to expand.

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[68] Existing projection from: DECC 2009, no official data available for 2030
[69] Existing projection from: IEA 2010

Projection 3 I Zero Carbon Britain

Efficiencies in economy and households cause primary energy demand and demand for electricity to stagnate. The shift to Zero Carbon Britain is characterised by a minimisation of fossil fuel use (especially in transport), the widespread deployment of carbon capture and storage technologies, and a rapid expansion of renewable power solutions, including the rapid expansion of Energy from Waste (EfW) and Anaerobic Digestion (AD) as well as the extensive use of waste heat from industrial, commercial, and domestic applications. Nuclear power capacity is also increased. In the UK, energy prices eventually rise, mainly due to the high investment requirements of renewables, but later stagnate and eventually fall as Britain develops into a highly efficient, zero-carbon society.

Projection 4 I Small-Scale Generation

Small-scale renewables boom, with a large number of households adopting photovoltaic or micro-wind power solutions for their homes. The shift to decentralised energy reduces demand for large-scale centralised power generation, where rising capacity demands are mainly met by gas-fired generation and Energy from Waste (EfW) solutions.

Projection 5 I Focus on Co-Firing and Fossil Fuels

In the UK, primary energy demand and demand for electricity continue to rise. Fossil fuels still dominate primary energy supply and electricity generation. CCS equipped coal-fired power plants, gas-fired capacity, and co-firing show particularly strong growth, while nuclear power capacity also grows. Renewable energy systems continue to expand, but slower than expected. Both globally and in the UK, energy prices rise. As prices for energy resources remain high, an increasing proportion of power systems fuel is provided by biomass and waste.

Global Commodity Markets (Availability and Costs)	
Definition	Price development of industrial metals, food, and other recyclable materials such as paper, plastics, and glass, expressed by commodity price index levels.
Summary	Industrial metals, food and other recyclable materials have seen an enormous price increase since the early 2000s, which resulted in all-time highs for almost all commodities in 2008. Current price levels are still higher than in pre-crisis times.

Dimensions considered in projections:

- Global demand for commodities
- Global accessibility of commodities
- Commodity price index levels
- Industry Metal Price Index
- Energy Fuel Price Index
- Food Price Index
- Price development of recyclable materials such as paper, plastics and glass

Projection 1 I Steadily Increasing Prices (Reference Case)

Global demand for key commodities – in particular energy resources, minerals, metals, and food – continues to rise. This, coupled with a limited expansion of supplies, leads to steadily increasing prices on world commodity markets. Markets remain largely open. Price increases for energy and metals are steady, showing little volatility. Price increases for food are particularly high, with regular intervals of strong price volatility. With higher prices for raw materials, demand for and prices of recyclates also increase.[70]

Projection 2 I Open Markets and Stable Supplies

Global demand for key commodities – in particular energy resources, minerals, metals, and food – increase only slightly. This, coupled with a strong expansion of supplies, leads to stable and in some cases decreased prices on world commodity markets. Markets are increasingly open, with greater incorporation of developing and emerging markets. Commodity markets for energy, metals, and food show little volatility. With stable prices for raw materials, demand for and prices of recyclates stagnate.

Projection 3 I High Prices and Strong Volatility

Global demand for key commodities – in particular energy resources, minerals, metals, and food – rapidly increases. This, coupled with a limited expansion of supplies, leads to a strong increase in prices on world commodity markets. Markets are increasingly restricted. Price increases for energy and food are particularly strong and highly volatile. Demand for and prices of recyclates are also highly seasonal and volatile depending on price developments in commodity markets.

[70] See WRAP 2010 market situation reports

Projection 4 I Closed Markets and Protectionism

Global demand for key commodities – in particular energy resources, minerals, metals, and food – rapidly increases. This, coupled with a limited expansion of supplies, leads to a strong increase in prices on world commodity markets. Markets are increasingly closed as countries take protectionist measures to secure domestic supplies. Demand for and prices of recyclates increase rapidly as industries look for substitutes to dwindling global commodity supplies.

Projection 5 I Price Drop

Global demand for key commodities falls. This, coupled with a continued expansion of supplies, leads to a strong decrease in prices on world commodity markets. Price decreases for energy, metals and minerals are particularly strong. With low prices for raw materials, demand for and prices of recyclates decrease significantly.

Corporate Eco-Behaviour	
Definition	Material consumption and used production technologies of UK's companies, as well as their environmental awareness and corporate culture.
Summary	The UK economy has improved greatly in terms of productivity, energy efficiency, and resource productivity. Domestic material consumption (DMC) reached its height in 1989, decreased in the early 1990s and stagnated later on. The recent global economic crisis led to a stark decline of domestic material consumption in 2008. The great majority of the largest companies in the UK issue Corporate Social Responsibility reports, but the implementation of environmental management systems seems to lag behind in comparison.

Dimensions considered in projections:

- Changes in corporate culture – level and type of CSR reporting
- Deployment of environmental management systems (ISO 14001)
- Demand for corporate eco-awareness by sector and industry
- Developments in production technology
- UK resource productivity and economic energy efficiency
- Impact of financial and competitive incentives
- Domestic materials consumption (also in relation to GDP)
- Type of materials consumed
- Material intensity of products
- Resource intensity of production/construction processes

Projection 1 I Diverse Approaches (Reference Case)

Corporate eco-awareness in the UK is highly sector-specific and diverse. While some sectors show strong shifts in corporate culture and some technological change, other industries fail to encourage substantial change and instead focus on "greenwashing" campaigns. The implementation of environmental management systems is highly sector-specific with little standardisation across industries and markets. Manufacturing investments are also highly sector-specific, with some sectors showing strong investments and others relying largely on dated, inefficient technologies. Resource productivity gains and improvements in economic energy efficiency are limited to specific sectors. There are partial efficiency gains in construction, the production of goods and provision of services. There is a mild relative decoupling of economic growth and material consumption. The use of sustainable and renewable materials is heavily sector dependent.

Projection 2 I Low Level of Concern and Efficiency

The UK economy is characterised by a low level of overall corporate eco-awareness. There is limited corporate culture and technological change and "greenwashing" continues to be widespread. This leads to a highly restricted implementation of environmental management systems and CSR measures. As a consequence, the economy shows little resource productivity gains, low improvements in economic energy efficiency, and low levels of investment in new manufacturing technology. The total amount of materials consumed by the UK economy grows significantly. Increased domestic demand for materials is driven by wasteful practices in the production of goods and the construction sector. There is a strong correlation between economic growth and increases in domestic material consumption. The volume and use of sustainable and renewable materials remains marginal.

Projection 3 I Sustainability Drive

The UK economy develops a high level of corporate eco-awareness. The shift is driven by strong regulation and supported by international and domestic standardisation of reporting and measuring procedures. Companies in all sectors show widespread use of the voluntary EU Eco-Management and Audit Scheme (EMAS), ISO 14001, and standard environmental management systems. The trend is accompanied by a strong shift in corporate culture and technological change and investments at the operational level, leading to widespread resource productivity gains and improvements in economic energy efficiency. Any increase in economic activity is offset by high efficiency gains, in particular in the construction sector and the production of goods. There is a trend towards a strong decoupling of economic growth and material consumption. The volume and use of sustainable and renewable materials increases significantly, while the consumption of finite materials decreases.

Policy: Further Development of LATS and Landfill Tax	
Definition	Schemes using tax and other monetary incentives to reduce waste arisings and to improve waste treatment shares according to the waste pyramid.
Summary	The landfill tax and the Landfill Allowance Trading Scheme are the two major fiscal incentive schemes that policy makers have devised to influence the amount of (bioactive municipal) waste being landfilled. With landfill tax rates increasing and authorities' landfill allowances diminishing, the amount of biodegradable waste sent to landfill has been effectively reduced.

Dimensions considered in projections:

- Impacts of schemes using tax and other monetary incentives to reduce waste arisings
- Development of waste treatment shares
- Development of UK landfill tax
- Development of Landfill Allowance Trading Scheme

Projection 1 I Gradual Tax Increases (Reference Case)

The Landfill Allowance Trading Scheme (LATS) is abandoned after 2013. The landfill tax escalator is stopped beyond 2014 and the landfill tax rate stabilises. There is a limited policy focus on fiscal incentive schemes to achieve a reduction in the amount of waste sent to landfill. Landfill is slightly more expensive than mass-diversion options.

Projection 2 I Hammering of Landfill

The Landfill Allowance Trading Scheme (LATS) is abandoned after 2020. The landfill tax escalator continues beyond 2014 and the landfill tax rate increases substantially. There is a strong policy focus on fiscal incentive schemes to achieve a massive reduction in the amount of waste sent to landfill. Landfill is significantly more expensive than mass-diversion options.

Projection 3 I Landfill Reduction and Incineration Tax

The Landfill Allowance Trading Scheme (LATS) is abandoned after 2013. The landfill tax escalator continues beyond 2014 and the landfill tax rate increases slightly. The policy is supported by the introduction of an incineration tax, to further strengthen the attractiveness of recycling and re-use over landfill and incineration. In most cases, landfill and incineration are more expensive than other mass-diversion options.

Projection 4 I Sophisticated, Materials-Based Approach

The Landfill Allowance Trading Scheme (LATS) is abandoned after 2013. There is a policy shift towards a much more sophisticated waste policy approach that differentiates tax rates for landfill and other mass-diversion options by materials and processes.

Policy: Measures for Voluntary Improvements	
Definition	Campaigns and voluntary agreements that seek to influence waste-related behaviour of businesses and private households through communication, information, and/or education.
Summary	In the UK, several publicly funded not-for-profit organisations have been conducting campaigns on national as well as local levels aiming to achieve a reduction of waste arisings and an increase in recycling and reuse rates. Campaigns like 'Recycle Now' and 'Love Food, Hate Waste' resulted in a significant change in individual behaviour.

Dimensions considered in projections:

- Impact of campaigns on household, demolition & construction and commercial & industrial waste prevention, recycling, and re-use
- Impact of voluntary commitments/agreements on household, demolition & construction and commercial & industrial waste prevention, recycling, and re-use

Projection 1 I Stable Support and Participation (Reference Case)

Policy support for not-for-profit organisations and industry driven campaigns and voluntary agreements for waste reduction continues at a stable level. Campaigns focus on information provision, education, and expert support. Voluntary improvements have an impact on waste arisings and treatment in both business and private households.

Projection 2 I Increase in Policy Driven Measures

Policy support for not-for-profit organisations and industry driven campaigns and voluntary agreements for waste reduction increases substantially. Campaigns focus on information provision, education, and expert support. Voluntary improvements have a significant impact on waste arisings and treatment in both business and private households.

Projection 3 I Decrease in Policy Measures and Industry Responses

Policy support and funding for not-for-profit organisations and industry driven campaigns and voluntary agreements for waste reduction decrease substantially. Industry does not fill the void and many campaigns and voluntary agreements eventually fade away or loose influence. Voluntary improvements have little or no impact on waste arisings and treatment in both business and private households.

Projection 4 I No Policy, but Strong Industry

Policy support and funding for not-for-profit organisations and industry driven campaigns and voluntary agreements for waste reduction come to an almost complete stop. Industry steps in to fill the void and take greater responsibility. Industry driven campaigns and voluntary agreements are highly influential in driving both corporate and private waste behaviour. Voluntary improvements have a significant impact on waste arisings and treatment in both business and private households.

Policy: System Support and Interventions	
Definition	This shaping factor summarises regulatory policy measures, e.g. landfill bans and shipping regulations[71], which are primarily targeted at the waste management industry and authorities.
Summary	The national government has introduced a variety of regulatory measures for the waste system. Several materials have been banned from landfills and further bans are being discussed. Moreover, the national government introduced programmes that support local authorities with expert knowledge and further consulting services. These measures are complemented with fiscal incentives for the procurement of environmentally friendly technology, the minimisation of waste, and the increase of recycling.

Dimensions considered in projections:

- Role and impact of regulatory policy measures
- Role of local authorities
- International regulations – EU and OECD

Projection 1 I Stable Legislation (Reference Case)

UK and EU waste legislation remains relatively stable, with little or no changes to existing legislation beyond 2020. Existing EU targets are implemented, but no new ones are accepted. There is some standardisation among the waste management of local authorities.

Projection 2 I Push for De-Regulation

There is a strong policy shift towards de-regulation. Existing targets to 2020 are amended and adjusted wherever possible. There are no new domestic targets beyond 2020 and no new EU targets are accepted. There is little standardisation among the waste management of local authorities.

Projection 3 I More Legislation, More Standardisation

There is a strong policy shift towards more legislation. The aim is to provide more targets, more support, and more stringent rules. A host of new domestic and EU targets is developed and implemented beyond 2020. Higher levels of standardisation lead to reduced waste management costs for local authorities.

[71] For further information see ENDS 2009
[71] For further information see ENDS 2010

Treatment Infrastructure and Technology: Recycling and Reuse	
Definition	Status quo of UK's recycling and re-use infrastructure and technology, expressed by the processing capacities of the country's materials recycling facilities (in tonnes) and other recycling supply chains, if possible for single materials such as paper, glass, plastics, or textiles. Re-use capacity is (where available) expressed by the size of second-hand markets for single product categories.
Summary	The recycling capacity in the UK has been growing in recent years, but varies according to product, ranging from well-established for glass to almost non-existent for batteries. As laid down in the English planning system, the responsibility for permitting or not permitting new reprocessing sites is in the hands of local authorities. The UK's reuse of products (second-hand markets) is also growing, whereas the exact market size for the total market and/or single product categories is difficult to pin down, due to a lack of available data.

Dimensions considered in projections:

- Shape and structure of UK's recycling and re-use infrastructure and industry
- Processing capacities of materials recycling facilities (in tonnes)
- Re-use capacity
- Domestic recycling capacity for single materials such as glass, plastics, paper, metals
- Composting capacities for food
- Level of investments in recycling and processing facilities
- Proportion of overseas export of waste for recycling
- Importance of environmental aspects and quality of material collected

Projection 1 I HH Waste Dominates Development (Reference Case)

The expansion of treatment infrastructure and technology for recycling and re-use in the UK develops haphazardly. The waste sector remains fragmented. There is a trend towards more coordinated collection, but also a persistent mismatch between recyclate supply and demand. The type of recycling infrastructure developed and deployed continues to be dominated by household waste with limited use of co-treatment options for plants accepting both HH & C&I streams. There is a limited expansion of domestic plastic recycling capacities, but stronger growth in paper and glass recycling capacities. Recycling capacity for Waste Electrical and Electronic Equipment (WEEE) is lacking. Re-use is mainly driven by services from the third sector, but the overall quantities of WEEE reused continues to decline as the large compliance schemes have no incentive to preserve the quality of WEEE to make reuse possible. Weight and quantity continues to be more important drivers for recycling than the environmental aspects and quality of material collected.

Projection 2 I Coordinated Expansion

The expansion of treatment infrastructure and technology for recycling and re-use in the UK develops in a coordinated manner. The waste sector is increasingly consolidated, leading to a standardisation of collection methods. The type of recycling infrastructure developed and deployed continues to be dominated by household waste, but the specific requirements of C&I waste are increasingly considered in planning processes. Processing capacities are largely modelled on household waste arisings with C&I consideration. There is a rapid increase in domestic plastic, paper, and glass recycling capacities, and strong expansion of recycling capacity for Waste Electrical and Electronic Equipment (WEEE). Re-use is increasingly driven by professional services and industry. The environmental aspects and quality of material collected are increasingly important.

Projection 3 I High-Tech Focus on Commercial and Industrial Waste

The expansion of treatment infrastructure and technology for recycling and re-use in the UK develops in a coordinated way. The waste sector is increasingly consolidated, leading to a standardisation of collection methods, in particular for C&I waste. New recycling infrastructure deployed is both high-tech and large-scale and balanced for household and C&I waste requirements. There is an increase in domestic plastic and paper recycling capacities, and a slight increase in recycling capacity for Waste Electrical and Electronic Equipment (WEEE). Re-use is driven partly by professional services as well as the third sector. The quality and quantity of material collected are increasingly important.

Projection 4 I Low-Tech, Uncoordinated and Diverse

The expansion of treatment infrastructure and technology for recycling and re-use in the UK develops haphazardly. The waste sector is increasingly fragmented, leading to a further diversification of collection methods. Recycling infrastructure develops uncoordinatedly with high local diversity in terms of treatment processes and capacities. Domestic plastic recycling capacities do not expand significantly, although there is a slight increase in paper and glass recycling capacities. There is a persistent lack of recycling capacity for Waste Electrical and Electronic Equipment (WEEE). Re-use, especially for textiles, is driven by the third sector. Weight and quantity continues to be more important drivers for recycling than the environmental aspects and quality of material collected.

Treatment Infrastructure and Technology: Energy from Waste	
Definition	Status quo and development of UK's energy from waste capacity and technologies, expressed in cubic meters and tonnes.
Summary	EfW technologies, especially incineration, witness a comeback. However, existing capacity is difficult to assess, ranging between 8.7 and 22.5 million tons. Waste burning technologies have become more environmental friendly and new technologies such as gasification, pyrolysis, and biological processes are under development.

Dimensions considered in projections:

- Development of UK's energy from waste (EfW) capacity

Projection 1 I Small-Scale EfW (Reference Case)

The development of the UK's energy from waste (EfW) capacity and infrastructure is highly diverse. Applications are pre-dominantly small-scale, with high regional variation in capacity and availability.

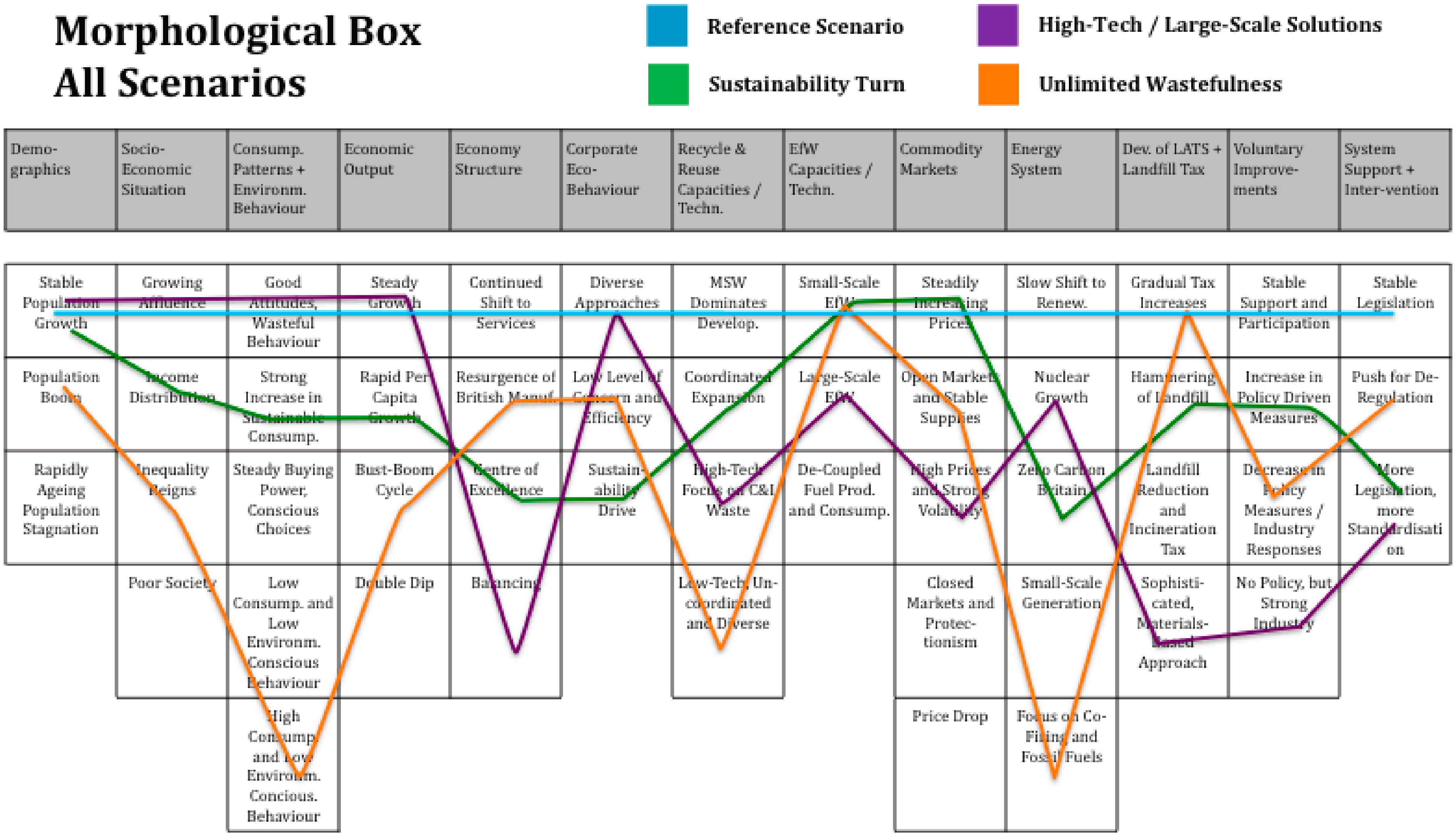
Projection 2 I Large-Scale EfW

The development of the UK's energy from waste (EfW) capacity and infrastructure focuses on large-scale applications. Regional capacity and availability is coordinated. Where feasible, waste producers engage in large, long-term contracts with EfW capacity providers.

Projection 3 I De-Coupled Fuel Production and Consumption

The development of the UK's energy from waste (EfW) capacity and infrastructure focuses on applications that require waste to be pre-treated and turned into transportable fuel. Regional capacity and availability varies, but is less dependent on local supplies, as fuel producers and energy utilisation are essentially separated and not geographically dependent.

5.5 Overview of Projections Used in the Scenarios



5.6 Sources

5.6.1 Sources Used for Research on Key Factors

UK's Demographics

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Department for Environment Food and Rural Affairs: Enhancing Participation in Kitchen Waste Collections URL:
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http://www.zeit.de/wirtschaft/2010-03/interview-recycling-kurth (German only, accessed 06/08/2010)
Eurostat 2010
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Forum for the Future 2010
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Office for National Statistics: Population Change URL: (accessed 06/08/2010)
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