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Material change for
a better environment

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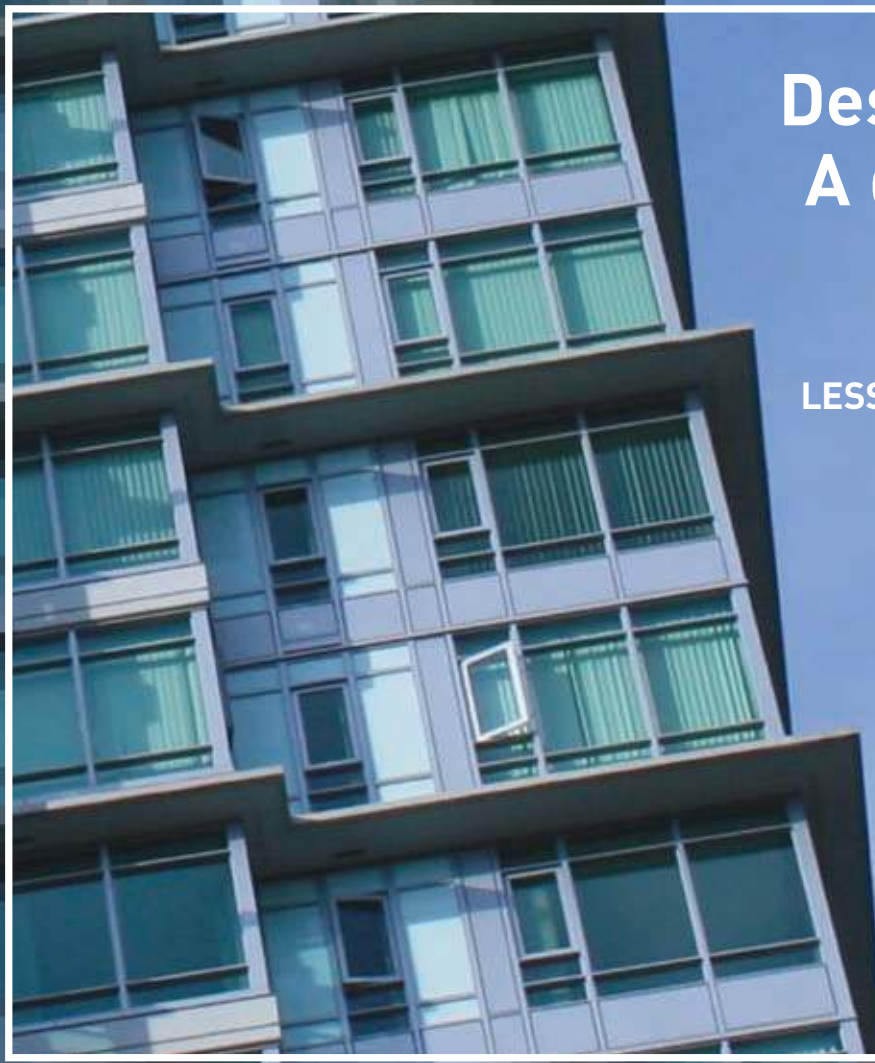

Designing out Waste: A design team guide for buildings

LESS WASTE, SHARPER DESIGN

RIBA · CPD · CORE CURRICULUM

Halving Waste to Landfill

"Clients are making construction waste reduction a priority and design teams must respond. This stimulating guide to designing out construction waste clearly illustrates how design decisions can make a significant and positive difference, not only through reducing environmental impact but also making the most of resources. It's a promising new opportunity for design teams, which I urge them to take up."

Sunand Prasad, RIBA President

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Written by: Davis Langdon LLP

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This document provides information on the key principles that designers can use during the design process and how these principles can be applied to projects to maximise opportunities to Design out Waste.

The concepts and information presented apply to all professionals who partake in the design process including construction clients, architects, engineers, design teams and contractors. This guidance should be read in conjunction with other WRAP (Waste & Resources Action Programme) documents relating to efficient use of materials in construction.

The concepts and guidance are broken down into the key sections opposite, which make it easier and quicker to find the relevant information. Highlighted below are the main objectives that will enable design teams to make a difference in Designing out Waste.

Construction clients:
Understand the potential to reduce construction waste that your designers can bring to help you deliver more sustainable, efficient projects, with cost savings from reduced material usage and waste creation.

Architects, engineers and design teams:
Stay up to date with the latest concepts in sustainable design that will improve a project's resource efficiency and reduce embodied carbon.

Contractors:
Understand how design can reduce construction waste, and how contractors can identify and implement the best opportunities on a project.

Section 2.0

Case for action – Presents to the construction industry the drivers on how to reduce construction waste to landfill and use materials more efficiently. It also demonstrates how effective planning at the early stages of a project can help to reduce waste.

Section 3.0

The five principles of Designing out Waste – Explains that there is a systematic way to help generate and prioritise ideas to reduce construction waste through design, by presenting five easy to follow principles.

Section 4.0

Project application of the five Designing out Waste principles – This section is aligned to the Job Book stages and shows how Designing out Waste can be integrated throughout the different stages in design, and what the priorities are. This includes a useful checklist of the key actions that can be implemented at each design stage.

Section 5.0

Design review process – Shows how to implement the best opportunities on a project. Trying to design out every source of construction waste on a project would be a difficult task, so key to the process is a workshop. This can be run as a part of a scheduled design team meeting, and the instructions for this workshop are outlined in this section.

Section 6.0

Waste reduction initiatives – This is a convenient and comprehensive look-up table showing the range of opportunities identified so far to Design out Waste. These are categorised under the five principles and key topics.

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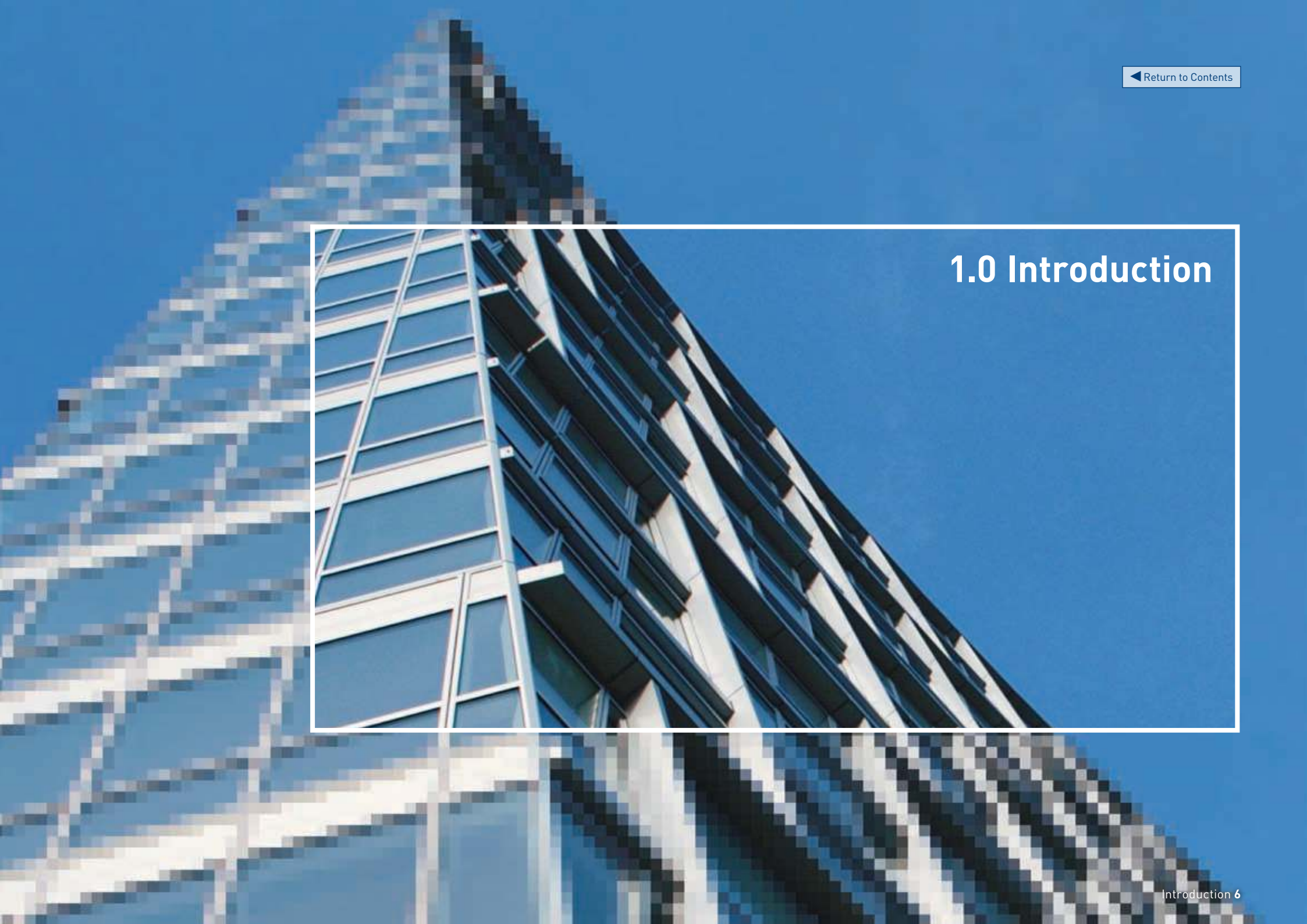

1.0 Introduction

Sustainability has risen rapidly up the construction agenda over the past few years. Designers play a key role in helping to deliver projects that are sustainable in terms of their environmental, social and economic impacts. One important impact is waste, particularly waste arising during construction. This guidance focuses on the influence design decisions have on construction waste and how it can be reduced through design.

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The construction industry is the UK's largest consumer of natural resources, using over 400 million tonnes of material per annum. The construction industry is also responsible for some 120 million tonnes of construction, demolition and excavation waste every year – around one third of all waste arising in the UK. An estimated 25 million tonnes of this waste ends up in landfill without any form of recovery or reuse. More efficient use of materials would make a major contribution to reducing the environmental impacts of construction including reduced demand for landfill and depletion of finite natural resources. This would also contribute to the economic efficiency of the sector and of the UK as a whole.

Recent research by WRAP has identified the important contribution that designers can make in reducing waste is through design. WRAP has developed a number of exemplar case studies on live projects, working with design teams to identify and build the business case for action around Designing out Waste. This work has improved current understanding of how to reduce construction waste and has led to the development of **five key principles that design teams can use during the design process to reduce waste:**

- **Design for Reuse and Recovery;**
- **Design for Off Site Construction;**
- **Design for Materials Optimisation;**
- **Design for Waste Efficient Procurement; and**
- **Design for Deconstruction and Flexibility.**

This guide outlines the case for taking action to Design out Waste, provides a detailed explanation of the five key principles and how they can be applied at project level to reduce construction waste. It also gives examples of Designing out Waste opportunities and how, in practice designers have helped achieve significant waste reductions.

The term 'designer' used throughout this guide primarily refers to architects, but the concepts presented also equally apply to other professionals who partake in the design process such as technical consultants, engineers, specifiers and specialist contractors. Many of these professionals and disciplines come together within the project design team, which provides the forum for conducting the design review process presented in this guide.

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2.0 Case for action

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A significant proportion of the environmental impact of construction arises from the use of resources – principally energy, water and materials. Using materials more efficiently (called 'materials resource efficiency') is a highly effective sustainability strategy and involves a balanced approach, ensuring that at each stage in construction (which includes demolition) materials are used in an efficient manner.

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2.1 Materials resource efficiency

The diagram opposite [Figure 1] shows how this can be approached and the white boxes highlight the areas where designers can have a significant impact.

It is important that designers also adopt the 'waste hierarchy' (Figure 2) that focuses initially on reducing waste, as this is where potentially larger impacts can be made. The efficient use of materials reduces the quantity of materials used in the first instance, lowers the material purchasing costs, minimises waste and eliminates the need for subsequent handling and disposal costs. Developing a strategy to reduce waste is one of the most effective ways to address waste in construction. Once effective waste reduction measures are in place, it is then more appropriate to consider how to reuse, recycle, recover or finally dispose of waste in a structured way.

Figure 1. Materials resource efficiency as part of sustainable construction

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In summary, major improvements in materials resource efficiency are possible without increasing cost by:

- reducing the quantity of materials being sent to landfill during the construction process by Designing out Waste and effective site waste management;
- reusing, recycling and recovering waste material as appropriate; and
- utilising more recycled materials and mainstream products containing high levels of recycled material ('recycled content'), including material not necessarily sourced from construction and demolition waste.

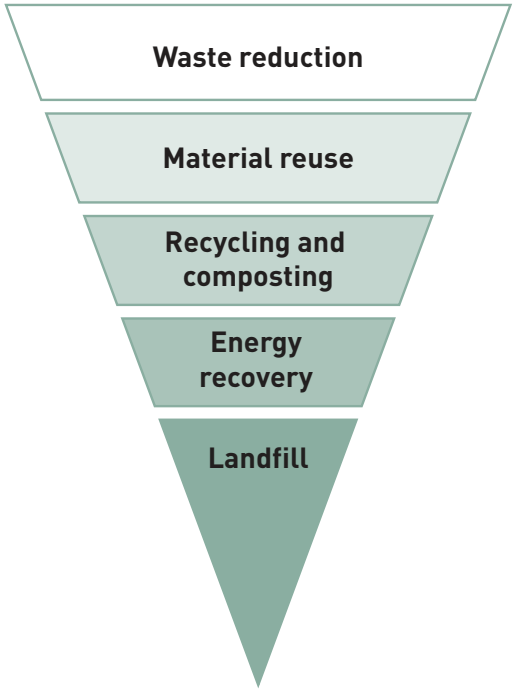

Figure 2. Waste hierarchy

Key:
☐ Areas designers can have most influence.

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2.2 Drivers for reducing waste

Waste management is a pressing issue in the UK with over 25 million tonnes of construction sector waste being sent to landfill each year. Landfill capacity is becoming ever more limited (for example, in the South East of England where capacity is estimated to expire by 2014). As well as legislation covering the management and disposal of construction waste, there are a number of Government and construction industry initiatives driving the need for waste reductions in construction.

UK Governments have set out to reduce construction waste to landfill, for economic and environmental reasons. Through a number of initiatives including:

- a target for halving construction, demolition and excavation waste to landfill by 2012, relative to 2008, adopted in England by the Government's Strategy for Sustainable Construction 2008, building on the Waste Strategy for England 2007;
- the Zero Waste Scotland policy goal;
- the Welsh Assembly Government's plan to move towards becoming a zero waste nation;
- Site Waste Management Plan Regulations, which became mandatory in England from April 2008; and
- the Strategic Forum's sector-wide Construction Commitments.

WRAP is supporting the target to reduce waste to landfill and designers can sign up to a voluntary commitment: Halving Waste to Landfill. For more information on this please refer to **Appendix A** or visit **www.wrap.org.uk/construction**. The significant financial gains available from effective waste reduction, together with the wider project and environmental benefits provide a powerful incentive for action.

The key drivers for waste reduction can be summarised as follows:

Key drivers

- Landfill Tax and Aggregates Levy, 2008/2009;
- Site Waste Management Plan Regulations (England), 2008;
- financial drivers, principally the savings available from greater materials resource efficiency and avoidance of waste disposal costs and taxes;
- environmental drivers, including reduced resource extraction, processing and consequential CO_2 emissions from transport and manufacture, as well as depletion of landfill capacity;
- Corporate Social Responsibility (CSR) drivers, especially for businesses that want to demonstrate their commitment to sustainable construction and good environmental management; and
- project specific drivers, particularly in relation to the adoption of good waste minimisation and management practices to meet requirements for improved performance and achievement of targets.

Appendix B provides more information about these key drivers.

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3.0 The five principles of Designing out Waste

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During the design process there are numerous opportunities to reduce waste and this guide provides a systematic approach to identifying and implementing them at project level. It is based on key principles distilled from extensive consultation, research and work carried out by WRAP directly with design teams. The guidance contained in this document is intended to be adapted to suit the specific requirements of each project.

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Research carried out by WRAP has identified five basic design principles that can be adopted to reduce the waste burden of projects through design:

- **Design for Reuse and Recovery;**
- **Design for Off Site Construction;**
- **Design for Materials Optimisation;**
- **Design for Waste Efficient Procurement; and**
- **Design for Deconstruction and Flexibility.**

WRAP has applied these principles in a series of engagements with design teams working on a wide range of real projects. The principles provide a proven, practical method of achieving waste reduction through the design process.

They also provide clients, designers and contractors with a practical means of ordering and prioritising waste saving strategies and of systematically considering and assessing waste reduction alternatives.

The approach in this guide is to proactively target options to reduce waste, recognising that some key solutions on a project are most likely to achieve waste reduction, along with cost-savings and other benefits. These will be different for every project, so it is important to have a process for prioritising these actions i.e. project 'Quick Wins'.

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3.1 Design for Reuse and Recovery

Research has identified that the reuse of material components and/or entire buildings has considerable potential to reduce the key environmental burdens (e.g. embodied energy, CO_2, waste etc,) resulting from construction. Much of this is common sense as, with reuse, the effective life of the materials is extended and thus annualised burdens are spread over a greater number of years. Reuse, in the waste hierarchy (see Figure 2) is generally preferable to recycling, where additional processes are involved, some of which will have their own environmental burdens.

In construction, reuse may imply the reuse of existing materials on site (the focus of this section of the guide) or the use of 'new' materials that contain a high level of recycled material (often referred to as 'recycled content'). Of course, reuse of existing materials is not simply limited to immediate on site material or components, but also to the reuse of materials and components that have been salvaged from other sites.

Extensive guidance on materials with recycled content can be found in the following WRAP publications:

- Setting a requirement for recycled content – summary.
- Setting a requirement for recycled content in building projects.
- Recycled content product guide.
- Reclaimed building products guide.
- Environmental impact of higher recycled content.

Please visit **www.wrap.org.uk/construction** for more information.

The first consideration of Design for Reuse and Recovery starts with the site analysis, a site visit being perhaps one of the very first activities carried out prior to design. The reuse of buildings (if any on the site, including parts of buildings) and or existing materials to accommodate the client's requirements should be considered from this very early stage (typically Stage A-C in the RIBA Plan or Work).

If the decision is made that only a new building will satisfy the client's requirements, demolition and site clearance consequentially follow. Even in these instances the following questions should be asked:

Key questions

- Can materials from demolition of the building or other phases be reused in the design?
- Can reclaimed products or components be reused?
- When materials are reused, can they be reused at their highest value?
- Can any excavation materials be reused?
- Can cut and fill balance be achieved? How can it be optimised to avoid removal of spoil from site?

Where opportunities exist for reusing materials and/or components, these will need to be reviewed to ensure that they meet the required functionality of the new building design. Where no such opportunities exist, then the architect should advise the client and/or the demolition contractor as appropriate and promote good practice in the demolition to ensure maximum recovery of materials through recycling. For further guidance refer to the WRAP publication **Linking demolition and new build – a step by step guidance: The efficient use of materials in regeneration projects.**

Whereas reuse of existing buildings (or parts thereof) and materials/components on site is subject to an examination of the site, the reuse of materials and components from other projects is not usually considered by designers, other than when there are specific heritage needs and, in particular, for projects involving refurbishment or extension. The possibility of design being driven more by reuse, marks a real change from established design practice where 'bespoke design' is the norm. Investigations therefore should be carried out to establish the possible extent of reuse (whether of major assemblies – e.g. structural steel frame - components, materials etc.) and its practicality as early as possible. Whilst this does require a fundamental shift in usual design practice, there are many significant benefits, not least of which might be a significant reduction in costs. For more information, there is a guide to using reclaimed products available on the WRAP website **www.wrap.org.uk/construction**

Example

Whole building systems are regularly reused in the agricultural sector and whilst this is uncommon in other, more mainstream construction markets there is no reason why such design practice could not become more commonplace. For example, there is no reason why a steel portal frame used often in buildings with a relatively short life span (distribution centres and warehouses often have a life span of twenty years or less) could not be considered for reuse in many other building designs.

Following this initial appraisal, and during design development (RIBA Stage D), the reuse of materials, components and even building elements should be considered in detail as these could have an impact on key design parameters such as critical dimensions, the design and planning of space, structural systems, etc. The results of the pre-demolition audit should be used as a key resource. Moreover, to assure the client, regulatory authorities, financial funds etc. that the proposed reused materials/components will meet the required functionality, further investigative work may be required as follows:

- the commissioning of materials/component testing and/or certification from experts;
- carrying out further consultations with the planning and building regulations authorities;
- initiating discussions with specialist subcontractors on the reuse of materials/components; and
- initiating discussions with other consultants (e.g. structural engineers, cost consultants, etc) to ensure that their requirements for material/component performance, cost, etc can be met.

During Stage E a final assessment confirming that the materials meet the correct quality, adequate technical standard and specifications and cost needs to be produced and agreed by all key stakeholders.

3.2 Design for Off Site Construction

The benefits of off site factory production in the construction industry are well documented and include the potential to considerably reduce waste especially when factory manufactured elements and components are used extensively. Its application also has the potential to significantly change operations on site, reducing the amount of trades and site activities and changing the construction process into one of a rapid assembly of parts that can provide many environmental, commercial and social benefits, including:

- reduced construction related transport movements;
- improved health and safety on site through avoidance of accidents;
- improved workmanship quality and reducing on site errors and re-work, which themselves cause considerable on site waste, delay and disruption; and
- reduced construction timescales and improved programmes.

Off Site Construction is one of a group of approaches to more efficient construction sometimes called Modern Methods of Construction that also include prefabrication, improved supply chain management and other approaches. Technologies used for off site manufacture and prefabrication range from modern timber and light gauge steel framing systems, tunnel form concrete casting through to modular and volumetric forms of construction, and offer great potential for improvements to the efficiency and effectiveness of UK construction[1].

In order to assess the most suitable Off Site Construction solutions, the following key questions need to be asked:

Key questions

- Can the design or any part of the design be **manufactured off site**?
- Can site activities become a **process of assembly** rather than construction?

The method of construction should be considered from the early project stages. RIBA Stages A and B may seem too early to assess construction methods but experience shows that it can have a significant influence on initial design considerations. If this aspect of the project is left until later stages then key construction choices could effectively be prohibited as design development advances and locks the solution in to more bespoke, on site approaches.

Therefore, the potential to use Off Site Construction should be made at the earliest stage of design because of its impact upon:

- space planning, especially structural and planning grids;
- structural design/system selected;
- project buildability;
- procurement routes; and
- consideration of how aesthetics are affected by Off Site Construction.

For smaller scale systems and/or components, usually procured through specialist subcontractors, it is likely that the designer will consider those elements suitable for Design for Off Site Construction during later design stages, possibly having identified the most suitable items to be manufactured off site during RIBA stage C.

[1] For example, see **Using modern methods of construction to build homes more quickly and efficiently,** National Audit Office, 2005 and WRAP case studies and guidance at www.wrap.org.uk/construction

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3.3 Design for Materials Optimisation

This principle draws on a number of 'good practice' initiatives that designers should consider as part of the design process. Good practice in this context means adopting a design approach that focuses on materials resource efficiency so that less material is used in the design (i.e. lean design), and/or less waste is produced in the construction process, without compromising the design concept.

Three main areas offer significant potential for waste reduction:

- minimisation of excavation;
- simplification and standardisation of materials and component choices; and
- dimensional coordination.

In order to assess the best project opportunities for material optimisation, the following key questions need to be asked:

Key questions

- Can the design, form and layout be **simplified** without compromising the design concept?
- Can the design be **coordinated** to avoid/minimise excess cutting and jointing of materials that generate waste?
- Is the building designed to **standard material dimensions**?
- Can the range of materials required be standardised to encourage **reuse of offcuts**?
- Is there **repetition & coordination of the design**, to reduce the number of variables and allow for operational refinement (e.g. reusing formwork)?

RIBA Stages A, B and C do not offer great opportunities for waste minimisation in respect to materials optimisation as the design is not normally sufficiently advanced at these stages. However, it is important to agree with the client and other consultants that materials optimisation is part of the overall design/project strategy for reducing waste so that all parties are committed to including it later in the design process. During RIBA Stage D the design of the building organisation and internal layout are finalised and this is where the application of Design for Materials Optimisation principle is most relevant.

Good practice means adopting a design approach that focuses on materials resource efficiency.

3.4 Design for Waste Efficient Procurement

Designers have considerable influence on the construction process itself, both through specification as well as setting contractual targets, prior to the formal appointment of a contractor/constructor. Designers need to consider how work sequences affect the generation of construction waste and work with the contractor and other specialist subcontractors to understand and minimise these, often by setting clear contractual targets. Once work sequences that cause site waste are identified and understood, they can often be 'designed out'.

During RIBA stages A, B and C, similar to Design for Materials Optimisation, the building design is not sufficiently advanced to offer many opportunities to consider detailed construction alternatives. However, as before, it is important at these stages to agree with the client and other consultants that Design for Waste Efficient Procurement is part of the overall strategy, so that all parties are committed to including it later in the design process.

During design stages C and D designers need to understand and identify how their design choices lead to the generation of on site waste using the methods outlined below. Once understood, methods can then be applied that can reduce waste through some or a combination of the following:

- design (e.g. designing building elements which can be constructed efficiently);
- specification (e.g. tighter specifications of work procedures to avoid waste and allow use of offcuts); and
- contracts (e.g. encourage early contractor involvement).

In order to assess the best project opportunities for waste efficient procurement, the following key questions need to be asked:

Key questions

- Has research been carried out by the design team and/or use of the WRAP Net Waste Tool to identify where on site waste arises?
- Can construction methods that reduce waste be devised through liaison with the contractor and specialist sub-contractors?
- Have specialist contractors been consulted on how to reduce waste in the supply chain?
- Have the project specifications been reviewed to select elements/components/materials and construction processes that reduce waste?

Designers need to consider how work sequences affect the generation of construction waste and work with the contractor and other specialist subcontractors to understand and minimise these, often by setting clear contractual targets.

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3.5 Design for Deconstruction and Flexibility

Designers need to consider how materials can be recovered effectively during the life of the building when maintenance and refurbishment is undertaken or when the building comes to the end of its life. Much work has been carried out to understand what prohibits the large scale reuse of materials and components in the construction industry. There are a number of barriers, not least of which is the challenge of detailing building assemblies so that materials/components can be easily disassembled and recovered. Yet another is providing adequate information so that future designers have an adequate understanding of the material/component attributes to facilitate their future reuse, and making this available in an assessable place where it can be easily referenced in future.

Perhaps the greatest difficulty in applying Design for Deconstruction and Flexibility however, is the time frame involved, which is very often longer than the financial and professional involvement of the client and design team. As buildings are sold and re-sold over time, any connection between the original client and designer and the ultimate beneficiary of Design for Deconstruction and Flexibility can become very remote. Nevertheless, designing for future generations is embedded in the concept of sustainability and Design for Deconstruction and Flexibility is essentially the outcome of extensive Design for Reuse. **Not to design with Design for Deconstruction and Flexibility in mind limits the future potential of Design for Reuse.**

During RIBA stages A, B and C, the building design is not sufficiently advanced to develop Design for Deconstruction and Flexibility proposals to any great extent. However, it is important at these stages to agree with the client and other consultants that Design for Deconstruction and Flexibility is part of the overall strategy so that all parties are committed to including it later in the design process. This is particularly important for Design for Deconstruction and Flexibility as decisions about appropriate structural systems and major components, for example, are likely to occur relatively early on in RIBA stage C and consideration of Design for Deconstruction and Flexibility opportunities will need to be made at this stage. Apart from the structure, a number of other key elements should be reviewed for their potential to exploit Design for Deconstruction and Flexibility opportunities. Whilst much of the detailing remains to be carried out during stage E, for these elements discussions with key subcontractors regarding the application of Design for Deconstruction and Flexibility should be initiated at the earliest opportunity to explore the available options and assess the practicality of their application.

In order to assess the best project opportunities for reducing waste at deconstruction stage, the following key questions need to be addressed:

Key questions

- Is the design adaptable for a variety of purposes during its life span?
- Can building elements and components be maintained, upgraded or replaced without creating waste?
- Does the design incorporate reusable/recyclable components and materials?
- Are the building elements/components/materials easily disassembled?
- Can a Building Information Modelling (BIM) system or building handbook be used to record which and how elements/components/materials have been designed for disassembly?

A range of alternative construction methods are likely to be suitable for Design for Deconstruction and Flexibility. Generally, those methods that facilitate easy disassembly at the end of the design/service life to improve the potential for reuse and/or recyclability should be selected in preference to the more contiguous structural systems. Reuse should invariably be chosen as a preferred end of life scenario rather than recycling. There is an added waste reduction benefit in the choice of such structural systems as they are likely to be fabricated using Off Site Construction and assembled on site.

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4.0 Project application of the five Designing out Waste principles

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Waste reduction should be addressed as part of the project sustainability agenda throughout the design process by the application of the five Designing out Waste principles. This section provides practical guidance on the application of the Designing out Waste principles in relation to the design stages outlined in the RIBA Plan of Work and Architect's Job Book, so that Designing out Waste can be integrated into processes that you currently use. The five principles should also be used to inform the project Site Waste Management Plan from an early design stage (see also Section 2.1).

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Overall, Stages A to D offer the best opportunities to implement Designing out Waste principles. This applies especially to Design for Reuse and Recovery and Design for Off Site Construction as they focus on identifying and implementing site waste reduction initiatives early on in the design process. After Stage D the opportunities to apply these principles are much reduced. This is due to the fact that the design is developed, becoming more complex and interdependent and thus more difficult to change fundamentally. Design for Materials Optimisation and Design for Waste Efficient Procurement principles focus mainly on refining the building design to minimise waste on site. Therefore, consideration and application of these principles occur later in the design process, typically during RIBA Stages D and E.

Design for Deconstruction and Flexibility is included in this guide not because its application reduces site waste during the construction process (although it may achieve this effect) but because of its influence on the Design for Reuse and Recovery principle. Design for Deconstruction and Flexibility has a considerable impact on the design process particularly as the choice of large scale structural elements (especially if the construction is contiguous) may prohibit future disassembly. Design for Deconstruction and Flexibility should be considered at early design stages and the design team should advise clients on cost and benefits to seek consent for this principle to be adopted on the project. The key point to determine here is if the client wants to prioritise Design for Deconstruction and Flexibility on the project. If not, the main opportunities for a positive impact on the project are in the other four categories. This is likely to be the case for the majority of projects.

Example

Large building elements may have significant potential to reduce the generation of construction waste. An example of this is structural design. After RIBA Stage D changes that aim to reduce waste can lead to substantial reworking of the design and therefore the options available for structural design should be considered at earlier stages.

After Stage D some alterations may still be possible but mainly for smaller building components. By their nature these components are not likely to have the same quantitative waste reduction potential as larger building elements. However they are still worth reviewing from a Designing out Waste perspective especially if they are repetitive components as the value of waste saved (rather than quantity) can be significant.

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4.1 Client brief and designers' appointments

Below are the key actions for clients and designers for achieving waste reduction.

The designer should ensure that the appointment documentation includes reference to efficient use of material resources as part of an overall project sustainability strategy.

Meeting these requirements may need specialist input and architects may be required to advise clients on the appointment of such consultants. If this is the case, it is important that all design team members are made aware of the project requirements for materials resource efficiency.

Key actions for clients	Key actions for designers
Set a target for reducing waste to landfill.	Create design solutions that minimise waste and use resources efficiently.
Embed the target within corporate policy and processes.	Identify for clients and contractors the best opportunities to reduce waste and use more recovered material.
Set corresponding requirements in project procurement (designers' and contractors' appointments, tender and contract documentation) and engage with the supply chain.	Measure the potential improvement at project level.
Measure performance at a project level relative to a corporate baseline.	Support design teams in broadening their knowledge of resource efficient design.
Report annually on overall corporate performance (this particularly applies when clients are signatories to the Construction Commitments: Halving Waste to Landfill).	Report annually on overall corporate performance (this particularly applies when designers and consultants are signatories to the Construction Commitments: Halving Waste to Landfill).

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4.2 RIBA Stage A/B: Appraisal and strategic brief

At this stage key project parameters are discussed with the client so that the Strategic Brief can be developed. Waste should be considered and the adoption of Design for Reuse and Recovery and Design for Deconstruction and Flexibility principles should be addressed as they can influence significantly the design approach. The strategic brief should incorporate requirements for materials resource efficiency. This should not be left as a high-level aspiration but practically applied on the project as the design develops and changes. This will allow the building design to include the waste reduction strategy during design development and construction.

RIBA Stages	Designing out Waste principles	Key actions
Stage A/B	Design for Reuse and Recovery	Assess if there are any existing buildings on the site that can be refurbished either in part or wholly to meet the client requirements.
		Identify all elements that can be reused, recovered or recycled on site and provide solutions for their use on the project.
		If existing buildings need to be demolished, use a pre-demolition audit to quantify materials and/or components that can be reused or recycled on site and the extent of material that would otherwise be sent to landfill that can be minimised (for further information refer to the WRAP Regeneration Guide).
		Check if materials salvaged for reuse from another project can be incorporated in the proposed new building design.
		Assess the likely impacts of Design for Reuse and Recovery opportunities on design, cost and project programme.
		Report findings to the client and include them in the Feasibility Report. See opposite for ideas on how to implement.
	Design for Deconstruction and Flexibility	Identify if Design for Deconsruction and Flexibility is a priority, or can be considered.

Feasibility Report

The Feasibility Report should include an assessment of the impact of applying the Designing out Waste principles on the project, including financial implications. These implications should also consider any potential financial benefits, such as savings from not removing waste from site, savings from avoiding demolition or savings from avoiding the purchase of new materials. At this stage this can be done at a notional level, assessing the barriers, complications, advantages, and disadvantages.

How to implement

- Present overall impact of Designing out Waste principles on the project, including how they enhance the project sustainability strategy.
- Present Design for Reuse and Recovery opportunities, such as buildings or structures that can be retained, refurbished and extended to achieve the client requirements; consider the potential to reuse materials and/or components from other projects.
- Present the impact of Design for Reuse and Recovery opportunities on design, cost and programme.
- Present Design for Deconstruction and Flexibility opportunities such as ensuring spaces are flexible for future use, dismantling the building at the end of its life and building components be reused or resold.
- Present the impact of implementing the Design for Deconstruction and Flexibility principles on the design, project cost and programme.
- Present any local or regional incentives/schemes for reuse, recovery or recycling that provide financial or other benefits.
- If necessary, make recommendations for the appointment of any specialist consultants.
- Present initial options for using Off Site Construction as a means of delivering the building or parts of the building and include positive benefits to the project.

Following on from this, the design team should continue to develop the client's requirements document and the design brief including reference to the five Designing out Waste principles.

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4.3 RIBA Stage C: Outline proposal

Stage C offers the best opportunities for the adoption of the five Designing out Waste principles as during this stage the design is developed from preliminary sketch design to concept design. The information from the Feasibility Report should be investigated in detail during this stage in order to assess suitability for practical implementation. When applying the Designing out Waste principles at this stage, the following information should be considered:

- feasibility report;
- design brief;
- site analysis (including pre-demolition audit and the results from any testing or scientific analysis);
- initial specification information; and
- information from other design team consultants including programme and cost.

RIBA Stages	Designing out Waste principles	Key actions
Stage C	Design for Reuse and Recovery	Identify materials, structures or existing building components that will be reused.
		If materials are reused or recycled, assess with other consultants whether they require testing, refurbishment, treatment or certification etc.
		Discuss the appointment and requirements of the demolition contractor with the client to maximise reuse, recovery and recycling opportunities (see the WRAP Regeneration Guide).
	Design for Off Site Construction	Assess the impact of Off Site Construction solutions on the building design, cost and programme.
		While conducting the site investigations identify any site conditions that either facilitate (easy access or use of local manufacturer) or impede (access/traffic problems, neighbours, air rights issues, buildability e.g. craneage) the use of Off Site Construction.
		While undertaking the necessary consultations assess and report any benefits or disadvantages to the use of Off Site Construction as opposed to traditional on site construction.
		Assess with other design team consultants the practicability, benefits, and disadvantages of Off Site Construction and alternative on site construction methods.
		Assess the cost of any testing and certification likely to be required.

RIBA Stage C: Outline proposal continued

RIBA Stages	Designing out Waste principles	Key actions
	Design for Materials Optimisation	Consider structural solutions that use less material and simplify the structural solutions as much as possible (e.g. use concrete solutions like post tensioning instead of cast in situ reinforced concrete). Group functions with similar special requirements so that the building is composed of repeatable special elements and the overall design is simplified. Consider the design of the building and how it might be simplified in terms of: ■ building form; ■ the structural system; ■ the building services; and ■ construction sequence/methodology. Investigate opportunities to avoid excavation (e.g. consider important aspects like orientation, existing services etc. when positioning the building on the site and set key levels in relation to site contours and ground conditions). Assess extent of excavation (e.g. assess the need for full or part basement). Review foundation solutions to ascertain if options such as rotary or displacement piles, (rather than replacement) can be considered. Discuss and agree with the client and design team the implication of minimisation of excavation solutions (impact on the building design, functionality, cost, programme aesthetics etc).
	Design for Waste Efficient Procurement	Discuss appointment and requirements of demolition contractor with the client to maximise reuse, recovery and recycling. Consider the implications the design solution to construction activities (e.g. specifications and contracts).
	Design for Deconstruction and Flexibility	Assess the application of Design for Deconstruction and Flexibility to major building elements e.g. structural frame, substructure).

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Site analysis

During Stage C, the architect, together with other design team members, will undertake a detailed site analysis. The five Designing out Waste principles should be used to inform this exercise (i.e. be formally part of the criteria for assessment during the initial detailed site analysis). In particular, application of the Design for Reuse and Recovery and Design for Off Site Construction principles should be considered as this is when waste minimisation opportunities, specific to these principles, are likely to arise.

The site analysis is not likely to be a singular event but a series of investigations carried out over several design stages. Findings of each of these stages together with any other relevant activities (e.g. inspection, testing etc) should be assessed for their effect on the application of the Designing out Waste principles (e.g. changes to the design, cost programme etc). As the design progresses through design stages C, D and E, any relevant opportunities to reduce construction waste should be reported in the Design Brief and Project Brief.

For more information on the five design principles and Designing out Waste opportunities, also refer to the tables in section 6.0.

Consultations

Ensure that Designing out Waste features in any consultations that are necessary to resolve any issues regarding the application of the Designing out Waste principles. The design team should identify all consultations required to obtain approval for the implementation of Designing out Waste opportunities. Some consultations are likely to have a significant impact on the project waste strategy, such as:

- planning and building regulations authorities;
- all statutory agencies, e.g. Environment Agency, Highways Agency etc.;
- utility providers; and
- neighbours and all other non-statutory organisations.

Planning authority

- Include all the waste minimisation opportunities identified so far in the project waste strategy and obtain the Planning Authority's view on their implementation.
- Include the waste strategy in the project Environmental Impact Assessment for the outline planning application.
- Assess the impact of the project site and location on demolition and excavation waste.
- Discuss the reuse of existing buildings or parts of buildings adapted for a new use.
- Resolve any conflicts that might arise from the implementation of the waste strategy e.g. the use of reused materials (certification requirements), Off Site Construction (aesthetics) etc.

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Embedding design options to reduce waste

Once decisions have been made they need to be embedded into the building design (e.g. the use of certain reused materials, adoption of Off Site Construction solutions). As the design is developed the following actions may be required:

- design development (e.g. a detailed assessment of how large volumetric units can be brought to site);
- testing (e.g. providing proof that certain reused materials are functionally appropriate); or
- revision of the project waste strategy (e.g. revision of targets to reflect new opportunities that emerge).

The CDM consultant should assess all the implications of the project waste strategy upon the tender Health & Safety aspects of the project (e.g. the reuse of particular materials that might require special handling or processes).

Once the site analysis is complete, the design is developed to Outline Proposal stage. During this process, all five Designing out Waste principles need to be considered as part of various consultations and design.

Other statutory authorities

- Commence consultations with other relevant authorities (e.g. fire, police, rivers authority etc.) to ascertain any restrictions and/or opportunities that impact on the project waste strategy.
- Identify any restrictions including those in relation to access, existing services, excavation and water courses.

The architect should advise the design team of the results of all consultations, amend drawings and commence preliminary specifications. Any potential opportunities, conflicts, uncertainties etc. (e.g. planning – special requirements; highways - access limitations) that arise from consultations need to be assessed and addressed by the design team. The client should then be advised of any design, cost and programme implications in the Stage C report.

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4.4 RIBA Stage D: Detailed proposals

This is the stage when a great deal of the design (form, construction materials, structural elements and space requirements) is finalised. Most of the decisions on the application of Designing out Waste principles therefore will have been made by the end of this stage. The key ideas for waste reduction identified at Stage C should be embedded in the development of the building design. As the design is developed, initial discussions with specialist subcontractors and suppliers may be required. Contractors, subcontractors and suppliers should be made aware of the project waste reduction aims and their engagement obtained, either formally (ECI) or informally. Relevant details should be included in initial discussions with them and ultimately included in the tender documentation.

The architect should review all the Stage C inputs with all the other consultants and advise the client of any necessary amendments to the cost plan programme and overall building design and this will include a review of the project waste strategy. The architect should continue consultations, with the planning and building regulations authorities and all other agencies and organisations that affect the project waste strategy.

Design for Materials Optimisation and Design for Waste Efficient Procurement principles should be adopted at this stage.

At the end of this stage an appraisal of the Designing out Waste opportunities should be included as part of the Stage D report to the client.

RIBA Stages	Designing out Waste principles	Key actions
Stage D	Design for Materials Optimisation	Begin the process of dimensional coordination by selecting appropriate structural and planning grids, together with an appropriate structural system when the design is at an appropriate stage.
		Standardise similar elements of the building so that repeatability of the process leads to manufacturing and installation efficiencies including waste reduction.
		Establish floor to floor heights, structural and services zones to minimise the extent of material offcuts.
		Carry out three-dimensional co-ordination exercises to eliminate all dimensional conflicts that lead to extensive on site waste.
	Design for Waste Efficient Procurement	Embed all of the design options to be pursued into project briefings and procurement.
		Consider how the building is going to be constructed and the impact on waste.
		Identify (in collaboration with the main contractor and/or specialist subcontractors) where potential significant on site waste streams are likely to occur. This can be done by making use of the project team's experience, the use of the WRAP Net Waste Tool or any other assessment methods.
		Determine the procurement routes responsible for the identified waste streams and initiate discussions with potential contractors and/or subcontractors to identify ways to minimise waste.
		Once waste minimisation initiatives during procurement are identified and agreed as practicable, they should be assessed in terms of the impact on cost, programme and building design.
		Agree the adoption of the waste minimisation initiatives with the client and embed them in drawings, specifications and/or contracts.
		Identify if there are any special contract conditions that need the input of the client's legal advisors and if so advise the client accordingly and initiate process.
		When incorporating requirements for waste reduction in procurement documentation, refer to WRAP guidance on model wording.

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4.5 RIBA Stage E: Technical design

Stage E is the last design stage when the technical design of the building is advanced. All five principles should have been applied and design solutions selected, will become 'embedded' in the building design by the end of this stage.

RIBA Stages	Key actions
Stage E	Include waste advice/input from specialist subcontractors and suppliers in drawings, specifications, schedules of information etc.
	Include the results of tests and/or certification (including consultation with the clients' insurers) for particular materials, components, and elements in specifications and integrate these results into the building design and SWMP.
	Identify solutions for any planning consent conditions with regard to waste.
	Obtain from the selected off site manufacturer all technical information required for the building regulations submission, including any information necessary to meet the project waste strategy.
	Submit a formal application for building regulations approval and continue consultations to identify if there are any conditions likely to have a direct bearing on the project waste minimisation strategy (e.g. if the use of a particular reused material requires building regulations approval).

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RIBA Stages	Key actions
Stage E	Include materials and waste actions information into any relevant applications that are submitted to other agencies including the client's insurers who also may have a direct interest in design and specifications that affect the project waste minimisation strategy.
	If Off Site Construction solutions are adopted, agree procurement route, programme etc. and assemble tender information packages.
	Develop tender packages for specialist subcontractors and include within the contract specific requirements with regard to waste by means of special clauses, drawings etc.
	When incorporating requirements for waste reduction in tender and contract documentation, refer to WRAP guidance on model wording available at **www.wrap.org.uk/construction**
	In consultation with other consultants, assess the impact on cost, programme, and the building design of all developments in the project waste strategy resultant from planning, building regulation requirements and all other consultations, negotiations etc.
	Include the above developments in the project waste strategy as part of the Stage E report to the client.
	Ensure any Design for Deconstruction and Flexibility elements are recorded in the BIM or building handbook, detailing their location, means of disassembly, reuse/recycling notes and any special considerations required.

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5.0 Design review process

In order to fully explore the opportunities for waste reduction, the design team should implement the process developed by WRAP to identify, prioritise and implement Designing out Waste opportunities on a project, as detailed in this section.

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5.1 Overview

During Stage C a facilitated workshop should be undertaken by the design team and the client. The purpose of this workshop is to identify key Designing out Waste opportunities for the project that can be implemented in subsequent design stages. This workshop should form part of the Stage C formal review process. The most appropriate time for this review is just prior to the submission of the outline planning application when the design is sufficiently advanced for initial material selection and method of construction to be discussed but still at a stage where options can be easily considered.

The process can be adapted to suit particular project circumstances and the modus operandi of the client and design team.

5.2 Workshop structure

An impartial facilitator should be nominated for the workshop. The role of the facilitator is to enable attendees to explore options and capture ideas in a flexible but structured manner. This is achieved by adopting the following structure for the workshop:

I. Awareness session: review of Designing out Waste principles.

II. Creativity session: ideas generation.

III. Reasoning session: ideas classification and prioritisation.

All these stages must be kept separate to ensure the success of the workshop – they are consecutive. It is important that all attendees participate to this exercise to make sure that all opportunities are explored. Experience to date shows that on average between 2 and 3 hours are required for this activity and it can be readily combined with a scheduled design team meeting.

5.3 Workshop delivery

I. Awareness session

During this session the facilitator should present the five Designing out Waste principles in conjunction with relevant WRAP sources of information. This session should also include a project overview including main design parameters and design development to date.

The aim of this section is to convey that the workshop is to determine options that can reduce waste on the project, introduce the drivers for this, give an overview of options that can reduce waste through design (including some of the case studies showing material, carbon and cost savings) and very clearly communicate the scope of the workshop – i.e. it is looking at ways to reduce construction waste through design. The outcome from this section should be that the team understands the focus of the workshop and is enthusiastic so that they can come up with creative and realistic options to reduce waste through design. This session should not last more than 30 minutes.

II. Creativity session

This session aims to generate ideas focusing on how the design of the building can be developed or even changed to reduce waste. The session should be completely open and inclusive and should create an atmosphere where ideas are generated and stimulated through people thinking 'outside of the box'. Attendees should be encouraged to 'brainstorm' a series of design opportunities in the context of the project that will effectively reduce waste generated in construction. The key question to base discussions should be:

What can you do or influence as a design team to Design out Waste?

The rules for this session are:

- free wheel for ideas, no criticism allowed;
- go for quantity and expand on other's ideas; and
- Write it, Shout it, Throw it' – Ideas should be written on note cards or post-its, one idea per card, maximum three lines.

For all ideas to be explored, it is important that no one feels disenfranchised and all ideas, no matter how improbable, should be collected and assessed along with all the others. This session can last between 45 minutes to one hour.

III. Reasoning session

When new ideas are exhausted the facilitator should collect all note cards and distribute them randomly between attendees. Attendees will then be required to classify them using the five Designing out Waste principles:

- Design for Reuse and Recovery;
- Design for Off Site Construction;
- Design for Materials Optimisation;
- Design for Waste Efficient Procurement; and
- Design for Deconstruction and Flexibility.

Ideas collected under each Designing out Waste principle will then be evaluated by the group for their waste reduction potential and feasibility for implementation assessed in terms of cost, programme and quality. Although a rough initial assessment (based mainly on the team's experience and knowledge of the project), this helps to quickly identify the top opportunities with the greatest impact on waste and the most likely to be pursued on the project. A simple categorisation matrix should be used with each idea allocated to one corner of the four quadrants as illustrated in Figure 3 and outlined below:

- Section A – High impact on waste reduction, easy to implement
- Section B – High impact on waste reduction, difficult to implement
- Section C – Low impact on waste reduction, easy to implement
- Section D – Low impact on waste reduction, difficult to implement

High/Low Impact on waste reduction refers to whether the design opportunity will greatly/minimally reduce the waste generated during the construction phase. Easy/difficult to implement refers to whether the project constraints (cost, programme, procurement method, availability of materials or other economic conditions) permit the implementation of the opportunity on the project.

The ideas that have high impact on waste reduction and are easy to implement should be analysed in more detail so that up to ten ideas in Category A can be selected for potential inclusion within the detailed design stage. These ideas should then be considered further by the design team so that only the ones truly beneficial to the project are taken forward and quantified for their impact using the quantification methodology developed by WRAP.

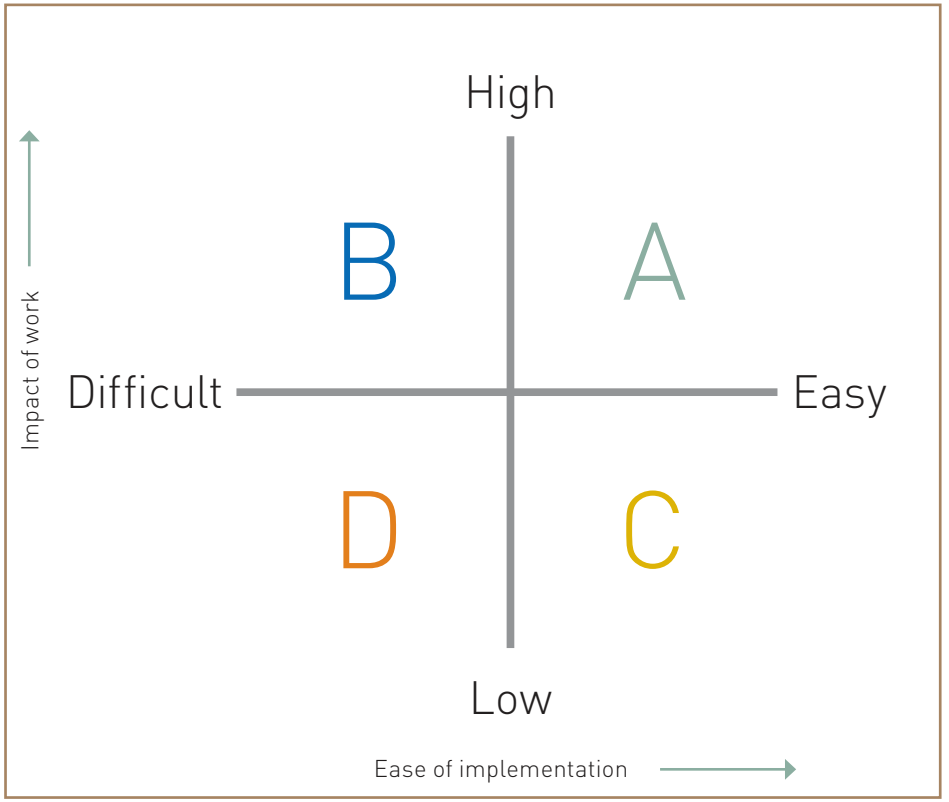

Figure 3: Opportunity matrix used to evaluate waste reduction ideas.

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6.0 Suggested waste reduction initiatives

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This section presents the Designing out Waste opportunities identified by a number of design teams during a series of consultation workshops undertaken as part of the research for this guide. Some of these opportunities have been subject to detailed quantitative analysis and/or adopted in design solutions. They are listed in the following tables against the five design principles; similar or related opportunities are grouped together for ease of reference. These tables should be used as point of reference when reviewing design opportunities for other projects.

6.1 Design for Reuse and Recovery

Opportunity	Description
Landscaping	Use on site demolition and excavated material within landscape design as: ■ drainage base; and ■ mound features.
	Reuse or recycle tarmac and asphalt (provided there is on site storage) for paths, car parking, construction storage space and hard standing for plant, etc.
	Retain top soil, treat it on site with compost (or other remediation) and use for green roofs, soft landscaping, etc.
	Manufacture top soil using surplus excavated soil blended with compost.
	Reuse bricks, concrete paving blocks and excavated rock for landscaping finishes feature, etc.
	Use existing soft landscape that can't be retained (trees, shrubs) as: ■ compost; ■ soft landscape top mulch; ■ external furniture; and ■ large features (e.g. tree stumps for benches).
	Reuse existing landscape items by repairing rather than throwing away (e.g. existing fencing, benches etc).
Concrete	Recycle aggregates (either on site or off site) in concrete mix, as fill etc.
	Incorporate cement substitutes PFA or GGBS as appropriate.
	Recycle concrete elements as aggregates and use them as a thermal heat store (thermal mass used as fabric energy storage to reduce the operational energy requirement).
Packaging	Reuse packaging by returning to supplier/manufacturer or using it for other purposes (e.g. timber packaging pallets can be chipped and used for landscaping top mulch).
Foundations	Reuse existing foundations.
	Extract and reuse existing H-pile foundations.

6.1 Design for Reuse and Recovery continued

Opportunity	Description
Timber	Reuse timber sprung floors.
	Reuse good quality timber for flooring.
	Reuse timber for cladding, fencing and other landscaping uses.
	Separate, de-nail and chip all timber arising from demolition and use either for composting, top mulch or take off site for energy generation.
	Reuse timber to construct landscape features (e.g. street furniture).
Bricks, Slates, Roofing tiles and Blocks	Reuse bricks, blocks etc for masonry, internal partitions and fair faced cladding.
	Reuse slate for roofing and landscaping.
Good Demolition Practice	Reuse dismantled elements, columns, beams portal frames curtain walling either on site or off site.
	Reuse water tanks on site for useable space within the design brief.
	Encourage the client to adopt a 'soft strip' demolition process.
	All found fixtures and fittings to be saved and donated to charities for reuse, or sold for reuse.
	Other floor finishes, carpet etc to be set aside for reuse, donated to charity or sold for reuse.
	Good quality doors set aside for reuse.
Contractor's site establishment	Reuse existing buildings on site for contractor's site establishment.
	Use temporary site establishment buildings that can be reused.

6.2 Design for Off Site Construction

Opportunity	Description
Modular Design	Design with modularisation in mind. Modularise cladding (e.g. unitised certain walking systems, masonry precast panels). Use door sets rather than doors. Use modular solutions for: ■ classroom units/wall with all fixtures and fittings; ■ services, plant room etc; ■ laboratory units, work stations etc; and ■ shuttering. Use timber panels as modular frame – used to construct up to nine storey buildings.
Volumetric	Use prefabricated solutions for: ■ toilet and shower blocks etc; ■ changing rooms; ■ hospital inpatient rooms with en-suite wc; ■ modular tea/coffee point stations for office spaces; ■ plant rooms; and ■ operating theatres.
Precast concrete	Use precast concrete solutions for: ■ stairs and stair wells; ■ flooring units; ■ cladding panels; and ■ lift cores.
Steel Construction	Use steel frame design. Use prefabricated steel stairs. Use bi-steel for lift cores and core units. Use H-pile foundation to enable future reuse.

6.3 Design for Materials Optimisation

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Opportunity	Description
Concrete	Use post-tensioned floor slabs instead of reinforced slab. Use reusable/modular shuttering for slabs cores etc. e.g. PERI system with integral handrails.
Design	Simplify plan shape and building form. Minimise external surface area to internal volume. Question and reduce if possible the car parking provision. Combine functions of materials (e.g. pin boards also used for their acoustic properties).
Services	Rigorously plan M&E plant and distribution routes to reduce access requirements and facilitate future maintenance. Rigorously plan M&E layout and distribution routes to reduce builders works by consolidating risers, ducts, etc. Enable consolidation of trades to reduce M&E penetrations in already finished surfaces. Avoid or reduce the extent of surface water attenuation systems and pipework by reducing run-off collection areas and consider other methods: ■ use of a green roof; ■ reduce surface areas for vehicles by use of grasscrete; ■ greater use of soakaways.
Detail design	Review the necessity for all finishes (e.g. assess if fair faced structure and other elements suffice). Optimise tile layout any size to reduce cutting and offcuts. Use new thin insulations to reduce depth of wall thickness and maximise overall building net/gross areas. For odd plan shapes consider the use of formless materials for finishes rather than formed materials (e.g. latex screed rather that vinyl tiles). Use full height doors or doors with fan lights above (i.e. to ceiling) to avoid cutting plasterboard sheets. Ensure door details have full returns to avoid plasterboard and angle beads forming opening returns. Use thicker plasterboard sheet rather than doubling up on board. Ensure sound insulation is not over-specified for the required purpose of the room/building, so avoiding unnecessary use of materials.
Avoidance of excavation	Use rotary pile foundations rather than replacement piles. Optimise building position and levels to minimise excavation required. Question the need for basements.

6.3 Design for Materials Optimisation continued

Opportunity	Description
Standardisation and dimensional co-ordination	Use 3D modelling to avoid clashes/conflicts of services/structure etc. and thus reduce construction errors and consequent rework.
	Co-ordinate structure and services so that both can be combined for off site or near site thus avoiding the need to cut chases on site and other builders work.
	Co-ordinate structural grid and planning grids etc. to avoid offcuts: ■ external finishes; ■ internal finishes; ■ internal partition layouts with ceiling and floor grids.
	Use 3D modelling to assess all finishes layouts and options to reduces on site waste such as: ■ sheet vs. tiles vs. formless materials; ■ plasterboard layout.
	Standardise light fittings and lamps.
	Standardise windows, doors and glazing areas.

6.4 Design for Waste Efficient Procurement

Opportunity	Description
Supply Chain	Employ waste specialist consultant/contractor with expert knowledge in waste minimisation.
	Discuss methods of waste minimisation with suppliers/manufacturers of wall lining systems.
	Discuss methods of waste minimisation with potential subcontractors and suppliers at an early stage.
	Discuss options for packaging reduction with subcontractors and suppliers.
	Discuss future flexibility with plasterboard manufacturers.
Specification	Simplify the contract specification to reduce number of plasterboard types.
	Specify responsibly sourced materials that reduce waste.
	Specify adequate protection to fragile materials to minimise damage on site.
Contract/ Contractor	Involve the contractor from early design stages to identify methods of waste minimisation in relation to procurement routes.
	Consider financial incentives and penalties to reduce waste.
	Involve the contractor from early design stages to identify methods of waste minimisation in relation to procurement routes.

6.4 Design for Waste Efficient Procurement continued

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Opportunity	Description
Contract/ Contractor	Consider financial incentives and penalties to reduce waste.
	Require the contractor to produce a SWMP at an early stage that includes a site storage and logistics plan.
	Require all tendering contractors to provide information on how they plan to reduce waste through the supply chain and site activities.
	Require Just In Time (JIT) delivery.
	Use 'consolidation centre' to facilitate JIT delivery.
	Select procurement route that minimises packaging.
	Use ordering procedures that avoid waste (e.g. no over ordering, take back schemes for both material surplus and offcuts).
	Plan the work sequence to reduce on site waste.
	Include within the tender documents, the requirement to sign off 'the waste per work package' – waste must not exceed a contractual agreed limit.

6.5 Design for Deconstruction and Flexibility

Opportunity	Description
Materials	Use lime mortar or other mortars so that bricks/blocks can be easily dismantled.
	Use mechanical fixings that facilitate deconstruction.
	Avoid gluing and composite materials.
	Specify materials that can be reused rather than recycled.
	Use landscaping materials that can be easily taken up and reused (e.g. grasscrete).
	Use structural elements that can be easily disassembled.
	Design foundations that can be retracted from the ground and reused after the service life of the building ceases.
Logistics	Design deconstruction at an early stage.
	Discuss with suppliers if components can be returned.

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The Construction Commitments: Halving Waste to Landfill

To promote best practice throughout industry, and to drive this right through the supply chain, WRAP has launched the Construction Commitments: Halving Waste to Landfill in October 2008. These Commitments build on the Construction Commitments launched by the Strategic Forum and focus on the specific target for waste: achieving a 50% reduction of construction, demolition and exaction waste sent to landfill by 2012 (from a 2008 baseline).

This is a voluntary agreement with signatories sought from all levels of the supply chain, including:

- clients;
- contractors;
- designers and consultants;
- manufacturers and suppliers; and
- waste management contractors.

Organisations are being asked to sign up to the following commitment:

"We commit to playing our part in halving the amount of construction, demolition and excavation waste going to landfill by 2012. We will work to adopt and implement standards for good practice in reducing waste, recycling more, and increasing the use of recycled and recovered materials."

Designers play a key part in meeting this target by responding positively to clients and contractors who are already supporting this campaign. Designers can demonstrate their commitment through consistent measurement and reporting, subject to independent monitoring.

Key actions for designers under the commitment are:

- set a target for reducing waste to landfill through design solutions;
- identify for clients and contractors the best opportunities to reduce waste and use more recovered material;
- support teams in broadening their knowledge of resource efficient design;
- measure the potential improvements in materials resource efficiency at a project level; and
- report annually on overall corporate performance.

For more information please visit www.wrap.org.uk/construction

Halving Waste to Landfill

APPENDIX B

Drivers for reducing waste

B1. Site Waste Management Plan Regulations 2008

New legislation came into effect in England, on 6 April 2008 requiring all construction projects with a contract value in excess of £300k to have a Site Waste Management Plan (SWMP). The requirements are somewhat more stringent for projects over £500k. These regulations apply to all projects where construction work began after 1 July 2008. A full copy of the legislation can be obtained from **www.opsi.gov.uk**

A SWMP is a document that identifies how waste arising during the construction process is to be managed, and ultimately reduced or recycled. This 'waste' includes construction, demolition and excavation arisings. The legislation places duties on both the client and the main contractor.

The client is required to... "give reasonable directions to any contractor so far as is necessary to enable the principal contractor to comply with these Regulations." There are also additional requirements on clients relating to the review of the SWMP and in relation to site security to ensure that waste is not disposed of illegally. Whilst clients will not usually draft the SWMP, they are responsible for ensuring that it is developed, and in accordance with the Legislation.

To be legally compliant, the SWMP should be developed by the main contractor before starting on site and should include:

- headline information about the project (location, date etc);
- the name of an individual responsible for waste;
- a forecast of the quantity of waste that will be generated, identified by material type;
- a set of clear actions to reduce waste, and to increase the level of recycling; and
- the end destination for each waste stream and the recovery rate that will be achieved.

A critical component of achieving good practice in waste reduction and recovery in construction involves the formulation and implementation of a **Site Waste Management Plan (SWMP)** at the pre-design stage. While SWMPs are the responsibility of the client and contractor, they determine key waste streams and set targets for waste reduction and, because of this there are advantages in thinking about them at an early design stage. It is essential that the appropriate planning for waste occurs up-front to ensure maximum impact and for key actions to be incorporated and implemented through the SWMP. Key to this is communication through the supply chain, and collaboration between the design team and contractor as early as possible in the design and planning stage.

WRAP have developed a downloadable excel based SWMP template that is available at **www.wrap.org.uk/construction**

B2. Landfill Tax and Aggregates Levy

Reducing construction waste provides a direct reduction of the cost of waste disposal. In addition, finding end destinations other than landfill are also likely to become more cost effective. The SWMP is a key tool in achieving these cost savings.

Limited landfill capacity has led to increased costs of waste disposal. This includes both gate fees and an escalator on Landfill Tax. Additionally, the extraction of quarry materials is subject to an aggregates levy that is ultimately passed on as cost in the price of construction materials and products. Although designers are not directly involved in the cost management of projects, it is important that they are aware of the costs associated with waste in order to assess the benefits of adopting waste reducing design solutions in projects.

Landfill Tax & Aggregates Levy [2008/2009]

- Landfill Tax has to be paid on waste sent to landfill.
- The current rate of landfill tax is £40 per tonne (current policy is that this will increase by £8 per tonne each year to £72 per tonne in 2013/2014). This rate applies to non-inert waste, that currently makes up around half of construction waste, and includes: plasterboard, timber, plastics, cardboard/paper and bio-organic materials.
- A lower rate of £2.50 per tonne applies to inert waste (an increase of £0.50 per tonne since last year). This waste makes up around 42%, of construction waste, and includes: glass, brick, concrete, soils and aggregates.
- Aggregates Levy has also increased from £1.60 per tonne to £1.95 per tonne for primary aggregates since April 2008.'

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B3. Financial drivers

Waste can be surprisingly expensive, since much of the cost is often not visible, being buried in wastage allowances and trade subcontractor prices. Few people look beyond waste disposal costs to assess the value of materials going into the skip.

The Environment Agency has estimated that true cost of waste on a commercial office project is around 4% of project value. Other research recently completed also shows that simple steps to reduce waste can achieve substantial savings in the value of new materials wasted, estimated on average at 3% of total construction costs and 20% of material costs on site. Taking action to reduce waste can therefore have a substantial impact on the overall cost of a project[2]. In addition, sending segregated waste offsite can result in substantially reduced disposal costs. One study has shown an estimated saving of £28 per tonne by segregating waste on site[3].

Reducing construction waste provides a direct reduction of the cost of waste disposal by both volume and value. Finding end destinations other than landfill are also likely to become more cost effective, especially accounting for the landfill tax escalator.

Wilmott Dixon's Corporate Responsibility report for 2007 estimated the true cost of waste management practices to be £10 million, with £1 million spent on disposal of skips, containing £8.3 million worth of materials, incurring £700,000 in labour. This represents £10 million on a turnover of £380 million, equivalent to their operating profit. In light of this, Wilmott Dixon now aims to reach zero waste to landfill by 2012.

The business risks of not considering waste in construction projects are:

- costs may be higher than you think - Landfill Tax is increasing;
- landfill capacity is running out and as availability reduces, prices could rise; and
- until very recently, materials prices have been outpacing general inflation.

B4. Environmental drivers

There are also strong environmental reasons for reducing waste:

- reducing waste leads to less landfill space being used. This is particularly relevant since the UK has limited landfill capacity in many areas: around 3-4 years in South East England, 17 years in Scotland and 8 years in Wales. As construction produces around one third of all waste in the UK, all construction professionals have a duty to act.
- reducing waste has a carbon impact at project level by reducing the embodied energy associated with the manufacture and transport of materials and landfill emissions.

B5. Corporate Social Responsibility (CSR) drivers

In recent years, clients and contractors have started to increasingly incorporate sustainability as part of their CSR objectives. Adopting targets and measuring results can demonstrate real performance against corporate responsibility and sustainability policies, meeting the expectations of stakeholders.

B6. Project specific drivers

Construction clients and planning authorities are increasingly setting targets and requirements for environmental performance (including materials resource efficiency and waste reduction and recovery) on projects. Adopting the principles of good practice waste minimisation and management on projects and measuring performance can demonstrate that these requirements are met.

In addition to this, more and more projects have requirements to achieve BREEAM ratings. Clients can gain additional BREEAM points and credits by setting actions and delivering tangible improvements in three areas: waste minimisation, waste recovery, and recycled content. The table below shows succinctly the link between good practice materials resource efficiency and BREEAM waste credits (2008).

[2] WRAP Taylor Woodrow case study on Laing Homes in Kent

[3] WRAP Simons Construction case study on waste segregation

The BREEAM credits associated with good practice materials resource efficiency are outlined in the table below.

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Sector Commitment	Linkage to BREEAM Requirements	BREEAM Requirements (2008 version). These are flexible rather than mandatory requirements under the BREEAM scale	BREEAM Points	BREEAM Credit
Collate data from project Site Waste Management Plans (SWMP) to evaluate progress towards your corporate target for reducing W2L.	The SWMP is now a legal requirement in England and no BREEAM points are allocated for implementing the SWMP.	No specific requirements. Credits available under the waste minimisation/recovery targets (as below) dictates that these targets should be set within the SWMP.	0	**NA**
Set procurement requirements for Good and Best Practice Waste Minimisation at project level to help deliver your corporate target – and then implement improvements, measure and report.	WRAP has recommendations for procedures to minimise waste creation, and wastage rates for various waste streams. Achieving waste minimisation will score BREEAM points based on waste creation benchmarks for the whole project. WRAP's Net Waste Tool will help you identify where to focus your effort to maximise waste and cost savings.	Amount of non hazardous waste generated per 100m² (GIFA) m^3 | tonnes 13.0 – 16.6 | 6.6 – 8.5 9.2 – 12.9 | 4.7 – 6.5 < 9.2 | <4.7	 1 2 3	Waste 1
Set procurement requirements for Good and Best Practice Waste Recovery to help deliver your corporate target – and then implement improvements, measure and report.	WRAP has recommendations for procedures to increase site waste recovery, including recycling and reuse (on site and off site) and established recovery rates for various waste streams. Achieving higher waste recovery will score BREEAM points based on whole project benchmarks for recovery.	Where at least 75% by weight or 65% by volume of non-hazardous construction waste generated by the project has been diverted from landfill and either: • Reused on site or other sites • Salvaged/reclaimed for reuse • Returned to the supplier via a "take-back" scheme • Recovered from site by an approved waste management contractor In cases including demolition, 90% by weight or 80% by volume of non-hazardous demolition waste has been diverted from landfill.	1	Waste 1
Set procurement requirements for reused and recycled content – and then implement improvements, measure and report.	Recycled content minimum targets are specific to the developer and these are expressed in value (rather than mass or volume) for the whole project. BREEAM awards a point for the use of recycled aggregates only, and not other material types.	Where the amount of recycled and secondary aggregate specified is over 25% (by weight or volume) of the total high grade aggregates uses for the whole building. Recycled aggregates should be sourced from within 30km radius of the site.	1	Waste 2

WRAP helps individuals, businesses and local authorities to reduce waste and recycle more, making better use of resources and helping to tackle climate change.

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