Sustainable Materials: Issues in Implementing Resource Efficiency – A UK Policy & Planning Perspective

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ABSTRACT

Increasing the recovery of construction and demolition wastes, and the use of sustainable materials in construction is dependent on a range of drivers that influence design and project planning decisions, as well as mainstream practice on construction sites. In the absence of sustainable materials standards in UK Building Regulations, behaviour is influenced by a combination of sustainability assessment ratings (e.g. BREEAM and the Code for Sutainable Homes), waste regulations, landfill taxes and planning guidance. However, there is still a lot of work to be done to achieve consistent and widespread improved waste recovery performance and procurement of sustainable materials. This paper presents the authors' views on the efficacy of current drivers, supported by a case study analysis and pilot survey of industry views. Indicating gaps between rhetoric, aspiration and delivery, it compares UK policy, regulatory and voluntary drivers with approaches in the Netherlands and Germany.

INTRODUCTION

How significant are the environmental impacts from construction and demolition waste that specific planning and policy initiatives should aim to improve recovery levels? The recovery of construction and demolition wastes, and use of sustainable materials has important global benefits. The Waste Strategy for England describes the benefits of avoiding CO_2 emissions by reusing materials:*"…substitution of locally-sourced reclaimed materials for new can radically reduce the lifecycle environmental impact ... with use of reclaimed timber ... 79% lower impact compared to new."* Such benefits can be complemented through the haulage emissions avoided by reusing materials on site, with the need to export wastes and import new materials and products avoided. [DEFRA, 2007, 1]

Construction in the UK is the largest consumer of material resources - the Sustainable Construction Strategy (SCS) for England, [2008] states that 400 million tonnes of materials are used annually (implying a much greater figure for the UK as a whole). Of these, an estimated 13 million tonnes of materials delivered to site are unused, often ending up as waste. [DTI, 2006]. 90.4 million tonnes of construction, demolition & excavation waste (CDEW) arisings were produced in England in 2003 [ODPM, 2004] a figure which excluded waste streams such as wood, plastic etc. The SCS [2008] also states the (CDEW) landfilled in England, as 25 million tonnes.

Research undertaken by the Waste and Resources Action Programme (WRAP) has demonstrated that construction products which are recycled, or have a high recycled content, will normally be produced using less energy than required for primary materials (that include extraction processes) again providing CO_2 savings. WRAP, an organisation funded by UK government and devolved administrations works to build capacity in the recycling and waste recovery market. According to WRAP: *"The UK's current recycling of those materials saves between 10-15 million tonnes of CO_2 equivalents per year compared to applying the current mix of landfill and incineration with energy recovery to the same materials. This is equivalent to about 10% of the annual CO2 emissions from the transport sector, and equates to taking 3.5 million cars off UK roads."* [WRAP, 2006b, Foreword]. Recent research by the Stockholm Environment Institute, has identified that prevailing emphasis on energy efficiency and renewable energy developments to meet CO_2 targets may hide the potential from material resource efficiency (MRE) which may be a 'secret weapon' to deliver nearly 18% reductions by 2020 (10% industry & 8% consumer). These could be implemented with existing technology and no significant negative effects for UK GDP [WRAP, 2009].

Definitions and Objectives. Sustainable construction products and materials referred to in this paper are those which are recovered for reuse, are recycled (e.g. recycled aggregates from bricks, blocks etc) or are products containing recycled content. This paper considers the range of methodologies, regulations and planning policy created in the UK to encourage and require resource recovery practices, describing how well these are embedded in the practices of developers and their construction teams. Increasing the use of sustainable products and materials requires more effective waste recovery practices and diversion of wastes from landfill or energy recovery facilities. This assessment is supported by case study experience, exploring the difference between rhetoric and reality. It tests this experience against a survey of practitioners to ask for their views. The paper finally compares the UK approach to date with those adopted in leading EU nations, highlighting barriers as well as providing an outlook on potential future developments.

INDUSTRY INITIATIVES TO SUPPORT MATERIALS RESOURCE EFFICIENCY

The UK government-commissioned a 1998 study known as the Egan Review, examining the efficiency of the construction industry. It initially focused on quality, value for money and reliability, and safety then was extended. The Review on Skills for Sustainable Communities [Egan, 2004, 27] described how government should incentivise progress to enable the construction of: "*developments that achieve carbon emissions and waste minimisation standards consistent with a sustainable one planet level within, say eight years.*"

Efforts to support industry to implement more sustainable construction practices, including materials resource efficiency, have come from a number of different sources, including the Building Research Establishment (BRE). The BRE Environmental Assessment Method (BREEAM) provides measurable methods, for developers with sustainability levels to aim for, applied to commercial projects. The government's national 'Code for Sustainable Homes' (CSH) sustainability performance rating system was established in 2006, to replace BRE's EcoHomes scheme (a BREEAM method for housing), for newly-built dwellings in England. It became a mandatory requirement for all new homes to be rated against the Code from May 2008, with every new home owner informed whether their home was built to higher standards than building regulations and what standard (Code levels 1-6) was met. Government's aim is to mainstream 'Zero-Carbon' homes (Code Level 6) from 2016 (2019 for non-residential development). A commercial code rating system is still being developed.

The use of sustainable/recovered materials allows developments to be rated following the BREEAM and CSH schemes. For the latter, this is one of the nine categories comprising the CSH, and is one of five categories (including energy/CO_2, water, waste management and surface water drainage) for which minimum standards exist under the Code. However, unlike energy and water, the minimum requirements for materials and waste do not increase for higher ratings, and their weighting relative to other categories is low. The complicated calculations for site waste management also do not encourage achieving higher Code ratings by improving materials/waste performance.

The Institution of Civil Engineers (ICE) produced an equivalent assessment methodology (CEEQUAL) for civil engineering projects – and initiated the 'Demolition Protocol' [ICE, 2003 and 2008] –a resource efficiency tool which, through both Planning Conditions and contract negotiation processes (the client and project team), can drive pragmatic approaches to the management of demolition and new build projects, in terms of resource recovery. The Protocol informed the methodologies described in the case study later in this paper. WRAP has also developed support tools to assist designers and project teams to procure reclaimed products and products with recycled content through a web-based evaluation toolkit. A project management mechanism for designers, it provides potential 'quick wins' listings of readily available components and finishes with a percentage of recycled/recovered content – for retail, residential and civil engineering projects. This was expanded in 2008 into a 'NetWaste' toolkit in 2008, including a function that assists in the production of SWMPs.

POLICY & PLANNING DRIVERS: UK, GERMANY & NETHERLANDS

The UK Treasury's decision to increase landfill taxes for non-inert wastes, by an annual escalator of £8/tonne, until it reaches £72/tonne (from the current £40/tonne) is an important one to encourage more diversion of waste from landfill. It will bring the UK closer to landfill taxes charged in countries such as the Netherlands that recover significantly higher levels of waste than the UK, with landfill taxes currently much higher, at €88 (euros/ tonne). Through the Site Waste Management Plans Regulations (SWMPs) 2008, the UK government is aiming to reduce the quantity of waste being hauled to landfill. In turn, and if effective, this will result in expanded markets for recovered materials. SWMPs were introduced as a key plank in government policy to deliver improved resource efficiency. A light touch approach to enforcement was adopted during the first year of operation with government describing how subsequent years would involve more robust enforcement. Anecdotal information suggests that their adoption and use, in a meaningful way, is patchy.

The UK town and country planning system has been developing significantly over the last decade with the aim of encouraging more sustainable design and construction practices, including resource efficiency. The system has undergone significant reform which is still ongoing. The purpose has been to streamline the process, transform 'land-use planning' into 'spatial planning', with greater public engagement and increased responsiveness to changing trends and industry needs [ODPM, 2005]. The Planning & Compulsory Purchase Act 2004, redefined the purpose of planning, as being *"to deliver sustainable development"*. Planning Policy Statements (PPSs in England) have been replacing the previous national Planning Policy Guidance (PPG) documents (NPSs Scotland). Two of these are of particular relevance; PPS1 [2005] with a Climate Change Supplement [2007] highlights the need for planners to ensure efficient use of resources, empowering them to include requirements in LDF policy, if founded upon a robust evidence base, taking project feasibility into account.

And PPS10 in 2005 with a practice guide, specifically addresses planning's approach to waste management. Most recently, the 'Strategy for Sustainable Construction' [BERR, 2008] for England, has a target of halving waste to landfill by 2012 (compared to 2008) which 200 construction organisations have so far, signed up to an agreement to meet [WRAP, 2009b].

The UK approach, by adopting the use of regulations and planning policy, or encouraging the use of tools, to prescribe specific types of behaviour at a site and project level, differs to those of leading European countries such as the Netherlands and Germany. In these countries landfill bans of recyclable waste streams, and far higher disposal costs are often cited as the reasons for higher recovery levels of CDEW compared to the UK, with 95%and 88% of construction and demolition wastes recovered in the Netherlands and Germany respectively [WRAP, n.d.; German Ministry of Environment, 2009]. The German Ministry of Environment has described how the source segregation of waste streams at even the smallest urban sites is a normal activity which greatly enhances the waste recovery process [WRAP, n.d.], with the landfill ban a key driver of this behaviour.

The UK has implemented a range of macro and micro-level interventions, requiring or encouraging the construction supply chain to produce defined outputs in terms of the waste streams being managed and the potential recycled content in products and materials. This compares with the policy interventions, fiscal and regulatory, in the Netherlands and Germany which apply on a macro-level rather than prescribing behaviour at the site and project level. Associated with this, sorting facilities have developed to higher standards than those in the UK, supported by the ability to charge higher gate fees which in turn allow greater investment in plant. They correspondingly recover higher percentages of material as a result, also at a higher cost than in the UK. This has accompanied development of markets associated with energy recovery, which are more developed and widespread than in the UK.

A UK CASE STUDY PILOTING MRE PLANNING POLICY – WEMBLEY

Elected Councillors in the Waste Management & Recycling Task Group recommended in 2003 that the London Borough of Brent's new *'Sustainable Design, Construction & Pollution Control' Guidance* (SPG19) for developers should require ICE Demolition Protocol application in redevelopment schemes. Adopted UDP Policy BE12 [2006] required development to include measures to minimize construction and demolition waste, and reuse / recycle materials. This included a new Sustainability Checklist for assessing major planning applications. Brent was the first Borough to adopt the Protocol, with the Greater London Authority (GLA) and several other Boroughs in England and Scotland, following suit. The timescale for review and adoption of Brent UDP policy (2000-2006) indicates the length of this process, the GLA's London-wide policy adoption taking nearly as long (2001-2006).

The ICE Demolition Protocol requires construction New Build to be assessed in terms of the potential to specify recovered materials in various parts of the development and now provides a SWMP format for managing, recording and setting targets for the recovery of demolition wastes. This was an important driver for the redeveloped 2008 Protocol, to respond to legislation requiring such plans to be produced for projects with a value exceeding £300,000. The revised Protocol provides framework methodologies for reducing waste, reusing structures and products –describing how the aspirations of the waste hierarchy can be delivered. Case studies describing the use of the 2008 Protocol, are not yet available, although a number are available for the 2003 version on WRAP's AggRegain website.

Brent was the first Planning Authority to impose a Planning Condition on a developer to use the Demolition Protocol within a Construction Management Strategy (CMS). To support application of the Protocol in the Stage 1 redevelopment of 17ha around Wembley stadium, a Supplier's Forum was convened in September 2004. It brought together major and local aggregate and concrete suppliers, with the developer's project consultants, the Protocol authors, contractors and officers from the Borough's Environmental departments. The objective was to establish the potential for structural concrete containing recycled aggregates to be supplied for Wembley redevelopments. A key conclusion from the forum was that there was no technical barrier to procuring structural concrete with recycled aggregates. The major concrete suppliers attending commented that any issues were more related to logistics, and the space available at their batching facilities to store recycled aggregates –therefore, orders from clients should be of a size that ensured there was a steady supply, for example, covering two to three months. Suppliers said this was necessary to make the management effort worthwhile. An initial pilot study resulted in support from consultants, funded by WRAP. It led to the production of targeted summaries for designers, planners, contractors and suppliers. On the recommendation of the developer's representative, and to raise awareness of developers in Brent as well as planning and other officers, the 'Brent Protocol Process Guidelines' were produced by the authors, and published on the Council website. Further work extended the materials to be targeted for recovery, to glass, plastics, etc.

Due to the major demolition and redevelopment projects in Wembley, the lead planning policy officer (first co-author) obtained London Remade funding to match Brent's –enabling experts to provide free technical support for major projects in Wembley to implement the Protocol for a year. The *'North-West London Construction Materials Recycling Pilot Study'* aimed to transfer skills to participating developers, their design & engineering consultants, contractors and local authority officers – as well as to provide templates for more sustainable planning, design, demolition and construction practices in other Brent and London-wide projects. The project delivery partners were; Brent Environment Directorate & Planning Service, EnviroCentre and London Remade. The project considered the following schemes:

- Stadium Access Corridor:
- Whitehorse Footbridge Link
- Quintain Stage 1 (Plot W01) development
- Elvin House & Wembley Conference Centre



Figs.1a,b,c: (Left-Right) Elvin House/Conference Centre; Wembley stadium with Whitehorse Footbridge foreground; Stadium Access Corridor: *EnviroCentre, 2007*

The Stage 1 developer had formed a joint venture with Bioregional development group (involved in the pioneering BedZED scheme in Sutton). 10 tonnes of furniture and fittings including carpets, light fittings, and 8 tonnes of Mechanical & Electrical items (6 generators, a water tank, a waste crusher, 2 milk floats) were reclaimed from the Conference centre and Elvin House. There was also assistance matching materials to end users through the National Industrial Symbiosis Programme (NISP). And these materials were reclaimed for both commercial and charitable purposes –the contractor allowing charities and other end-users

on site, to remove materials. Reclamation required no further labour and occurred within demolition contract timescales [Bioregional, 2007]. Data was recorded using the Protocol template. A simplified example of recovery outputs using the Protocol is shown in Table 1.

Table 1: Demolition arisings & recovery targets Summary – *EnviroCentre, 2007*

	Materials arising	Recovery approach	Tonnes Arisings	% verified recovery (or estimate)	Tonnes Recovered
COMBINED PROJECT DATA	Concrete	Recycling	3,063	95%	2,910
	Masonry	Recycling	2,583	95%	2,454
	Steelwork	Recycling	174.5	98%	170
	Brick	Reclamation	5	80%	4
	Slates	Reclamation	1.5	80%	1
	Timber	Recycling	67	50%	34
	Miscellaneous		52	25%	13
	TOTALS		**5,946**	**94%**	**5,586**

A valuable part of the Protocol's methodology is the transparency that it requires from developers, both in terms of setting targets for the recovery of demolition materials, as well as setting targets for the procurement of recovered (reused/recycled) materials in the new build. Generally, demolition recovery targets were achieved on all projects. In fact, Demolition Protocol case studies have shown the demolition industry can achieve significantly more than 90% recovery with the right contractor. Table 2 shows the Wembley pilot projects combined performance and the new build data needed -Bills of Quantity based.

Table 2: NB-BOQ Summary data joint Wembley projects– *EnviroCentre, 2007*

Description	Total Material Weight (tonnes)	Aggregate Weight (tonnes)	Recycled Aggregate Allowed	New Build Recovered Materials Potential (tonnes)	New Build Recovered Materials Index (NBRI)	New Build Recovered Material Target (tonnes)	New Build Recovered Material Actual (tonnes)
Granular materials							
Type 1 & sub-base	8,700	8,700	100%	8,700	100%	8,081	7,065*
6f,6f1,6f2,6n	8,261	8,261	100%	8,261	100%	8,261	7,253*
Type A, B filter drain	256	256	100%	256	100%	0	100
Pipe bedding	601	601	100%	601	100%	0	41.5
Sand bedding	629	629	100%	629	100%	0	0
Soil	2,107	2,107	100%	2,107	100%	215	215
General fill	217	217	100%	217	100%	217	217
Subtotal 1	**20,771**	**20,771**	100%	**20,771**	**100.0%**	**16,774**	**14,892**
						81%	**72%**
Bound Materials							
Structures, pile caps, piles, etc	33,631	14,584	20%	2,917	53.5%	1,516	0*
Asphalt	1,542	1,542	33%	509	33%	343	320
Pipes	342	342	100%	342	100.0%	34	0
Edging , kerbs	98	46	100%	46	93.2%	10	0
Subtotal 2	**35,613**	**16,514**		**3,814**	**11%**	**1,903**	**320**
						5%	**1%**
TOTAL	**56,384**	**37,285**		**24,585**	**44%**	**18,677**	**15,212**
						33%	**27%**

The New Build Recovered Materials Index (NBRI) indicates the design view on the theoretical potential (from specifications and standards) for specifying recovered materials.

The New Build Recovered Materials Target (NBRT) is then the procurement target, on the basis of the availability of recovered materials, in terms of price, quality and tonnage. Once a target has been set, the developer then has to demonstrate actual performance on site.

Targets were achieved in the Stadium Access Corridor project. Another project, a major mixed-use development, Forum House (the first block W01 of Wembley City Stage 1 scheme) was completed in September 2008. The eight-storey building has 286 residential apartments with a crèche and a new employment portal. It also includes the first underground waste disposal system (Envac) in the UK. However, although a target (NBRT) was negotiated with the developer's consultants for use of 10% recycled aggregate in structural concrete, and included in contract tender documents, it was not achieved on this project. As the requirement was a 2004 Planning Condition, little practical action could be taken retrospectively by the Borough. This led to changes, with later Protocol requirements for other projects, being secured through legal Section 106 (S106) agreements for Post-Construction Reviews (PCRs) with financial penalties for non-compliance.

It is hoped the potential for the 10% recycled aggregate in structural concrete can be realised on the next phase of the re-development (W04) – and in the rest of the 85ha regeneration area. However, since the first co-authors' departure from the Borough, and following the credit crisis, it is understood that here have been fewer application. In addition, the post has not been refilled, and due to other work pressures, it has been difficult to exert the same level of pressure on developers. Recent Planning Annual Monitoring Reports (AMRs) (for financial years [April to March]) indicate commitments secured. Fewer S106 agreements in 2006/07 than normal (See Table 3) reflect many signed just before/after monitoring dates.

Table 3: S106 Agreements 2006-7 & 2007-8 *–Adapted from Brent Planning AMRs*

Out Of 2006-07 Permissions	No. of Agreements	**20**
	No. with Sustainability Clauses (BREEAM/CSH -energy, water, DP, etc)	**7**
Out Of 2007-08 Permissions	No. of Agreements	**64**
	No. with Sustainability Clauses (BREEAM/CSH -energy, water, DP, etc)	**46**
	No. with only Considerate Contractor clauses	**27**

More non-financial S106 obligations are being secured, e.g. on-site training, community and sustainability requirements (including air quality monitoring, sustainable drainage, onsite renewable energy, the Demolition Protocol (DP) and Considerate Constructors scheme) were signed on all larger applications. There have been only 3 Post-Construction Reviews (PCR) initiated on schemes, and officers were considering taking action, and seeking compensation –if the PCR's are not forthcoming, or if they show required standards were not delivered onsite. Reminder/warning letters sent out in 2008, led to some developers' seeking advice on the PCRs requirements, to avoid action. However, no PCRs were submitted (or sought) on completions in the last 12 months.

This highlights the role of 'Champions' within organisations, in pushing colleagues, and/or external partners to adopt policy, and more importantly, to implement it. The importance of follow-through to secure implementation on the ground tends to be underestimated – experience gained in this case study shows that simply stating requirements in Policy, Planning Conditions or S106 agreements are not enough to guarantee effective delivery of approved measures. Enforcement capability is thus required, but this also requires an adequate monitoring system to be established. Work did begin on this at Brent, but resources are needed to ensure it is comprehensive, linked to other databases, and can be kept up to

date. The authors' understand that in the current economic climate since 2008, the priority given to this is (perhaps understandably) not as high. Still, Brent as a Client (through planners' efforts) has done well to promote adoption and implementation of the Protocol within its own major developments, such as the Stadium Access Corridor, to conserve resources, reduce waste, and maintain credibility in negotiations with developers.

Other Demolition Protocol case studies provide both data and anecdotal perceptions on the processes involved in quantifying waste streams and identifying recovered materials. A significant challenge is that associated with maintaining the delivery of consistent quality and transparent methodologies. This can in turn, demonstrate the target setting actions taken forward for MRE –as well as post construction/demolition compliance and verification.

PILOT INDUSTRY SURVEY –LEVEL OF AWARENESS, PERCEPTIONS & USE

The case study has described views and perceptions on the role of policy, guidance and the efforts of planners and construction development teams to secure the use of sustainable and recovered materials in the absence of limited targets in national policy or building regulations. But do these perceptions reflect the awareness of wider practitioners and how they view the issues? To gain further insights into the extent of such impressions beyond the case studies, a pilot survey was developed by the authors, and emailed to development organizations in London, East of England and Scotland – for distribution to their members.

This survey of individuals working in construction was carried out in the Autumn of 2009, to assess views on how well current policies, legislation and methodologies are delivering resource efficiency in practice. The 91 Respondents included policy-makers, designers, contractors, environmental / sustainability advisers and suppliers –of which 50-70 answered each of the ten questions in the survey (some respondents skipped specific questions). The numbers of surveys completed do not therefore enable conclusions to be made which represent the views of the construction industry within specified confidence intervals. However, the resulting qualitative dataset can be compared with the authors' experiences in delivering and influencing projects over the last decade. To gauge the level of awareness and usage, Respondents were asked to describe methods they used to establish percentages of sustainable and recovered materials in projects:

Table 4: Methodologies Used to Set Recovery Targets *–Pilot Survey Responses Nov. 2009*

Method	Don't know this method	Never use	Occasion-ally (if required)	Frequently	Always	Total
WRAP's Site Waste Management Plan Tool ('NetWaste')	25.0% (13)	**26.9% (14)**	**26.9% (14)**	15.4% (8)	5.8% (3)	52
BRE's 'SmartWaste' Tool	28.6% (14)	**34.7% (17)**	24.5% (12)	10.2% (5)	2.0% (1)	49
ICE Demolition Protocol (2003 & 2008 update)	32.7% (16)	**44.9% (22)**	14.3% (7)	4.1% (2)	4.1% (2)	49
SALVO Materials Exchange Website	**47.9% (23)**	43.8% (21)	8.3% (4)	0.0% (0)	0.0% (0)	48
National Industrial Symbiosis Programme (NISP) Exchange/Network	**46.9% (23)**	44.9% (22)	6.1% (3)	0.0% (0)	2.0% (1)	49

The answers indicate that even the most popular methodology, WRAP's NetWaste tool, was identified by only 21% of respondents as being used frequently or always, with another 52% not knowing about it, or never using it. This survey was completed by organisations more likely to be "on-board" in terms of advocating sustainable construction practices. The wider construction supply chain and influencers (e.g. planning officers) may be less likely to advocate more demanding policy and legislation approaches.

Respondents were asked to identify the most significant barrier to specifying or requiring compliance with sustainable construction practices (procurement and implementation). The most significant response (58%) indicated client/developer ignorance or resistance, with the next most significant barriers being no requirements for such practices through building regulations, policy and legislation. Respondents also considered the question *"What do you think is needed to really ensure sustainable construction (particularly use of sustainable & recovered materials) in the UK"*. They were asked to identify their top 4 recommendations. The result was that 68% identified Building Regulations as the key requirement, with legislation and policy mentioned by 63% of respondents. And 48% of respondents identified financial rewards (e.g. VAT discounts) in their top 4 recommendations, for projects which demonstrate exceptional sustainable practices. These recommendations compare well with what respondents identified as the key barriers to delivery of sustainable construction. A larger, wider survey should further clarify these perceptions.

CONCLUSIONS AND OUTLOOK

Significant resources in the UK have gone into developing a regulatory and policy framework to provide transparency (e.g. Site Waste Management Plans) and encourage prescribed approaches to behaviour on construction and demolition sites, requiring methodologies to recover wastes more efficienctly and encouraging the procurement of sustainable products and materials. Various bodies and institutions have provided support to change behaviour, to develop tools, methodologies (e.g. the Demolition Protocol) and provide financial support for more sustainable activities and research. The implementation of methodologies such as the ICE Demolition Protocol has been shown to be successful when supported by human resource to monitor, appraise and then implement corrective actions. Often, without this resource, delivering success through the use of such methodologies is more challenging, the result of developers and their construction teams not prioritising the use of the required tools and methodologies, or finding them overly complex. The result will then often be a failure to deliver the required level of performance.

Sustainable waste recovery practices and the procurement of sustainable materials and products in construction new builds are rewarded through methodologies such as the CSH, BREEAM etc, to encourage more environmentally sustainable buildings and infrastructure. The requirement to use the CSH for housing in England means that this has the potential to become an increasingly effective driver for resource efficiency. However, the reality at the moment is that resource efficiency considerations in the CSH and BEEAM methodologies represent a relatively small part of a larger appraisal framework incorporating a wide range of environmental factors (e.g. energy efficiency, ecological impacts etc). It is therefore debatable how significant these methodologies are in driving forward MRE.

Compared to the Netherlands and Germany the UK's recovery performance, is still lagging behind. These countries have taken a different tact to the UK, by introducing wide-ranging landfill bans of recyclable materials, and charging significantly higher landfill taxes than the

UK to date, in effect providing a policy and regulatory model at a macro level. The UK's approach at a macro-level has been less hard-hitting, in terms of landfill taxes, bans on recyclable wastes etc. The UK has adopted a number of micro-management approaches to require or encourage MRE, for example through Site Wastes Management Plan regulations and methods such as the ICE Demolition Protocol, BREEAM etc. However, this does not mean that these methods represent ineffective and bureaucratic approaches by comparison. They do provide the opportunity to require consideration of the potential to reuse buildings, recover components for reuse, and to minimise CO_2 emissions through avoided haulage of wastes and the use of products with recycled content etc. But, the level of support required for effective implementation means that further work should be undertaken to establish when, where, why and by whom these methodologies should best be applied. Alongside tougher fiscal and regulatory regimes, as exist in Germany and the Netherlands, the potential benefits associated with such methods could be significantly improved, supported by more engaged and motivated stakeholders in the process.

Programmes being undertaken in the UK to develop markets for products with recycled content, may provide the basis for a more developed market for such products than in other countries. And, a tougher fiscal and regulatory regime could also assist this market development process. For example, additional pressures to source segregate wastes should lead to the availability of higher quality recovered materials.

There has been more active development of the technology sectors in Germany and the Netherlands, to design and manufacture waste sorting plant, and to develop energy recovery markets. This higher level of investment was only possible because of the landfill taxes and bans described in this paper. Further work is required to assess how well the fiscal and regulatory approaches for managing CDEW in different European countries is leading to the recovery of specific waste streams, and to their subsequent specification and procurement in new build projects, as required by methodologies e.g. the Demolition Protocol, or tools such as WRAP's NetWaste.

It is worth noting that following the landfill ban in 2005, Germany saw a reduction in the percentage of waste streams being recycled, with a shift towards energy recovery [Karavezyris, 2007]. There is the potential for the same outcome in the UK if similar regulatory approaches are taken. However, this will also be very much influenced by the demand generated in the market for sustainable products and materials in new build projects. As the UK waste management industry moves increasingly towards the development of energy recovery facilities, a process which will be encouraged through annual increases in landfill tax, markets for waste streams currently being sent to landfill will develop. There is the potential for this to impact on recycling markets, with less substance recycling, and more energy recovery, as witnessed in Germany. More work is needed to establish if the policy, regulations and tools developed in the UK in the future will result in different outcomes.

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