

# **Green Public Procurement and Product Performance Requirements**

## **Case Study on Selected Energy Using and Non-energy Using Products**

**Prepared by:**  
David Legg, Marton Herczeg  
Hubert Reisinger, Philipp Schepelmann & Carol Wilson  
**European Topic Centre on Resource and Waste Management**

**March 2009**

**Project manager:**  
Pawel Kazmierczyk  
European Environment Agency

**DG Environment contacts:**  
Jill Michielssen  
Monika Wasilewska



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**Author affiliation**

David Legg, Environment Agency, England and Wales

Marton Herczeg, Copenhagen Resource Institute

Hubert Reisinger, Umweltbundesamt Austria

Philipp Schepelmann, Wuppertal Institute for Climate Environment and Energy

Carol Wilson, Environment Agency, England and Wales

**Context**

This working paper is published by the European Topic Centre on Sustainable Consumption and Production but prepared by its predecessor, the European Topic Centre on Resource and Waste Management for the European Environment Agency (EEA) under its 2008 work programme as a contribution to the EEA's work on environmental impacts from consumption and production.

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European Topic Centre on Sustainable Consumption and Production

Højbro Plads 4

DK-1200 Copenhagen K

Phone: +45 72 54 61 60

Fax: +45 33 32 22 27

[etc@etc.mim.dk](mailto:etc@etc.mim.dk)

<http://scp.eionet.europa.eu>

# Executive Summary

## Policy Background

The recent EU Sustainable Consumption & Production and Sustainable Industrial Policy (SCP & SIP) Action Plan sets a new framework for environmental product policy “..to improve the environmental performance of products and stimulate the demand for more sustainable goods..”, with particular reference being made to the need to reinforce and better integrate:

- Existing energy and environmental labelling
- Green Public Procurement (GPP).

This was further emphasised in July 2008, with the publication of the Communication on “Public Procurement for a Better Environment”, which sets out to “ ...provide guidance on how to reduce the environmental impact caused by public sector consumption and to use GPP to stimulate innovation in environmental technologies, products and services.”

## The Brief

This study aims to inform the implementation and further development of the Action Plan and actions related to the Communication, by:

- Assessing current energy and environmental performance-related product labelling programmes, regulations and standards, and identifying what lessons can be learnt from best practice;
- Reviewing current practice in GPP, and identifying what lessons can be learnt from best practice and what possible measures could be used to reinforce GPP procedures, using product labelling as a common reference system;
- Highlighting where possible, other measures that could be used to further stimulate the market for energy efficient and environmentally sustainable products.

The work draws on the experience in Austria, Denmark, Germany and the UK in relation to three building / construction-related product

groups: (i) water heaters; (ii) windows; (iii) and recycled mineral construction and demolition waste, as examples of both energy and non-energy using products.

The study is based on a desktop review of current literature, focussing on particular experience and practice in the four countries identified above, and referring to experience in other parts of the world, as appropriate.

An important remark needs to be made concerning the relative prominence of labelling in this report. Labelling, explicitly emphasised in the SCP Action Plan, has been used here to provide a common reference system for the different products. However, while labelling provides helpful guidance to suppliers and purchasers, it should not be considered as a precondition for GPP but rather as one of available support instruments.

## Green Public Procurement

Legislation and / or national GPP action plans exist in all four countries requiring the public sector to take environmental considerations into account in their procurement procedures. There is evidence of this being taken up already at both a regional and local level. For example in the United Kingdom the performance of each of the government departments is now audited by the independent Sustainable Development Commission comparisons are made to encourage action.

In all of the four countries reviewed, current GPP guidance is already using the various national eco-labelling / rating systems in existence to specify the recommended products performance levels, which is encouraging the market to develop in response to demand.

The public sector, particularly at a regional and local level, is also using voluntary codes to raise the standard of environmental building design relating to both the energy performance of the finished building and other environmental aspects, such as water demand.

## **Energy-related labelling, regulations & standards**

Energy labelling is already proving to be an effective means of stimulating the market for more sustainable products. Mandatory energy efficiency labelling of domestic appliances has succeeded in increasing consumer awareness, which in turn has encouraged manufacturers to actively use the labelling system to gain a competitive edge.

The success is further demonstrated by the extension of voluntary labelling schemes into the non-domestic sector, and includes products that form part of the components (e.g. fixtures and fittings) of a building.

The combination of energy labelling and national building regulations, which incorporate the requirements of the Energy Performance of Buildings Directive, has been effective in raising the energy efficiency standards of individual building components. In all of the countries examined, building regulations now specify the minimum energy efficiency and energy-related criteria for water heaters and windows. This change in policy is often acknowledged to have led to a strong trend towards the use of even more energy efficient products and building models.

## **Other environmentally-relevant labelling, regulations & standards**

Several of the national eco-labelling schemes already incorporate a wider set of environmental criteria, e.g. greenhouse gas emission levels relating to water heaters and the content of hazardous chemicals in preservatives and protective coatings for window frames.

In the case of recycled mineral construction and demolition waste, in all four countries there is a rating system based on acceptable levels of contamination, which relates to specific re-uses as an aggregate-replacement material, e.g. in backfill, concrete or road surfacing.

The standards of building design relating to the other environmental aspects of the building's performance, such as water demand and use of recycled materials, are often being raised through the application of voluntary codes or standards on sustainable construction. These set standards above those required by national building regulations, and are also using labelling and rating sys-

tems to identify the required level of product performance. In the case of waste construction materials, voluntary codes have been supportive in overcoming the associated stigma and provided greater certainty to buyers of these recycled materials.

## **Water Heaters**

- The energy efficiency of water heaters is already well covered in national labelling schemes in three of the four Member States studied. However experience in the USA and Canada would indicate that more stringent minimum standards could be prescribed.
- In terms of measuring energy efficiency, evidence would suggest that the metrics used in the USA, based on demand patterns over a 24-hour tapping cycle would appear to be more appropriate than current measures based on standing losses. Draft EC papers would indicate that Europe seems likely to follow suit.
- Other criteria of importance, including carbon monoxide, nitrous oxide and nitrogen dioxide emissions, are also covered in national labelling schemes in three of the four Member States considered.
- In terms of green public procurement, various support services are available, offering advice on the energy efficiencies of different products, but to date it would appear that only the UK, "Buy Sustainable – Quick Wins" website specifies mandatory minimum energy efficiency ratings for water heaters.
- In the UK, a water demand rating is also indicated on the labelling for some products. This together with the emissions labelling schemes above would demonstrate that it is possible to provide more than one piece of information on a label without confusing the consumer, provided the rating system can be easily understood.
- Another factor affecting the energy efficiency of water heaters relates to measures to prevent exposure to Legionella bacteria, with many countries stipulating minimum water storage temperature of 60°C. This is substantially higher than the functional requirement of 45°C and does not appear fully substanti-

ated by the science. Some countries have lower temperature requirements (e.g. 50° C in Sweden) without any added increase in occurrence of Legionella. Some relaxation in the standard could result in significant additional energy savings.

## Windows

- Energy performance labels covering the thermal insulation properties of windows are available in most of the countries. Additional environmental criteria (such as the source of wood for framing and chemical content of preservative and protective coatings for window frames) are covered primarily by eco-labelling schemes (e.g. in the Nordic countries and Austria).
- The development of the European market for windows has experienced significant change over the past three decades, particularly in relation to their energy saving performance, with the average U-value being reduced by more than fifty percent to 1.68 W/m<sup>2</sup>K. The main driver for this was the Energy Performance of Buildings Directive (2002/91/EC).
- In case of windows and window frames, regulation is mainly focused on the heat transfer and solar gains through the window. However, considering the whole life cycle, other material resource and environmental aspects are also important, such as embedded energy, the composition of protective / preservative coatings for frames etc.
- There seems to be a growing consensus regarding the life cycle impact of different materials used in window frames, with most studies concluding that timber is the most environmentally preferred option, aluminium ranking second and plastic / PVC as third. It is therefore becoming common for procurement specifications to identify specific requirements relating to the timber used for the frames, including certification of country of origin and a preference for timber sourced from sustainable forestry.
- Current green public procurement initiatives in most of the countries in relation to building construction target high energy performing windows. Where available, products covered by eco-labelling or an equivalent volun-

tary national labelling scheme are generally specified.

- Including in green public procurement guidelines some additional aspects going beyond use phase of windows could be justified in terms of the environmental impacts associated with the extraction, production and end-of-life treatment of window frame materials.

## Recycled Mineral Construction & Demolition Waste (CDW)

- In contrast to water heaters and windows, the labelling of recycled mineral CDW is not focussed on energy efficiency but on technical specifications and levels of pollutant concentrations. In the EU Member States, certification / rating schemes and the associated quality assurance systems range from voluntary (UK) to mandatory (Netherlands), with the Austrian system somewhere in between. The requirement for obligatory third party certification also varies.
- In the context of green public procurement, recommendations to use a certain percentage of recycled CDW in construction material were only found in a limited number of case studies and only in the UK.
- In Denmark and the Netherlands there is no need for such a recommendation, as already virtually all available CDW is already recycled. However in the EU as a whole only 30 % of the available material is recycled. Meanwhile, the EU Waste Framework Directive stipulates that 70 % of construction and demolition waste should be recycled by the year 2020.
- The Austrian system of measuring the compliance with environmental standards aims to strike a balance between minimising the environmental impact and minimising the costs associated with demonstrating compliance. Only a limited number of parameters is measured as a standard procedure, but it can be extended if there is an indication that pollutant contamination might occur, e.g. through any leachate leakage.
- As the public sector is the largest ‘consumer’ in the construction market, recommendations or obligations to use more recycled material

in public work projects could considerably increase the market for recycled mineral CDW.

- It is estimated that an additional 120 million tonnes of CDW with a market value of more than 1 billion Euros could be safely recycled annually without harming the environment. This would lead to a reduced consumption of primary material and energy and would also reduce pressure on landfill capacity.

### **Possible areas for Future Action**

Based on the analysis conducted for this study, there is a need for more consistent practical guidance on product selection in GPP, using a standard set of rating criteria, publicised through a labelling or a benchmarking system, which would help the procurer to compare the performances of different products within any particular product group.

The literature reviewed indicates that existing energy labelling standards would benefit from more regular review to ensure they keep abreast of advances in technology and changing environmental requirements, e.g. new climate change targets.

Concerning environmental performance requirements, except for some provisions in the European Eco-Label and in a handful of national initiatives, there is no evidence of any consistent standards or guidelines which take into account the life cycle aspects of products, in terms of:

- Embedded energy and water use
- Resource use (natural and mineral) and
- End-of-life disposal and waste recovery

Expanding the range of considered criteria beyond energy performance would help raise awareness of these issues and provide suitable metrics for a more consistent and comprehensive comparison of products.

Other instruments for market stimulation could be considered to support further growth of GPP, including a number of wider measures used in combination with labelling schemes. Three key types of supporting measures could include:

#### ***Fiscal Incentives***

Fiscal incentives can be used effectively to stimulate the market, particularly when there is an economic downturn, as at present. These forms of incentive were identified in the study in at least two of the four countries reviewed. In the UK, for example, 100% tax relief is offered to businesses on capital expenditure on energy-efficient products within the year of expenditure. This would appear to be having a positive influence on both the consumer and the market.

#### ***Grants***

As with fiscal incentives, grants are also used with effect in some countries, particularly to further stimulate the uptake of energy efficient products, e.g. the Wohnbauförderung (Residential-Building-Sponsorship) grant scheme for energy efficient buildings in Austria and the Energy Savings Trust and Carbon Trust grant schemes in the UK.

#### ***Voluntary Codes***

Voluntary codes, which set standards higher than those required by the national building regulations or codes, are also proving a very effective way of stimulating the market for energy efficient and environmentally sustainable products. Such voluntary initiatives tend to use product labelling / rating schemes to measure the different energy-related performance properties of different product groups / building components.

Recent initiatives at the EU level to establish targets for GPP for priority products are likely to stimulate the market for environmentally preferred goods and services. While provisions for mandatory GPP could provide further impetus, political viability of such an initiative at the present time remains to be seen.

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# 1. Introduction

## 1.1. Policy Context

The drive towards sustainable consumption and production (SCP) in Europe was given added impetus in July 2008 with the publication of the EU Sustainable Consumption & Production and Sustainable Industrial Policy Action Plan (SCP & SIP Action Plan) (EC Communication, 2008a). This forms an integral part of the EU Sustainable Development Strategy, whilst also complementing existing EU policies on:

- Energy, and climate change, including the Commission's Action Plan for Energy Efficiency, which reflects growing concerns about climate change, rising energy prices and security of energy supply;
- Resource use, including the Thematic Strategy on the Sustainable Use of Natural Resources (EC Communication, 2005).

In the 2007 Monitoring Report on the EU Sustainable Development Strategy (EUROSTAT, 2007), the headline indicator for SCP is resource productivity, which is an aggregate measure of the material efficiency of the economy. Between 2000 and 2004, this measure actually increased on average by 2.3% per annum, revealing some decoupling of consumption from economic growth during that period. However, in spite of these positive developments, the Thematic Strategy on the Sustainable Use of Natural Resources notes that an analysis of materials and waste streams in the EU over the last 20 years showed that overall per capita consumption in the EU has remained virtually unchanged at around 16 tonnes per year, although the economy increased by more than 50% during the same period.

The SCP & SIP Action Plan sets out to address this, establishing a new framework for environmental product policy “*..to improve the environmental performance of products and stimulate the demand for more sustainable goods..*”, with particular reference being made to the need to reinforce and better integrate:

- Existing energy and environmental labelling and eco-design
- Green Public Procurement (GPP).

Emphasis on **Green Public Procurement** was further reinforced in July 2008, with the publication of the Communication on *Public Procurement for a Better Environment* (EC Communication, 2008b), which sets out to “*...provide guidance on how to reduce the environmental impact caused by public sector consumption and to use GPP to stimulate innovation in environmental technologies, products and services.*”

In 2004, the Commission produced a handbook on environmental public procurement (EC, 2004) which explained how best to integrate environmental considerations into public procurement procedures based on the provisions of the Public Procurement Directives of 31 March 2004.

European public authorities spend around 16% of the annual EU Gross Domestic Product on goods and services (EC Communication, 2008a:3). Much of this amount is spent in sectors with high environmental impacts, such as transport, buildings and furnishings, where public authorities can give

strong signals via their purchasing decisions and influence suppliers to innovate and produce more environmentally friendly goods and services. There is therefore considerable potential to increase the market penetration of sustainable products through GPP, relating to:

- *Cost-reduction*: Procurement decisions solely based on purchase price may not always be the most cost-effective option (EC Communication, 2008b:9), e.g. a decision to invest in a new building based solely on capital cost, ignoring the operations and maintenance costs, which are estimated to be about 85% and thus may exceed the initial costs of construction by far (Davis Langdon Management Consulting, 2007:5). Building design costs can be 0.3–0.5% of the lifetime costs, and yet it is through the design process that the largest impact can be made (EC 2008).
- *Innovations in Eco-Technologies*: GPP can be a powerful economic driver for environmental technologies, generating a significant demand from public authorities for green goods and services, thereby enlarging the market.
- *Increased Resource Efficiency*: minimising the resources used in production and consumed in consumption, and minimising the waste to landfill.

Until now, the potential of green public procurement has only been marginally exploited, due to insufficient, often inconsistent information on and / or low awareness of the:

- Benefits of using green products and services
- Life cycle costing of products
- Options to include environmental criteria in tender documents
- Relative cost of green products.

With the potential to encompass all of these, an over-riding factor is the lack of established, consistent and transparent SCP procurement criteria. Product legislation often only addresses specific aspects of a product's life cycle, and whilst the Eco-design Directive takes a life-cycle perspective, the impacts currently covered by the Energy Using Products Directive account for only 31-36% of the environmental impact of those products (EC Communication, 2008a).

The Commission is undertaking a series of new actions to address current obstacles to the uptake of GPP, including establishing a procedure for setting common GPP criteria and providing information on the costing of a product over its life cycle, legal and operational guidance and political support linked to indicators and future monitoring.

Criteria have been developed for product and service groups in 10 priority sectors, based on existing European and national Eco-label criteria, where appropriate, as well as on information collected from stakeholders in industry and civil society. The ten priority sectors for implementing GPP identified in the 2008 Communication on public procurement for a better environment include:

1. Construction
2. Food and catering services
3. Transport and transport services
4. Energy
5. Office machinery and computers
6. Clothing, uniforms and other textiles
7. Paper and printing services
8. Furniture

- 9. Cleaning products and services
- 10. Equipment used in the health sector

To date, concrete examples of environmental criteria which could be included in tender documents have been published for the following product and service groups: copying and graphic paper; cleaning products and services; office IT equipment; construction; transport; furniture; electricity; food and catering services; textiles; gardening products and services; and equipment used in the health sector (the latter to be published at a later date)

Furthermore, GPP criteria are currently being discussed for another 10 product groups: mobile phones; combined heat and power, boilers, air condition units and heat pumps; thermal insulation; wall panels; hard floor coverings; windows; street lighting and traffic signals; road construction and traffic signs.

In addition, under the renewed Sustainable Development Strategy (Council of the European Union, 2006), the EU leaders adopted a target for GPP stating that by 2010, the average level of GPP should be the same as the level of the best performing Member States at the time. The Commission recently proposed that by 2010, 50 % of all tendering procedures should be "green", complying with endorsed, common GPP criteria.

Over the past ten to fifteen years considerable progress has been achieved in sustainable consumption and production through energy labelling on household appliances, such as dishwashers and washing machines. The question now is how public procurement could be used to influence the market for a wider range of products and further reduce energy consumption and the environmental impacts.

Some progress has already been made in this area, as noted in research conducted for the European Commission by a consortium of consultants, Bouwer et al (2005), which highlighted seven countries (Austria, Denmark, Finland, Germany, Netherlands, Sweden and the UK) which had consistently more public procurement tenders with green criteria. However the question remains as to the extent to which these programmes have succeeded in delivering environmental benefits.

**Box 1: Assessing environmental benefits from GPP**

Environmental benefits from GPP can be separated into direct effects, spill-over effects and market impacts, where the :

- *Direct Impact* is equal to the environmental benefits, or avoided environmental costs, caused by the switch from non-labelled to labelled goods or services.
- *Spill-over Effect* is achieved through the public sector leading by example, encouraging the private and domestic sectors, and thereby leading to increased purchases of more 'green' alternatives in the same product group. This could also influence the purchases of other product groups, referred to as secondary spill-over effects. The environmental benefit caused by spill-over effects can be larger than the direct effect of GPP.
- *Market Impact*, where in fully flexible market, the increase in demand for 'green' products may lead to an increase in prices. The implied decrease in demand for non-labelled products could lead to a decrease in prices for these products. Motivated by higher profits margins, existing producers may increase the production of labelled goods and new producers may appear<sup>1</sup>. This will encourage an increase in the overall supply of labelled products and reduce the supply of non-labelled products.

The effects on markets depend strongly on whether the public sector purchases sufficient quantity to influence the

<sup>1</sup> In the long-run profits would return to normal, reducing the number of new-entrants to the market.

market for the products in question.

Figure 1.1 below shows the relationship between direct impacts, spill-over effects and market effects. An important point raised in this figure is that current public and private procurement decisions can cause changes in the future supply of labelled products, in turn influencing future procurement decisions and creating a virtuous circle. Moreover, public procurement decisions that increase the supply of labelled products should make the purchase of labelled products more cost effective in the long-run as supply expands and prices fall.

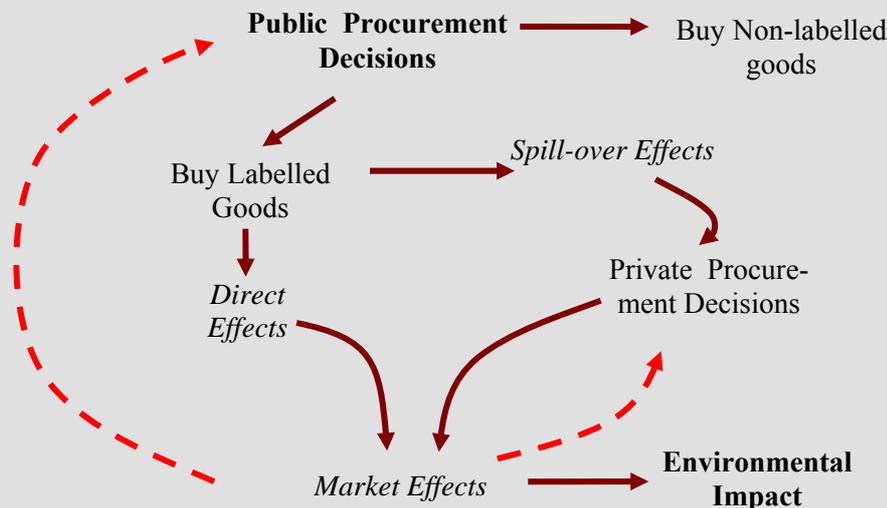


Figure 1-1: Pathways from GPP to Environmental Impacts / Benefits

**Source:** Authors own (2008)

Other factors that can enhance or inhibit the overall environmental benefit of GPP could include:

- The extent to which environmental considerations are covered in legislation, standards, labelling and GPP guidelines.
- Sharing of experience and good practice in product labelling and GPP
- Stringency of green labelling conditions.
- Accessibility, ease of understanding and recognition of green labels by private actors.
- Scale of potential energy savings or other environmental benefits.
- The effects of other policy instruments
- Future developments in policy, technology, etc.
- Financial cost implications
- The ability of the public sector to influence the market

Consideration of these and other factors could help assess the strength of the pathways linking GPP and overall environmental benefit for the each product in each country considered.

## 1.2. Objectives, Scope and Product Selection

The objective of this study is to inform the implementation and further development of the SCP & SIP Action Plan. In order to achieve this, the study will:

- Assess current energy and environmental performance-related product labelling programmes regulations and standards and identify what lessons can be learnt from Best Practice (*Labelling, Regulations & Standards*);
- Review current practice in GPP in relation to the use of product labelling and identify what lessons can be learnt from Best Practice and what possible measures could be used to reinforce GPP procedures in this particular area (*GPP*);

- Where possible, highlight other measures that could be used to further stimulate the market for energy efficient and environmentally sustainable products (*Other Measures of Market Stimulation*).

An important remark needs to be made concerning the relative prominence of labelling in this report. Labelling has been used here to provide a common reference system across the different products. However, it needs to be noted that while labelling can certainly provide helpful guidance to suppliers and purchasers, it should not be considered as a precondition for GPP. More green public procurement can also be achieved by purchasing of non-labelled products as long as they provide an environmentally advantageous alternative.

The study is based on experiences in Austria, Denmark, Germany and the UK in relation to three building / construction product groups, one energy-using (water heaters) and two non-energy using (windows and recycled mineral construction and demolition waste). Further details on the scoping exercise and product selection process is given below.

The report consists of five main chapters: Introduction, including the policy context; three product-specific chapters (water boilers, windows, and recycled mineral construction and demolition waste); and Conclusions. A glossary of terms and abbreviations used in the main chapters of the report is provided in Appendix B. Furthermore, detailed technical information for each product group reviewed is also provided in Appendices. The work is based on a desktop review of current literature, drawing on particular experience and practice in the four countries identified above, with reference to experience in other parts of the world, as appropriate.

On the advice of DG Environment, the original project brief was extended to cover both:

- Energy performance criteria
- Other environmental performance criteria, including resource use

The analysis was to examine the suitability of labelling as one of the possible market drivers for other environmental performance issues, including energy-related issues, use of recycled material and the life cycle impact of the product.

An initial product-selection scoping exercise was therefore carried out, which identified a shortlist of seven product groups, comprising both energy using and non-energy using products selected from products used in building and construction – as this has been identified as one of the areas where public procurement has the greatest potential influence in terms of purchasing power. The products selected were:

**Energy using products:**

- Boilers & Water Heaters
- Street Lighting
- Light Bulbs
- Computers and Monitors

**Non-energy using products:**

- Pipe Insulation
- Recycled Construction & Demolition Waste
- Windows

A short review was prepared on each product group identifying:

- (i) Market coverage: household, business, government
- (ii) Product research: why of interest, what could be the focus, practicality etc
- (iii) Availability of existing evidence based on a quick literature review
- (iv) Links with wider policy (Europe, international, domestic)
- (v) Pros and Cons of the option (highlighting how this could be of particular value and any drawbacks)

Based on this review, three product groups were finally selected for this study: one energy-using (water heaters), one energy-related (windows) and one non-energy using (recycled construction & demolition waste). The sections below highlight particular aspects which particularly influenced the selection of each product group.

### ***Water Heaters***

As an energy-using group of products, dedicated water heaters, together with the water heating element of central heating boilers, is the second largest group of products covered under the Energy-Using Products (EuP) Directive 2005/32/EC in terms of energy consumption and CO<sub>2</sub> emissions. Their annual consumption amounts to some 86 million tons of oil equivalent and contributes 6% of all EU fuel-related CO<sub>2</sub> emissions in the EU-25 (VHK, 2007). In terms of EU domestic household emissions, water heaters alone represent in excess of 20% of the direct CO<sub>2</sub> emissions and around 10% of the total (direct and indirect) emissions.

The Eco-design of Water Heaters study by VHK identified that possible energy efficiency measures through labelling could achieve savings of between 35% and 60% in terms of CO<sub>2</sub> emissions based on Least Life Cycle Costing (LLCC) and Best Available Techniques (BAT) respectively.

It was therefore considered that the scale of potential savings warranted this product group being selected as an energy-using group of products. In addition, it was also identified that water heater systems play an important role with regard to other aspects such as CO and NO<sub>x</sub> emissions and water consumption.

### ***Windows***

Windows, as a non-energy using but energy-related group of products, can contribute to the energy demand of a building to overcome heat loss through the window and associated ventilation mechanisms. However the embedded energy, the materials and the waste arising from their removal / replacement can also have a significant impact in terms of SCP.

The Institute for Polymer Testing and Polymer Science (IKP 1998) comparison of aluminium, wood, wood-aluminium and PVC window frames identified that the associated potential damage to ecosystems could vary by as much as a factor of 50, depending on the material in question. It also identified that for most indicators, production accounts for about 30-40% of the environmental impact during a window's lifetime, the majority of the balance generally being associated with disposal.

The project "Environmental Improvement Potentials of Residential Buildings (IMPRO-Building) " (2008) highlights the importance of windows in relation to acidification, eutrophication, photochemical, ozone creation and ozone depletion impacts. Together these can amount to between 4 and 14% of the impact of the total building, depending on the type of glazing and the frame materials.

It was therefore decided to include windows as a group of non-energy using but energy-related products

to explore how these wider SCP issues could also be covered by labelling and promoted through GPP.

### ***Recycled Mineral Construction and Demolition Waste***

Mineral use in building and construction (above-ground construction, road construction etc.) accounts for the largest material stream in the EU, with domestic extraction in the EU-15 amounting to 7.0 tonnes/capita or 2,600 million tonnes in 2000. This equates to about 50 % of all the material movements within these countries (Weisz et al. 2007).

The reuse of construction and demolition waste (CDW) through recycling as secondary building material has the potential to substantially reduce this figure and the associated environmental impact, resulting in:

- Less primary material extraction and processing, with reduced resource use in terms of materials, land and energy consumption, and a reduction in the production of particulates into the atmosphere from quarrying activities
- Less waste material to landfill, resulting in reduced land use and avoiding potential ground contamination.

While some European countries, such as Denmark and the Netherlands, are already recycling almost 100% of their available mineral CDW, the overall performance in the European Union as a whole, would indicate that there is still room for considerable improvement, with the average recycling percentage estimated to be about 30% of 180 million tonnes of waste arising annually (FIR, 2004). Furthermore, in this particular area GPP can act in synergy with the EU Waste Framework Directive, which sets the target that 70 % of construction and demolition waste should be recycled by the year 2020.

Recycled construction and demolition waste was therefore selected as a suitable non-energy using product group, where labelling of other environmental criteria could be of considerable value in terms of sustainable consumption and production.

## 2. Water Heaters

### 2.1. Product scope

Water heaters can be fired by a number of energy sources including biomass, gas, oil, solar, solid fuel (coal etc) or electricity. However for the purposes of this study, in order to keep the scope manageable, boilers have been excluded and the scope of the study is restricted to dedicated water heaters<sup>2</sup> fired by oil or gas-fired or run on electricity, which, the study by VHK Consulting (VHK, 2007) identified as forming the bulk of the market. It also excludes district heating and combined heat and power (CHP) schemes.

Solar heaters are excluded on the grounds that one of the primary objectives of this study is to influence the consumption of non-renewable energy and the associated carbon dioxide emissions. Solar heating, by definition uses renewable energy, and is thus excluded. However back-up systems fired by oil, gas or electricity are covered.

The scope of the study on water heaters covers energy-use, energy-related and other non-energy-related performance criteria, such as their impact on water consumption.

### 2.2. The Market

#### 2.2.2 *Production*

In terms of the value of this sector to the economy, EUROSTAT reports that in 2004 production within the EU-25 totalled some 18.4 million units with a value of EUR 2.54 billion, with a split between electric and gas-fired of around 4 to 1.

#### 2.2.3 *Consumption*

The consumption of water heaters is generally driven by the construction market requiring new installations and the replacement market. As water heaters have a life expectancy of between 8 and 15 years, depending on the type of heater, the state of the existing stock is likely to be the dominant factor in this market.

The VHK report notes that in 2004/05 there was an installed stock of 146 million dedicated water heaters, covering just under 50% of the primary heaters (main supply to the dwelling) and 100% of the secondary heaters (serving one room only, e.g. shower in bathroom). Market penetration in the same year was 132 %, i.e. 32% of EU households owned a secondary / supplementary water heater.

Table 2-1 in Appendix C gives a further breakdown of stock and sales in 2004/05 for the EU-22<sup>3</sup> as a group, and individually for Austria, Denmark, Germany and the UK. Country figures show that the types of water heaters used in the four countries vary quite considerably; for example, in the UK the majority (56 %) are combination boilers, while dedicated water heaters, particularly electric storage heaters, are predominant in Germany, Austria and Denmark.

In terms of sales, the 2007 EU-25 consumption of dedicated water heaters was estimated by VHK to be

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<sup>2</sup> For this study “dedicated water heaters” are defined as heaters with no space-heating function.

<sup>3</sup> EU22 excludes Cyprus, Luxembourg & Malta (Bulgaria and Romania were not EU members at the time of publication of the study).

EUR 3.1 million. However it also noted a degree of uncertainty with this data due to possible under reporting. The data for 2004/05 provides a greater breakdown of the dedicated water heater market, with total sales amounting to 10.4 million units, of which 8.3 million were electric and 2.1 million were gas-fired. As might be expected, 70 % of these sales were replacement sales and just 30 % were new sales.

The 8.3 million electric heaters consisted of:

- 5.9 million storage heaters, i.e. where the water is pre-heated and stored in a tank
- 2.4 million were instantaneous.

With gas-fired water heaters the pattern is reversed, with:

- 0.23 million storage heaters
- 1.85 million instantaneous.

This covers around 50% of primary water heaters and 100% of secondary heaters. A more detailed breakdown of consumption in the EU25 is given in Table C-2 and Figures 2-1 and 2-2 in Appendix C.

This also shows that while each category of heater grew in market size between 2004 and 2007, electric storage heaters saw the biggest increase, contributing 65% of the overall growth in market value. Combination boilers are 62% of the 2007 market value, but just 15% of the total units sold. This reflects the higher costs of these items.

In terms of energy consumption and CO<sub>2</sub> emissions, VHK identified that dedicated water heaters, together with the water heating function of gas, oil and electric central heating boilers, represent the second largest product group covered by the EuP Directive and amount to around 20% of all direct household emissions in Europe. This is supported by data in the UK; Young (2008) found that dedicated water heating represents 23% of energy consumed by the existing housing stock.

## 2.3. European Performance Criteria

In Europe, the performance of water heaters is controlled to varying degrees by a number of existing policies, directives, regulations and standards. These are based on a number of different approaches, including:

- Eco-design (a **life-cycle** approach)
- Energy performance related labelling (a **use-phase, product-based** approach)
- Energy performance of buildings (a **use-phase, systems-based** approach)

These measures, together with a voluntary commitment by the European Committee of Domestic Equipment manufacturers (CECED, 1999), are outlined in greater detail below.

### 2.3.1. Eco-design of Products

Water heaters are covered by the EU Eco-Design for Energy-Using Products (EuP) Directive (EC, 2005a), which establishes a framework for setting eco-design requirements for energy-using products based on a life cycle approach. Whilst not directly introducing binding requirements for specific products, the Directive enables the Commission to enact implementing measures setting minimum

requirements for specific products associated with their environmental aspects, such as energy consumption (with a strong focus on energy efficiency), waste generation, water consumption etc.

Although currently this only applies to energy-using products, the new SCP and EIP Action Plan aims to extend this to also cover all “energy-related” products, i.e. products, which although non-energy-using themselves, nevertheless have a direct influence on the energy required to heat and / or cool buildings.

### ***2.3.2. Energy Performance Related Labelling***

Energy performance related labelling for oil and gas-fired water heaters is currently covered under the Boiler Efficiency Directive (EC, 1992a), which specifies minimum mandatory energy efficiency standards for water heaters of between 4 and 400 kW output.

Electric water heaters are generally not in themselves covered by labelling, with energy losses generally associated with the insulation or otherwise of the water tank and the generation of the electricity at source, with the result that the units themselves tend to have an operational efficiency close to 100%.

The framework Energy Labelling Directive (92/75/EC) (EC, 1992b) requires a prescribed list of energy-using appliances, including water heaters, to be labelled with a mandatory EU Energy Label in accordance with the Directive. However this has yet to be implemented for water heaters, pending the development of appropriate test standards.

Three draft Water Heater Directives (EC 2005b, EC 2005c & EC 2005d) were produced in 2005, covering electric, gas-fired and solar water heaters and water storage devices. However, when considered by the Energy Labelling Regulatory Committee (ELRC) and subsequent stakeholder consultation, the question was raised as to whether these activities would be best taken forward under this Directive or alternatively, under the information provisions of the Eco-design Directive. This issue has yet to be resolved.

However some progress has been made, as outlined in EU mandate M324 (EC, 2002a) under Directive 92/75/EEC, issued to the European standardisation institutions, CEN and CECELEC, which establishes important principles for standards in this area, in that they:

- Should allow the performance of water heaters, hot water storage appliances and water heating systems to be measured on a comparable basis
- Must use the same daily hot water demand patterns or “tapping cycles” when setting standards for measuring performance as defined in the mandate (see Table C-3 in Appendix C).

In addition, any Energy Labelling should be based on measured energy performance, preferably to a European harmonised standard compliant with mandate M342, which has been used as the basis for European standards, EN 13203-2 and proposed EN 50440. Further information can be found in Appendix C, which includes a list of the EN standards applicable to testing the energy performance of water heaters and Figure 2-3 which summarises the demand pattern tapping cycles to typical applications.

Information on the energy performance of water heaters has also been provided on a voluntary basis since 1991 by the European Committee of Domestic Equipment manufacturers (CECED), which represents more than 70% of the European market, under a voluntary agreement recognised by the EU. This commits CECED members to making a:

- Clearly visible declaration of standing losses (kWh per 24 hrs)
- Step-wise phase-out of less efficient appliances, ranking in certain draft energy label classes

- Reduction of the European consumption of appliances.

### **2.3.3. Energy Performance of Buildings**

The Energy Performance of Buildings Directive (EC 2002b) identifies minimum energy performance requirements for all:

- New buildings (residential & commercial)
- Existing large commercial buildings subject to major renovation

Existing residential buildings subject to major renovations, although not currently covered, will be included at a later stage. In addition to the above energy certification of all buildings is to be mandatory, with regular inspection of boilers installed with a power rating exceeding 10kW.

Whilst energy labelling can be a key driver in the water heater replacement market, for installations in new buildings and building refurbishment, this directive, implemented through the national legislation of the individual Member States through the national building codes or regulations, may have a much greater influence on the market.

A report from BSRIA (2008) notes that the implementation of this Directive in the UK through Part L of Building Regulations, has “sent shock waves through the structure of the UK heating market and has led to a strong trend towards the use of condensing boilers in domestic, non-domestic and commercial buildings”. Compliance with UK Building Regulations requires designers to achieve a specified CO<sub>2</sub> target. As a result, many designers are choosing boilers with an efficiency higher than the statutory minimum, with condensing boilers often being the preferred option, although not demanded by the Regulations.

## **2.4. Member State & Non-European Performance Criteria**

### **2.4.1. Energy Labelling**

In many Member States, the energy performance of water heaters is covered in national eco-labelling schemes, which started in Europe in 1978 with the German Blauer Engel certification scheme, using a life cycle analysis approach to trace product environmental performance, assured by a third party. By 1990 Spain (AENOR), France (Norme Francaise Environnement) and the Nordic countries (Nordic Swan) also had similar schemes in existence (see Parry et al 1995).

Since then eco-labelling schemes have developed in many countries throughout the world and the International Organisation for Standardisation (ISO) has classified environmental product claims and eco-labels under three headings:

- Type 1: declarations that meet criteria set and verified by third party & based on life-cycle impacts, e.g. the EU eco-label and the US Green Seal;
- Type 2: manufacturers’ or retailer’s claims with no externally pre-defined criteria or third party verification;
- Type 3: quantified environmental product information based on life-cycle impacts in relation to specific aspects, e.g. energy consumption or output.

The following sub-sections highlights how energy efficiency criteria are covered in each of the four countries covered by this study.

### Austria

Energy efficiency criteria are currently covered in three pieces of legislation relating to:

- *Energy-using products:* Eco-Design Ordinance 2007 (Oeko-Design Verordnung 2007), which transposes the EuP Directive into Austrian legislation;
- *Minimum efficiency standards:* Austrian minimum efficiency standards, which currently cover only refrigerators and freezers;
- *Energy efficiency labelling:* Austrian Energy Efficiency Labelling Schemes, covering electric ovens, washing machines, dishwashers, tumble driers, refrigerators, freezers and household lamps.

Several voluntary agreements also exist. However so far, nothing has been established to cover water heaters, other than a series of standards from the OVE – Oesterreichischer Verband fuer Elektrotechnik (Austrian Association for Electrotechniques) for electrical warm water preparation covering safety aspects.

### Denmark

Denmark participates in the Nordic Swan labelling system, which for water heaters, stipulates the minimum energy efficiency of different burner / boiler combinations as indicated in Table 2-1.

Table 2-1: Nordic Swan Labelling System

Fuel	b	
	Measured at nominal effect	Measured at low effect
Oil	91,77	89,77
Gas	95,83	93,83

Min efficiency (defined in CEN 303 and 304),  $y = (1/60) x + b$

Where  $y$  = required efficiency, and  $x$  = rating of the boiler in kW

### Germany

In Germany the Blauer-engel (<http://www.blauer-engel.de>) scheme covers around 10,000 products in 80 product categories, including water heaters. The criteria are based on steady-state energy efficiency with a minimum value of 89.5% for 10 kW heaters and 90% for 30 kW heaters. Auxiliary power demand should also not exceed 80 watts when operational and 8 watts when in sleep mode.

The Blauer-engel website also lists a number of manufactured products of between 7 and 50 kW capacity which meet their criteria.

### United Kingdom

Water heaters in the UK are labelled according to the SEDBUK (Seasonal Efficiency of Domestic Boilers in the UK) ([www.sedbuk.com](http://www.sedbuk.com)) rating, which was developed under the Government's Energy Efficiency Best Practice Programme with the co-operation of boiler manufacturers, to provide a basis for fair comparison of the energy performance of different boilers.

The SEDBUK rating is the average annual efficiency achieved in typical domestic conditions, making reasonable assumptions about pattern of usage, climate, control and other influences. It is calculated from the results of standard laboratory tests together with other important factors such as boiler type,

ignition arrangement, internal store size, fuel used, and knowledge of the UK climate and typical domestic usage patterns.

SEDBUK provides an Information System and a Database aimed at informing the end user in a simple way through the Internet, giving consumers, installers and designers an accurate tool to compare different boilers. At the same time, the application of a label on the same basis makes it possible to obtain simplified information using the now well-accepted A to G system of the labelling directive 92/75 (EC, 1992b). This has encouraged all manufacturers to provide the highest-rated energy efficient boilers.

Incorporating results obtained from the Boiler Efficiency Directive (EC, 1992a) 30% and 100% load performance tests, the SEDBUK scheme is now widely recognised and has helped transform the UK market for domestic gas and oil-fired water heaters in recent years (UK Market Transformation Programme, 2008). The SEDBUK website also provides an indication of the typical initial purchase and annual fuel-running costs for different boiler types and ratings.

### Non-European Countries

Minimum efficiency performance standards (MEPs) and / or labelling programmes now exist throughout much of the world. The VHK study of water heaters notes that Europe (the EU) and Africa (with the exception of South Africa) would appear to be the only continents without MEPs.

In terms of the metrics on which the MEPs are based, the US and Canada were considered by VHK Consulting to be leading the way, with measurements based on 24 hour tapping patterns and demand cycles, as opposed to the traditional measures of storage losses and steady-state combustion efficiency. Australia and New Zealand, although currently using steady-state metrics, are reported to be considering changing to a methodology similar to the US. The majority of other countries also currently use steady-state metrics.

The approach proposed by the EU in mandate, M324, is consistent with the US metrics, being also based on a series of tapping patterns to reflect differing hot water demand patterns, as outlined in Section 2.3.2 above, is consistent with this.

In the USA, Energy Star ratings for water heaters are based on Energy Factor (EF), which is the ratio of the energy output of the heater (i.e. heat delivered as hot water) to the total amount of energy consumed by the water heater. More specifically it is the added energy of the water drawn from the heater divided by the energy required to heat and maintain the water at the heater's specific set point temperature.

New Energy Star criteria for water heaters were announced by the US Department of Energy in April 2008, which requires the energy factors outlined in Table 2-2 below.

Table 2-2: New Energy Star Criteria (US Department of Energy, 2008)

Heater Type	EF 2008	EF 2010
Gas-fired storage	$\geq 0.62$	$\geq 0.67$
Whole-home gas tankless	$\geq 0.82$	
Gas condensing	$\geq 0.80$	

The European Union has had a partnership agreement with the US Environmental protection Agency since 2001 to introduce the Energy Star programme in Europe, however to date this covers only office equipment.

In Asia, the Japanese Front Runner Programme sets efficiency values approaching 83% on Gross Calorific Value and China is reportedly contemplating MEPs at levels of 88% for 2008 and 95% for 2015.

Although no longer mandatory, in Russia GOST (GOSudarstvennie STANDarty) (2001) standards exist for gas-fired water heaters, with MEPs of 80% for heaters of less than 10 kWh capacity and 84% for those in excess of 10 kWh.

In its review of these standards, VHK concluded that the most stringent MEPs are to be found in:

- USA for storage heaters, which tend to be followed by Canada, Australia and New Zealand;
- Asia for gas-fired instantaneous heaters.

#### 2.4.2. Energy Performance of Buildings

##### Austria

The implementation of the Energy Performance of Buildings Directive, implemented through OIB-Richtlinie 6, „Energieeinsparung und Wärmeschutz“, 04/2007 is mainly in the responsibility of the Bundeslaender (building codes and inspection of heating, aeration and cooling systems) and the Ministry of Economy and Labour (selling and renting of buildings).

Similarly, the Energy Certification Providing Act 2006 (BMJ, 2006), which implements Directive 2002/91/EC (EC, 2002b) stipulates the provision of energy certificates for buildings, as required by when they are sold or rented. These energy certificates are further specified in OIB-Guideline 6 “Energy Conservation and Heat Protection (OIB, 2007).

This defines how the annual heat losses of a building are calculated and the subsequent allocation of the building to a certain energy class. It also defines limiting values for the annual heat loss and limits for the final energy demand of the building. The end energy demand calculation takes account of the energy efficiency of water heaters, as set out in OIB-Guideline 6.

Over and above this, the efficiency requirements for new hot-water boilers fired with liquid or gaseous fuels according to the Boiler Efficiency Directive (EC, 1992) are valid in Austria. By agreement between national and regional governments (Bund und Laender 1995), the following minimum efficiencies ( $\eta_{\min}$ ) are specified for pre-1995 natural gas-fired hot water boilers:

- Flow heaters
  - Up to 12 kW heating capacity:  $\eta_{\min} = 83 \%$
  - Above 12 kW heating capacity:  $\eta_{\min} = 78,7 + 4 \log(\text{heating capacity in KW}) \%$

Tank heaters:  $\eta_{\min} = 82 \%$

A guideline on low-energy houses of two Austrian ministries (Lebensministerium et al. 2008) stipulates the following order of preference for warm water preparation:

1. Solar heating with well insulated hot water tank
2. Wood-fired combined room and hot water heating
3. District heating
4. Heat pumps (room heating and warm water preparation)
5. Natural gas or oil-fired condensing boilers (room and hot water heating).

Other Natural gas or oil-fired boilers must not be used. Electricity can only be used as a back-up for solar heating or heat pumps. Although this guideline is aimed at residential buildings it is also applicable to public buildings.

### Denmark

Denmark has implemented the Energy Performance of Buildings Directive since January 1st, 2006. The country has had fairly strict energy requirements in the building regulations for many years, with obligatory labelling scheme for buildings and inspection scheme for boilers but the energy requirements in the building regulations have now been tightened even further and new labelling and inspection schemes have been developed.

The 2006 Regulations promote the best boilers; i.e. boilers with full-load and part-load efficiencies according to the CE labelling tests of above 96 % and 104 %, respectively, thereby effectively limiting the choice of water heater to condensing gas for both replacement and installation in new buildings.

### Germany

All aspects of the Energy Performance of Buildings Directive have been implemented through the Energy Saving Ordinance (Energieeinsparverordnung) 2007, which places limiting values on the primary energy demand for buildings, including hot water systems. This legislation also requires boilers older than 1978 to be removed.

In support of this, a new calculation method, DIN V 18599, was developed, which takes an integrated approach, assessing the thermal shell, built-in lighting, heating, ventilation, cooling and hot water supply appliances, with consideration for the climatic conditions in Germany. Thus the assessment process will inevitably require energy efficiency of the water heater to be considered and is therefore likely to be an influencing factor on the ultimate choice of heater.

In order to increase energy efficiency in buildings the Energy Saving Ordinance 2009 will tighten existing standards by 30%, from 70 kWh/m<sup>2</sup> to 50 kWh/m<sup>2</sup> (Ornth, 2008). This will be followed by a further 30% in 2012.

### United Kingdom

The requirements of the Energy Performance of Buildings Directive (EC, 2002b) are covered in the national legislation in the Sustainable & Secure Buildings Act 2004 (HM Government, 2004) and have been enacted into UK law in relation to:

- 1) New & Existing Buildings, through Part L of Building Regulations (ODPM, 2006)
- 2) Certification of Buildings, through the Energy Performance of Buildings Regulations 2008 (HM Government, 2008), which requires Energy Performance certificates for all buildings that are being sold or rented out.

Part L of the UK Building Regulations specifies the minimum thermal efficiency (gross calorific value) of 86% for domestic hot water systems in new and existing buildings.

For non-domestic buildings, the minimum seasonal boiler efficiency values are, for:

- New buildings: 84% for a single boiler systems or 80% for multi-boiler systems;
- Existing buildings: 80% for gas, 81% for LPG and 82% for oil-fired systems.

### 2.4.3. Other Performance Criteria

#### *Other Energy-Related Criteria*

A further aspect of hot-water heaters that affects their energy consumption is the degree to which they are insulated and / or controlled. An Austrian study (SAVE, 1998) in 1998 under the SAVE programme into the standing losses and optimum tank jacket insulation values of domestic electric storage heaters recommended a foam thickness of between 6.4 and 9.3 cm.

Although this aspect does not appear to be covered currently under labelling in the four countries covered by this study, it is directly or indirectly covered in the country-specific Buildings Codes / Regulations, as part of the implementation of the Energy Performance of Buildings Directive.

In Austria at the regional / provincial level, the Vienna Oekokauf specifies a minimum thickness of insulation material or jacket for the water tank of at least 100 mm of material with a heat transmission of less than 0.035 W/(m\*K), which is in line with the recommendations of the SAVE study.

In the UK, Building Regulations stipulate the minimum heat loss for local electrically heated water systems as 1.28 x (0.015V) kWh where V is the nominal capacity of the tank. It also specifies minimum thermostat and time control packages to regulate the use of water heaters when not under draw-down / demand.

A consultation exercise has recently been carried out in the UK, looking at further possible means of improving the energy efficiency of a building. The resultant recent policy brief issued by Defra (Defra, 2008a) recognises that as technological improvements have almost reached their limit, in addition to the SEDBUK minimum 86% efficiency rating now required by Building Regulations, other standards will need to be established, with particular reference to control systems for water heaters. Accordingly the brief proposes:

- Better use of standard controls, i.e. in the case of water heaters, cylinder thermostat and for combined space heating and hot water systems full programmer or programmable room thermostat or thermostatic radiator valves. No of households using controls correctly rising from 50% to 75% by 2020;
- Use of advanced controls to exploit the characteristics of condensing boilers, giving a further 5% saving in energy consumption, with target of 50% market penetration by 2020.

#### *Greenhouse Gas & Other Air Emission Criteria*

Maximum carbon monoxide, NO<sub>x</sub> and particulate (PM<sub>10</sub>) emission criteria are also stipulated in several of the national eco-labelling schemes, as indicated below.

In Austria, emissions of CO, NO<sub>x</sub> and PM<sub>10</sub> emissions for fossil fuel-fired heaters are covered in “Kleinf Feuerungsanlagen”, with the limiting values indicated in the table below.

Table 2-3: Kleinf Feuerungsanlagen Maximum Emissions Criteria

Fuel	CO (mg/MJ)	NO <sub>x</sub> (mg/MJ)	PM <sub>10</sub> (mg/MJ)
------	------------	-------------------------	--------------------------

<i>Oil-fired (all types)</i>	20	35	1
<i>Gas-fired (atmospheric):</i>			
Natural gas	20	30*	-
LPG	35	40*	-
<i>Gas-fired (fan-assisted):</i>			
Natural gas	20	30	-
LPG	20	40	-

\* For instantaneous, storage & local heaters, these NOx limits can be surpassed by a max of 100%

In Germany, the Blauer-engel stipulates maximum levels of 56 ppm for carbon monoxide, and 34 ppm for nitrogen oxides (NO<sub>x</sub>) for gas-fired water heaters.

In Denmark, the Nordic Swan requires the following maximum emission criteria:

Table 2-4: Nordic Swan Maximum Emissions Criteria

<b>Fuel</b>		<b>CO (ppm)</b>	<b>NOx (ppm)</b>	<b>PM<sub>10</sub> (ppm)</b>
Gas	Burner	49	35	-
	Burner/boiler combination	16	35	-
Oil	Burner	48	43	.05
	Burner/boiler combination	16	43	0.5

Although emissions criteria are not included in the SEDBUK system, the Energy Performance of Buildings in the UK is linked to the CO<sub>2</sub> emissions per square metre of the building, with the designer required to demonstrate that the emissions are lower than the specified target. The designer must therefore refer to the CO<sub>2</sub> emissions associated with water heaters, as part of the overall assessment of the building under the Standard Assessment Procedures (SAP) for the Energy Rating of Dwellings (BRE, 2005).

#### *Water Consumption Criteria*

Water consumption is a further aspect on which attention is becoming increasingly focussed. The concept of water efficiency labelling is not new, the WELS scheme existing in Australia since 2005 and other similar schemes also existing in the US, China, Israel, Ireland and Singapore.

In the UK, household water consumption has increased by 55% since 1980 due to an increasing range of water-using appliances. Approximately 95% of households have a washing machine and 33% a dishwasher. It has been estimated by the UK water companies that household consumption could increase by a further 12% over the next 25 years unless action is taken to constrain demand, which could lead to demand out-stripping supply in some areas, where already two regions in England are recognised as “water-stressed”.

The UK Code for Sustainable Homes (CLG, 2008), which sets national standards for the sustainable construction of new homes, with homes being rated on a scale of one to six. In terms of water consumption, level one equates to an average consumption of 120 litres per day and level six 80 litres per day.

In relation to water heaters, various studies have been carried out into the water losses during draw down on the system until the water runs hot. However this is generally due to combinations of the length of supply pipe run and the level of insulation of the pipe work, i.e. the hot water system. The only really direct relationship exists with instantaneous shower units, where water savings could also result in further energy savings. Currently it would appear there are no upper flow limits in Europe, however in the US the maximum flow rate is 9.5 litres per minute.

#### *Health & Safety Criteria*

Fifty percent of the EU water heater market consists of various types of storage water heaters, i.e. appliances with a storage vessel where the sanitary hot water is stored at a continuous temperature.

This temperature is generally determined by national requirements and tends to be set at 60°C, which is determined by health reasons, to prevent Legionnaire's disease, and is substantially higher than that which would be required for functional use where 45°C would be more normal.

Research carried out by VHK as part of the Eco-design of Water Heaters (VHK, 2007) study concluded that "the recommendations by some public health authorities to store sanitary hot water continuously at a temperature of at least 60°C in all types of water heating installations may be, in view of the scientific evidence, too blunt."

VHK therefore proposes for:

- Hot water storage vessels - to follow a risk-based system
- Hot water piping - to follow / adhere to the legislation in some Member States (e.g. Sweden) and assume a minimum water temperature of 50°C at the tapping points, with a mandatory mixing valve in Germany where the maximum tapping temperature should not exceed 45°C.

## **2.5. Green Public Procurement**

The following sections review green public procurement initiatives in the four countries, highlighting whether and how water heaters are either directly or indirectly covered. This is followed by examples of some other incentives influencing the water heater market as well as Life Cycle Costs (LCC) analyses of boilers / water heaters.

### ***2.5.1. Austria***

The Austrian Act on Public Procurement (Bundesvergabegesetz, 2006), requires all procured services to be provided in an environmentally-friendly way. This is generally achieved through environmental clauses in the procurement documentation / specification, such as specified environmental criteria that have to be met. This may include the use of life cycle costing.

"Check it!" Guide, (Okoeinkauf, 2008), provides hands-on information on general and product specific aspects on integrated planning, energy balancing, and energy-efficient systems. In relation to heating for hot water, whilst not covering energy efficiency, it includes an outline of elements to be considered in any invitation to tender, such as fuel characteristics and hot water distribution systems.

However specific initiatives are generally taken at provincial government level. The longest established green public procurement initiative is that the provincial government of Vienna, the Oekokauf initiative (Oekokauf Wien, 2006), which includes public purchasing criteria for "hot-water boilers and tanks". This specifies minimum efficiency ratings for gas and oil-fired heaters as  $90 + 2 \times \text{Log}(\text{heating capacity in kW})$ .

### ***Denmark***

The concept of GPP has existed in Denmark since 1992, when the Environmental Protection Act (Ministry of Environment and Energy, 2006) required that "Public authorities must... in connection with procurement...endeavour to promote the objectives of this act". GPP then became a legal obligation for all government and state bodies in 2004 under the Environmental Protection Act 1994.

In relation to energy efficiency, government bodies are required to procure energy efficient products. This was supported by the establishment of a public procurement panel to provide environmental

guidance on a range of products, which has since been translated into a web-based procurement portal provided through SKI, created by the Ministry of Finance and the National Association of Local Authorities, to contribute to greater efficiency in public procurement through two web-based portals<sup>4</sup>. However currently this does not cover water heaters.

### **2.5.2. Germany**

In Germany, public procurement for construction projects is regulated by the “Official Contracting Terms for the Award of Construction Performance Contracts” (Vergabe- und Vertragsordnung für Bauleistungen (VOB)), which was amended in March 2006 (Vergabe- und Vertragsordnung für Bauleistungen, 2006) in order to comply with the EC (2004) . Equivalent regulations exist at the regional (Laender) level.

The environmental requirements of the VOB are very similar to those of the Austrian Act on Public Procurement, with one major difference that there is no general obligation to take environmental effects into consideration. However it does include options to incorporate specifications such as eco-labelling requirements (§9 (9)). The technical specification shall refer to European, national, multinational or other eco-labelling standards (§9 (9)), as far as they:

- Are based on scientific secured information, or
- Have been defined and agreed on in an open stakeholder process, and
- Are accessible to all potential tenderers.

Guidance is provided on a number of websites<sup>5</sup> on environmental criteria for products, however none of these yet contain specific guidelines for water heaters.

### **2.5.3. United Kingdom**

In the UK, the concept of GPP is now contained within the more wide-reaching framework of *sustainable procurement*. A national Sustainable Procurement Action Plan (HM Government 2007 was published in March 2007, which together with HM Treasury’s *Transforming Government Procurement* (HM Treasury, 2007) provides a new framework for sustainable procurement in the public sector. In addition to the overall sustainability objectives, these have been designed to help the UK to meet its obligations under the Energy End-Use and Energy Services Directive, with the public sector setting an exemplary role in energy efficiency.

A new Centre of Expertise in Sustainable Procurement has also been established within the Office of Government Commerce, which is responsible for providing cross-departmental support on all aspects of government procurement, to help deliver this by providing product-specific guidelines and information.

Public sector guidance on both the mandatory (for national, regional and local government bodies) and Best Practice sustainability criteria for a small range of products is currently also available on the government’s sustainable development website, “Buy Sustainable – Quick Wins” (DEFRA, 2008b), which includes water heaters and showers. This will be replaced in due course once the Centre of Expertise in Sustainable Procurement is properly established, which will cover a much more comprehensive range of products.

For water heaters, the 2008 mandatory criteria specified is an energy efficiency rating of 90%, equivalent to a SEDBUK rating of A. It is proposed that these criteria be regularly reviewed and

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<sup>4</sup> For example, [www.gronindkobsportal.dk](http://www.gronindkobsportal.dk)

<sup>5</sup> For example, [www.label-online.de](http://www.label-online.de)

updated regularly.

However, as noted in the section 2.4.2 above, the ‘systems approach’ which focuses on the energy performance of the whole building is increasingly becoming established as a major driving force in the public sector in the UK, with some authorities specifying higher standards than required by Building Regulations.

In relation to domestic dwellings, the main point of reference in this respect is the *Code for Sustainable Homes* (CLG, 2008), a voluntary standard introduced in 2007 to improve the sustainability of new homes, based on nine design criteria:

- Energy and CO2 Emissions
- Water
- Materials
- Surface Water Run-off
- Waste
- Pollution
- Health and Wellbeing
- Management
- Ecology

Like Building Regulations, the various Code ratings are based on a calculated estimate of the sustainability of a building. However, whereas Building Regulations specify the minimum mandatory levels, the Code specifies a series of stepped stages between now and 2020 towards a “zero carbon” home, all of which exceed minimum requirements of Building Regulations.

A Code for Sustainable Homes One Star rating equates to a 10% reduction in the building CO<sub>2</sub> emissions rate over the target emission rate, a Five Star rating equates to a 100% reduction and a Six Star rating equates to the zero carbon home, where over a year the net emissions from the home are zero. This is indicated in the table below.

<b>Date</b>	<b>2010</b>	<b>2013</b>	<b>2016</b>
Energy efficiency compared to Building Regulations part L	25%	44%	Zero Carbon
Equivalent Code for Sustainable Homes standard	Code level 3	Code level 4	Code level 6

For non-domestic buildings, the BREEAM (BREEAM, 2008a) rating system is normally used, which now has procedures covering multi-residential buildings, offices, retail, industrial, schools and courts. It also has a special section covering fit-out or refurbishment. The system is essentially a point-scoring one, which includes:

- BREEAM rating benchmarks
- BREEAM environmental weightings
- Minimum BREEAM standards
- BREEAM credits for Innovation

The ratings range from Pass, Good, Very Good, Excellent to Outstanding (introduced in 2008).

Regional and local authorities often specify a minimum requirement of BREEAM excellent for all of their construction projects, which in turn requires the designer to critically consider all of the sustainability aspects of the building to come up with score achieving that overall rating, whilst still achieving other cost, technical and fit-for-purpose criteria. Several examples are quoted in the 2008 BREEAM Awards report (BREEAM, 2008b), including Defra's new headquarters in Alnwick.

#### **2.5.4. Other Incentives & Barriers**

##### Incentives

Another form of incentive to encourage investment in energy efficiency improvements are grants and tax incentives. In Germany the Government KfW bank provides:

- €1 billion per annum in the form of reduced interest loans and small grants for residential buildings and schools for building renovation works
- €275 million tax relief against expenditure on improvements in the energy performance of buildings
- €120 million for a special modernisation programme for federal buildings.

The UK offers a tax relief scheme for business through the Enhanced Capital Allowance scheme, where businesses can claim 100% tax relief in the first year against capital expenditure on energy efficiency measures incurred within that year. Grants towards energy efficiency measures such as loft and cavity wall insulation are provided for the domestic market through the Energy Savings Trust.

In addition to the above, a further initiative in the UK that is likely to have a significant influence on the market for energy efficient products is the new emissions trading scheme, introduced in the Energy White Paper (DTI, 2007), the Carbon Reduction Commitment (CRC) (See DEFRA, 2008c). The CRC aims to cost-effectively deliver carbon emission reductions and cost savings in the service sector, public sector and other less energy-intensive industries, with the objective of reducing carbon emissions in large non-energy intensive organisations by 1.2 million tonnes of carbon per year by 2020.

Starting in April 2010, the CRC will be a mandatory emissions trading scheme targeting emissions currently not included in the EU ETS or Climate Change Agreements, such as supermarket chains, hotel chains, office-based corporations, government departments, including hospitals and local authorities. In its current proposed format, it will cover all organisations whose electricity consumption through half hourly meters is greater than 6,000MWh/yr – equivalent to an annual electricity bill of ~£500k. All energy other than transport fuels will be covered, such as electricity, gas, fuel and oil.

##### Barriers

In terms of barriers or hindrances, a study commissioned in 2006 by ANEC and Defra's Market Transformation Programme found that the energy labelling is given a relatively low priority in many Member States, with irregular and / or insufficient budgets allocated for testing and little in the way of enforcement action (ANEC, 2006). It noted that whilst impressive gains had been made in market transformation in the early 1990's, in the absence of any review or revision since then, the scheme appeared to have lost momentum.

It also noted that in some countries where the labelling scheme is controlled by the local authorities operating independent of each other, considerable gains might be achieved through better coordination and information sharing.

There is often a general perception that "green" products are more costly than conventional ones. However a study carried out for DG Environment by Oko-Institut e.V and ICLEI (2007) established some evidence, albeit inconclusive, that green products are neither more or less expensive than non-green products, though this masks significant variation within product groups. If the purchase costs are slightly higher, this is often outweighed by energy savings when in use. This aspect was included in an

assessment of water heaters by VHK into the life cycle costs of eco-friendly water heaters, where it was found that energy use could fall by significantly by switching from a commonly purchased heater to the lowest-life-cycle cost target design.

Further analysis of the findings indicated that the cost and energy savings tend to increase with the larger water heaters, which may be the type more commonly purchased by public authorities. It also clearly shows that both cost and energy savings can be significant and that increased levels of GPP in relation to water heaters can be highly cost effective when viewed over the life-time use of the product. Further details of the findings can be found in Table 4-1 in Appendix C..

A Cost Benefit Analysis (CBA) has also been carried out of the proposed introduction of mandatory performance criteria for gas water heaters in Australia and New Zealand (Syneca Consulting 2007) which aims to reduce growth in energy-related emissions from the use of this product from 15.7% to 12.2% between 2009 and 2020. This showed that benefits of the new proposed MEPs in terms of energy cost savings exceed the difference in purchase price by more than 150%. This provides additional support for the VHK findings.

## 2.6 Summary & Conclusions

- National labelling schemes in three of the four Member States studied already specify minimum energy efficiency standards for water heaters.
- In terms of best practice, where the US has been identified as setting the most stringent current standards, Europe would appear to be adopting a similar approach, in relation to the energy efficiency metrics proposed, based on demand in the form of a 24-hour tapping cycle, as set out in mandate M324.
- A new risk assessment in relation to Legionella bacteria may be well worth investigating, if it enables a relaxation of the current minimum water storage temperature of 60<sup>o</sup>, which is currently applicable in most Member States.
- Other criteria of importance in terms of greenhouse gas emissions include carbon monoxide, nitrous oxide and nitrogen dioxide emissions, which are already covered in national labelling schemes in three of the four Member States considered.
- Consideration could be given to widening the scope to cover the water heating system as a whole and include energy related criteria for the system as a whole. This could perhaps best be achieved through the implementation of the Energy Performance of Buildings Directive.
- Improvements through labelling need to be supported by regular review of progress and the standards set in terms of their relevance and advances in technology, with better sharing of good practice.
- In addition to labelling, the “system based” approach of the Energy Performance of Buildings Directive is perhaps a more effective way of encouraging the adoption of energy efficiency measures in building and construction projects, although this still needs a considerable level of resources to monitor the construction and to ensure that what is built actually reflects what is specified in the design / building approval documentation.
- In terms of green public procurement, various support services are available giving advice on the energy efficiencies of different products, but to date it would appear that only the UK, “Buy Sustainable – Quick Wins” website specifies mandatory energy efficiency ratings for water heaters.
- Legislation on labelling and GPP on their own may not be sufficient to achieve the level of

market penetration required and additional incentives, such as tax incentives can make a significant difference to the speed of take-up.

## 3. Windows

### 3.1. Product scope

For the purpose of this study, this product group covers fixed and opening windows and fully glazed windows / French doors, including both the glazing and the frames.

Although windows do not consume energy directly, they contribute to the energy demand of a building as a result of heat transfer and solar gains through the window. This can be through the glazing unit itself or the frame may also play a significant role, depending on the material used, e.g. plastic and wood having better thermal properties than metal, because of its higher conductivity.

The glazing unit may consist of one of the following types of glass, with double or triple glazing often used to improve the thermal and / or acoustic properties:

- Clear soda lime silica window glass
- Tinted flat glass
- Flat glass with highly transparent thermal insulating coatings (e.g. ClimaGuard, K glass etc)
- Laminated glass
- Fire resistant laminates (e.g. Pyrodur, Pyrostop etc)

The principal framing materials are wood, plastic and metals, such as aluminium. There are also composite frames, where for example, the wood frame is strengthened with aluminium. Plastic and metals may also be used for fitting and sealing the glazing unit in place, together with putty, glue and other sealants. Finally various finishes such as paint and preservatives can be used to form a protective coating to the frame.

In a study from the UK, “Life Cycle Analysis of Window Materials - A Comparative Analysis,” (Asif et al, 2002) an embodied energy analysis of standard windows concluded that aluminium windows used the most embodied energy – about twice as high as PVC frames - while PVC required about three times as much embodied energy as wood. The study also noted that whereas the optimum life span for a PVC window is generally around 25 years, the life span for aluminium and wood windows can exceed 40 years.

Based on a 1993 preliminary air and water emissions study by the Western Woods Products Association, which indicated that significantly less pollution is generated during the manufacture of wood frames compared to aluminium or PVC ones the UK study concluded that:

- Aluminium frames cause the highest environmental impact in terms of waste emissions and energy use during production;
- In terms of life cycle impact, significant waste arising is associated with PVC frames, with wood frames having the lowest impact.

The scope of the study therefore considers both the energy-related and non-energy-related performance criteria associated with other life cycle impacts.

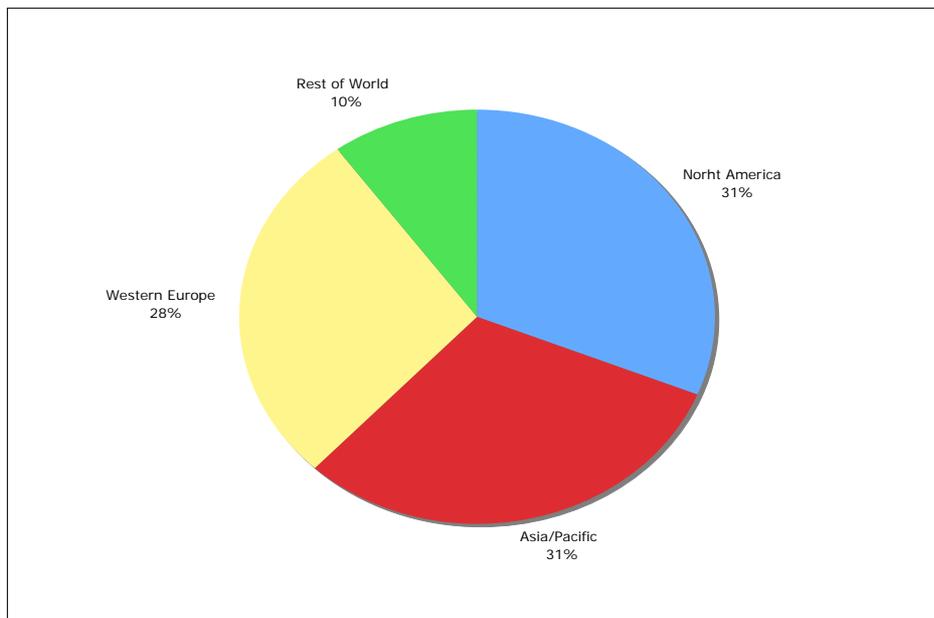
## 3.2. The Market – Supply and demand

### 3.2.1. The Global Market

According to a study by Freedonia Industry Research, global demand in 2006 for fenestration (windows, doors, skylights, etc) was EUR 94 billion per annum and is projected to rise by 5 % per year, reaching EUR 120 billion in the year 2011 (Freedonia Industry Research, 2007), with rising per capita income and ongoing industrialization in developing countries expected to expand. The strongest growth is anticipated in China, India, Mexico and Russia, as well as in lower-volume markets, such as Malaysia, Indonesia, Ukraine, Iran and Turkey. In contrast, growth in the industrialized countries is expected to be lower and will consist mainly of repair / replacement and the renovation market. Figure 3.1 below gives a breakdown of the global market in 2006.

Non-residential building demand is expected to expand at a faster pace than residential sales, benefiting from a step-up in non-residential construction activity in Western Europe, Brazil, Canada and South Korea.

Figure 3-1: Global Market Demand for Windows and Doors (2006)



Source: Freedonia Industry Research (2007).

In some areas it is anticipated that sales of plastic windows will grow at above-average rates up to 2011 due to their lower costs and low maintenance requirements, e.g. the overall window demand in China is expected to grow by 43 % from 1998 to 2010, while the share of PVC windows is expected to expand six-fold. However, wood and metal products are likely to continue to account for a large share of window and door market in many areas, including Europe.

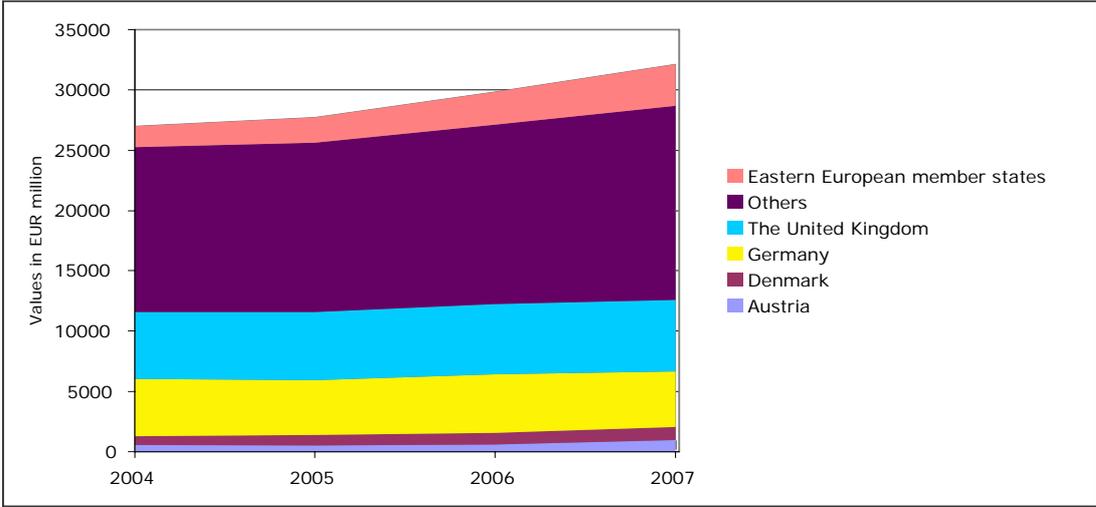
### 3.2.2. EU Production

Within the EU 25 the window/door industry sector comprises 50 510 manufacturers. Of these only 10 are multi-nationals and 500 are medium or large of size, with 50 000 manufacturers being micro or small enterprises (Postler et al, 2007). The domination of micro and small manufacturers characterizes the European window market as a local market.

Around 6 % of the sales are intra EU exports, with exports out of the EU accounting for 2 % and the imports into the EU for 1 % of the production volume.

Between 2004 and 2007 the EU 25 value of window production increased by 5 % per annum on average, reaching EUR 32.1 billion (adapted from Postler et al) by 2007, with the eastern European countries experiencing accelerated growth, nearly doubling the production value between 2004 and 2007. Significant growth rates over this period were also achieved in Austria (78 %) and Denmark (48 %), whereas the growth rate in the United Kingdom was only 7 % and Germany saw a decline in demand of -3 %. The average growth rate in the other member states was 18 %.

Figure 3-2: EU 25 window/door production value 2004-2007



Source: Eurostat PRODCOM 2004-2007.

**3.2.3. EU Consumption**

The information in the PRODCOM database has a high level of uncertainty due to gaps in the data and some potential under reporting and has therefore not been used to assess the consumption of windows in Europe. However the above analysis of production within the EU 25 does enable an estimate to be made of the home consumption, at around EUR 31.7 billion (adapted from Postler et al, 2007) in 2007. The following data are deduced from other sources and should be interpreted with some caution.

According to a study by the InterConnection Consulting Group (IC, 2008), 76 million window units<sup>6</sup> were sold in 2005 in the European Fenestration Market, with a corresponding growth rate of +0.6 %. Looking at the market segmentation, the residential sector accounted for 65.3 % of sales and was the key factor for market growth. Norway, Sweden, and Finland grew by 6.5 %, 7.9 % and 5.4 % by volume respectively. French and Spanish markets increased by more than 4 % in 2005. The second largest market in the EU, namely Germany, decreased by 6.6% in 2005.

One of the main driving forces in the Western European window market is the building renovation market, which accounted for more than half of the market (54.6 %) in 2005, due to a combination of stricter building regulations and rising energy costs, resulting in an increased rate of window replacement with units with higher thermal performance.

The penetration of double-glazing is high in all countries except for the Mediterranean countries, with

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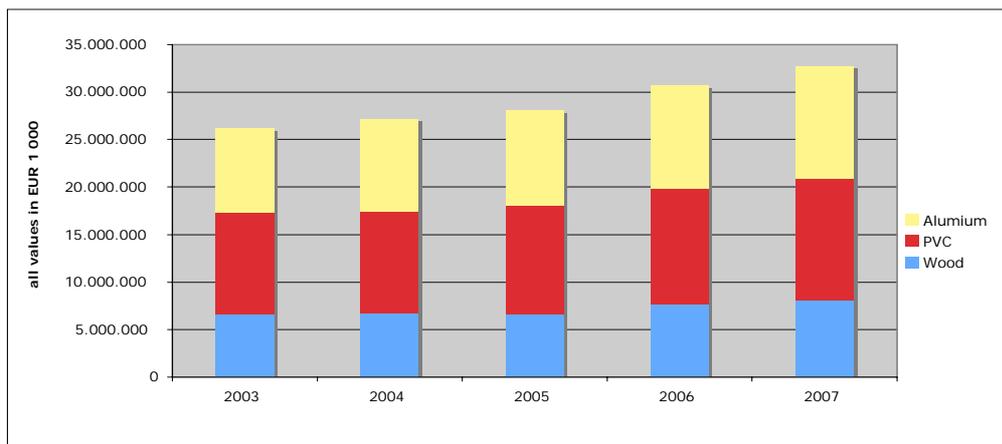
<sup>6</sup> Window unit = 1,69 sqm

triple glazing restricted mainly to Finland and Sweden. According to the ERABUILD study in:

- Austria - 90% of the glazing in dwellings is double glass and 5% is triple glass, mainly in modern low energy or passive houses. Single glazing is almost non-existent;
- The United Kingdom - 71% of dwellings are fitted with double-glazing, and the remaining 29% having single glazing in the main.

In relation to framing materials, the chart below indicated the relative split between the different types of framing materials between 2004 and 2007 across the EU 25.

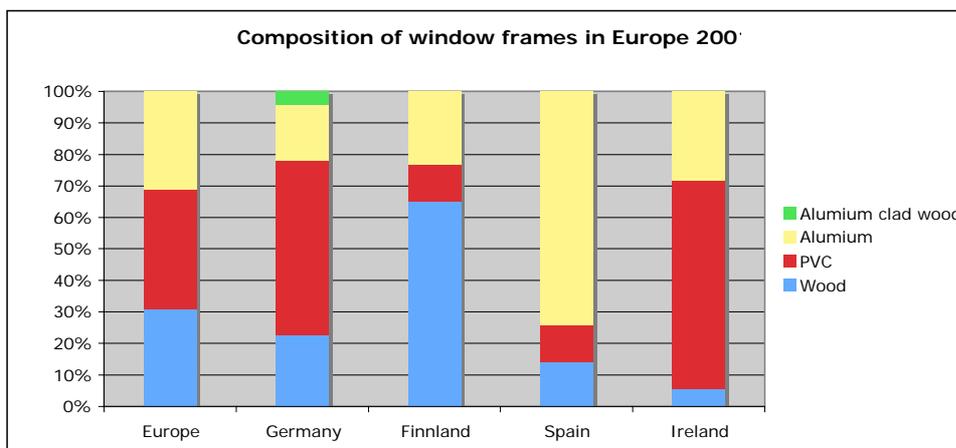
Figure 3-3: EU 25 window/door market by materials



Source: Eurostat PRODCOM 2004-2007.

When analysed on a country-specific basis, this shows even greater variations, as can be seen from the chart below, with wood windows being predominant in the Balkan States, Scandinavia and the Central European member states, PVC dominating the German and UK markets, and aluminium being the material of choice in Italy and Spain. This perhaps reflects different levels of interest in thermal performance related to the warmer climates.

Figure 3-4: Country specific window/door market by materials



Source: Herbert, 2001.

### 3.3. European Performance Criteria

As with water heaters, performance of windows is controlled / influenced to varying degrees by existing policies, directives and regulations, based on a number of different approaches, including:

- Eco-labelling & energy performance related labelling (a **product-based** approach)
- Energy performance of buildings (a **systems-based** approach)

These mainly focus on the energy-related aspects of heat loss and solar gains through both the glazing unit and frame.

#### 3.3.1. Eco & Energy Performance Labelling

The Eco-label Regulation EC (2000) does not cover windows directly, but defines the scope and parameters to be met in the award of any eco-label, accredited by testing under the appropriate EN European norm or standard including building components. The thermal performance of building components is assessed in terms of the overall transmission heat loss coefficient and calculated using EN ISO 13789. A full list of the EN European norm for testing and assessment of U-values can be found in Appendix D.

The Eco-Design for Energy-Using Products (EuP) Directive (EC, 2005) currently only applies to energy-using products. However recent proposals in the SCP Action Plan include a possible extension of the scope of this directive to cover:

- Energy related products (with the exception of transport vehicles, which are subject to separate policies and legislation)
- Minimum requirements to be set for products with significant environmental impacts .

The Energy Labelling Directive currently covers only energy-using products and therefore does not cover windows. However the European Commission recently held a consultation on possible changes, including extending the scope to cover:

- Non-energy using products, such as window frames, whose insulation properties influence the energy demand of a building, and water-using appliances, whose water consumption influences the energy required for heating;
- Non-domestic appliances / products (industrial & commercial)

These proposals received support from the vast majority of stakeholders represented.

#### 3.3.2. Energy Performance of Buildings

Windows are covered by the Construction Products Directive (89/106/EEC) and have to be CE marked to prove compliance with the essential requirements of the Directive. The directive addresses the energy efficiency and heat retention of buildings, where *“the construction works and its heating, cooling and ventilation installations must be designed and built in such a way that the amount of energy required in use shall be low, having regard to the climatic conditions of the location and the occupants.”*

However the energy-related performance of windows is increasingly being influenced by the Energy Performance of Buildings Directive (EC, 2002), the first of a range of measures designed to increase

the energy performance of public, commercial and private buildings across the EU. Although not actually specified at present, it is understood that the Directive may be extended to include minimum performance requirements (defined in kWh/m<sup>2</sup>) for building components such as windows. The European Commission also proposes to expand the scope of the Directive to include the large stock of smaller buildings currently not covered, by abolishing the current minimum threshold of 1000 m<sup>2</sup>.

For new buildings, within the revision of the "Energy performance of buildings" Directive the Commission also proposes a strategy for very low energy or passive houses, to be developed in dialogue with Member States and key stakeholders, towards more wide-spread deployment of these houses by 2015.

In terms of effect on the market, the average U-value of windows in the European building stock has shown a significant change over the past thirty years or so, largely as a result of the above. For example windows in pre-1990 dwellings have an average value of 3.5 W/m<sup>2</sup>K (Petersdorff et al, 2005), with the exception of replacement windows where it drops to 2 W/m<sup>2</sup>K and increased insulation was often a primary reason for the replacement.

However since 2003 the specified minimum U-value has progressively dropped to 1.64 W/m<sup>2</sup>K, as highlighted in the table below, for both new-build and renovated buildings. The main driving force for this latter change has been the Energy Performance of Buildings Directive.

Table 3-1: Insulation in European building stock

U-value [W/m <sup>2</sup> K]	Build before 1975 Not retrofitted	Build before 1975 Already retrofitted	Build from 1975-1990	Build from 1991-2002	2003-2006 Newly built & retrofit	>2006 Newly built & retrofit
Windows	3.5	2.0	3.5	2.0	1.84	1.68

Source: Petersdorff et al, 2005

### 3.4. Member State & Non-European Performance Criteria

#### 3.4.1. Eco & Energy Labelling

##### Austria

Austrian standards for the performance of windows are established by the Austrian Standards Institute (ON, under the Austrian Federal Act on Standardization of 1971. These are listed in Table 3.2 in Appendix D. Besides those standards relating to methods of testing, construction, maintenance, fire-resistance and other safety aspects, a number of standards specifically refer to the thermal properties of the glazing and frame components, with specified U-values required listed in the table below.

Table 3-2: Insulation requirements for windows

Component	U-value (W/m <sup>2</sup> K)
Windows, French windows, doors with or without glazing, other vertical transparent components towards unheated parts of the building	2,50
Windows, French windows in residential buildings towards surrounding air	1,40
Other windows, French windows, doors with or without glazing, other vertical transparent components towards surrounding air	1,70
Skylight towards surrounding air	1,70

Source: OIB-Richtlinie 6, „Energieeinsparung und Wärmeschutz“, 2007

The Austrian eco-label (Oesterreichisches Umweltzeichen) is assigned by the Federal Ministry for Agriculture, Forestry, Environment and Water Management, however currently there are no eco-labels that directly refer to the energy performance of windows, covering only other environmental criteria.

More details of this are given in section 3.4.3 below.

#### Denmark

Danish Window Certification (DVC) is an independent control body under Danish Technological Institute, which provides a certification system for products manufactured by its members, satisfying certain quality and design requirements. These consist of three main elements:

1. *Energy performance criteria* for façade windows, in line with those specified in the Danish building code set standards;
2. A *voluntary energy labelling scheme* proposed by the Danish trade organisation, which will categorise products into a scale from A to C. The companies and products will be subject to regular checks and companies will be required to state the energy properties of their products.
3. The *phasing-out of traditional sealed units and promotion of energy-efficient windows*, as a result of an agreement between the Energy Authority, glass industry, glaziers' trade organisation and Vinduesproducenternes Samarbejds Organisation (VSO) (window manufacturer's cooperation organisation). As a result, energy-efficient sealed units have become standard products and a campaign to promote their sales and those of other energy-efficient window solutions has been launched.

Windows are also covered by the Nordic Swan Eco-labelling scheme, the prime objective of which is to stimulate the use of energy-efficient products manufactured with minimal environmental impact. The criteria are designed for the eco-labelling of fixed and opening windows and window-doors, and exterior doors forming the boundary between free and heated areas.

For a window to be granted the Swan eco-label, the U-value must be 1.3 W/m<sup>2</sup>K or lower, for a 12 x 12 M window. The solar energy transmittance of the glass must be at least 52±2%, to enable the incoming solar energy to contribute to the heating of the building. For the window not to be considered as daylight shielding, a minimum of 63±2% daylight transmittance is stipulated.

#### Germany

The Blue Angel is the German eco-label scheme, awarded by the RAL German Institute for Quality Assurance and Labelling. However no eco-label guidelines have as yet been issued, relating to the energy performance of windows.

#### United Kingdom

The British Fenestration Rating Council BFRC was originally established in 1999 with assistance from the Government and the major fenestration Trade Associations as part of a research project to develop a Window Energy Rating scheme for the UK. BFRC Ltd was established in 2006, to take over and further develop the activities of the original BFRC. BFRC Ltd. is part of the Glass and Glazing Federation (the largest trade association for the glazing and fenestration sector in the UK).

The window energy rating is the objective method used to assess the total energy performance of a window; it takes into account the materials used (glass, framing materials etc), the air leakage and the solar gain to determine the rating which expresses the energy efficiency of the product.

The determined value will place the window design into a rated band (A to G). The rating compares standard size windows; this provides a simple method of comparing different products from either the same supplier or from different suppliers. The BFRC window energy scheme is applicable to the UK only due to the constants within the formulae which are based on average UK climate conditions.

Table 3-3: Energy ratings under the BRFC scheme

Energy Rating	kWh/m <sup>2</sup> /year
A	0+
B	-10 to 0
C	-20 to -10
D	-30 to -20
E	-50 to -30
F	-70 to -50
G	-70+

Source: BFRC

### *Finland*

In 2005, a labelling for energy-efficient windows has been piloted in Finland by Motiva, the Technical Research Centre of Finland (VTT) and the Finnish window-manufacturing industry to establish a rating system on the window market, which covered 160 different windows from 8 Finnish manufacturers, representing a major share of the brands on the Finnish market.

The rating is based on tests carried out by VTT on heat transmission, solar radiation transmission and air tightness, following the respective standard testing procedures. Based on the findings from this pilot, consideration is now being given to commercial application in the country.

### *Non-European Energy Countries*

In the USA, the National Fenestration Rating Council (NFRC) operate a national labelling and rating program under the Energy Policy Act of 1992, which in 2005, introduced a new energy performance label. The energy performance values / rating on the label relates to the window/door as a complete systems (i.e. glazing and frame).

Building codes in Idaho, Alaska, and Minnesota have now adopted NFRC values, and a dozen other states are considering them or are in the final stages of adoption. Several states (e.g. California, Washington, and Oregon) in their procurement procedures also specify windows rated under the NFRC scheme. By using the information contained on the label, builders and consumers can reliably compare one product with another, and make informed decisions about the windows, doors, and skylights they buy.

## **3.5.1 Energy Performance of Buildings**

### *Austria*

As identified in Section 2 above, the implementation of the Energy Performance of Buildings Directive is mainly in the responsibility of the Bundesländer (building codes and inspection of heating, aeration and cooling systems) and the Ministry of Economy and Labour (selling and renting of buildings).

Building codes are regulated by building codes on a Länder (regional) level and include criteria requiring construction materials and building components to comply with the standards defined by the Austrian Standards Institute (ON) and referred to above. For non-residential buildings, the Health and Safety at Work Acts (Arbeitsstättenverordnung – AstV) of the Länder defines general requirements for windows in relation to safety and light transmission .

### *Denmark*

Denmark has a long tradition of using building regulations / codes to achieve policy targets. Since the early 1980's, the Danish Buildings Regulations have progressively set more stringent targets than industry, including the energy efficiency aspects, which came into force on 1 January 2006 with the implementation of the Energy Performance of Buildings Directive.

This now requires applicants for a new building permit to document that it complies with the energy regulations, using a prescribed calculation methodology. Moreover the new energy labelling scheme introduced at the same time also requires all new buildings to obtain an energy label before they get a

use

permit.

Regarding the performance of windows, since 1998 any replacement window, (when a building permit is required) should have a U value below 1.8 W/m<sup>2</sup>K and since January 2006, windows for new buildings must have a U-value below 1.5 W/m<sup>2</sup>K.

### Germany

German public building law consists of the Land-use and Zoning Law (Bauplanungsrecht) and the Building Regulation Law (Bauordnungsrecht/Bauaufsichtsrecht).

As in Austria, building regulations are regulated on a Laender (regional) level and primarily cover the health and safety aspects of the construction activities. These laws are generally product-oriented rather than spatial. They require construction products (e.g. windows) to conform with either European technical approvals (ETA) for construction products or national technical approvals (Allgemeine bauaufsichtliche Zulassungen (abZ), stipulated by the Construction Products Act (Bauproduktgesetz (BauPG) 31.10.2006 I 2407), which implements of the Construction Products Directive.

Standards under to the Construction Products Act are issued by the German Institute for Standardization (Deutsches Institut fuer Normung e.V., DIN). Currently there are 54 DIN standards, which apply to windows, including certification under the German Mark of Conformity. In relation to energy performance, this requires windows to comply with the criteria for insulation and energy saving in buildings (DIN 4108, 2003) and the classification for the air-tightness of windows and doors (DIN EN 12207, 2000).

The minimum requirements for windows are stipulated by the German Regulation for Energy Saving in buildings and building systems (EnEV, 2007), which implements Directives 2002/91/EC, 92/42/EEC and 2005/32/EC. This specifies a maximum thermal transmission coefficient for different types of external windows and replacement glazing panes as indicated in Table 3.4 below.

Table 3-4: Upper limit value of the thermal transmission coefficient for New-build, renovation or replacement windows and glazing (EnEV 2007)

Construction product	Activity	Residential buildings and zones of non-residential buildings with an inside temperature of $\geq 19\text{ }^{\circ}\text{C}$	Zones of non-residential buildings with an inside temperature 12 to $< 19\text{ }^{\circ}\text{C}$
		Maximum thermal transmission coefficient - $U_{\text{max}}$	
External windows, skylights , roof lights and French doors	New build in, replacement, refurbishment	1,70 W/m <sup>2</sup> K	2,80 W/m <sup>2</sup> K
Glazing	Replacement	1,50 W/m <sup>2</sup> K	No requirements

These figures will be further reduced in 2009, through an amendment to the Regulation, as indicated in Table 3-5 below.

Table 3-5: Upper limit value of the thermal transmission coefficient for new-build, renovation or replacement windows and glazing (EnEV 2009)

Construction product	Activity	Residential buildings and zones of non-residential buildings with an inside temperature of $\geq 19\text{ }^{\circ}\text{C}$	Zones of non-residential buildings with an inside temperature $12\text{ to } < 19\text{ }^{\circ}\text{C}$
		Maximum thermal transmission coefficient - $U_{\max}$	
External windows, roof lights and French doors	New build in, replacement, refurbishment	1,30 $\text{W}/\text{m}^2\text{ K}$	1,90 $\text{W}/\text{m}^2\text{ K}$
Skylights	New build in, replacement, refurbishment	1,40 $\text{W}/\text{m}^2\text{ K}$	1,90 $\text{W}/\text{m}^2\text{ K}$
Glazing	Replacement	1,10 $\text{W}/\text{m}^2\text{ K}$	No requirements

### United Kingdom

As identified in Section 3.2 above, the requirements of Energy Performance of Buildings Directive covered in the national legislation in the Sustainable & Secure Buildings Act (HM Government, 2004) and have been enacted into UK law in relation to:

- New & Existing Buildings, through Part L of Building Regulations (ODPM, 2006)
- Certification of Buildings, through the Energy Performance of Buildings Regulations 2008, which requires Energy Performance certificates for all buildings that are being sold or rented out.

Part F of the Building Regulations covers specific ventilation requirements applicable to windows, whereas Part L stipulates that maximum U-values for different types of windows and doors. Measurements of thermal transmittance must be made according to BS EN ISO 12567-1 or alternatively, U-values may be calculated using BS EN ISO 10077-1 or BS EN ISO 10077-2. The U-value calculated must be for the whole window opening, including the frame.

Since 2002 the minimum energy efficiency requirements for wood and PVC framed windows have been a U-value of  $2.0\text{ W}/\text{m}^2\text{K}$ , and a U-value of  $2.2\text{ W}/\text{m}^2\text{K}$  for aluminium frames. The area-weighted average U-value specifies for windows, roof windows, skylights and doors  $2.2\text{ W}/\text{m}^2\text{K}$ , with a limiting U-value of  $3.3\text{ W}/\text{m}^2\text{K}$ . The BFRC Window Energy Rating scheme (BFRC, 2007) can also be used to demonstrate compliance with the thermal performance requirements for windows, as an alternative to U-values.

### **3.5.2 Other Performance Criteria**

The primary issues considered in this section relate to the:

- Ability to recycle the waste products at the end of their life
- Pollution potential of surface coatings and preservatives
- Use of sustainable sources of natural material for framing

The Austrian eco-label provides some environmental guidelines on “wood and wood materials”

(Lazslo, 2007) which can be of relevance for wooden window frames, in that:

- At least 70 % of the wood must come from sustainably managed forest, certified by PEFC-, FSC- or other certification systems according to the European Forestry Strategy (EC Communication, 2005)
- Varnishes should not contain more than 10 % volatile organic compounds, exceeding this value only if the varnishes are produced by extraction or distillation from forestry or agricultural products;
- Varnishes must not contain halogenated organic compounds, antimony, arsenic or boron, as well as bio-acidic compounds beyond those required for surface conservation; maximum concentrations are limited to 0 % for aromatic organic compounds, 50 ppm for heavy metals (including lead, cadmium, chromium (VI)), 0.1 % for cobalt and 0.5 % for manganese;
- Total emission rates for volatile organic compounds and specifically formaldehyde, phenols and Diphenyl-4,4-diisocyanate must not exceed a specified value;
- Imported products are manufactured using the best available technology, as per the EU standards for cleaner production.

Guidance applicable to wood-framed windows is also provided on chemical compounds and their concentration in “varnish, glazes and wood-sealing varnish”.

In Denmark, ecological definitions and measuring rules of timber materials are included within the DVC system, which dictates that the entire surface of the windows unit - the area shaded in grey - must have a share of 90 % heartwood. The units should be made from pinewood, should not be vacuum impregnated, should use surface treatment which meets the performance requirements of the international standard DS/EN 927-1.

Nordic Swan also stipulates other environmental requirements on chemicals, wood preservatives, sorting waste at source, and additives in plastics. The requirements also apply to subcontractors of insulating glass units, frames and casements. The most important environmental criteria are the following:

- Halogenated plastics are not permitted. Plastic materials must not contain additives of lead, cadmium, chloro-brominated paraffin's, organic tin compounds, phthalates or polybrominated diphenyl ethers.
- Plastic casement and frame parts heavier than 50 g must be visibly labelled for recycling in accordance with ISO 11469. This requirement applies also to glazing beads and glazing blocks that constitute less than 3% by weight of the total weight of the window.
- Greenhouse gases with a Global Warming Potential (GWP) > 5 over a period of 100 years, may not be used as a filler gas in double / triple glazing units. Inert gases (e.g. argon, krypton) must have a GWP <5.
- Exterior doors must not contain chemical products classified as carcinogenic, toxic to reproduction, causing inheritable damage, toxic or sensitising by inhalation in accordance with regulations regarding the classification and labelling of hazardous chemicals in force in any Nordic country and/or EU classification system 1999/45/EC (with amendments).
- Chemical products (paint, adhesive, sealants, putty, etc.) in the finished window or exterior

door must satisfy one of the following two requirements:

- The product may not be classified as environmentally hazardous according (EC, 1999)
- The product may contain a maximum of 2% by weight of substances classified as environmentally hazardous (EC, 1967) or according to prevailing regulations in each Nordic country.
- The licensee must ensure that wood raw materials do not originate from forest environments meriting protection due to their high biological and/or social value. Nordic Ecolabelling may revoke a licence if it is found that wood raw materials are derived from forest environments of this type.
- At least 70% on an annual basis of the solid wood (wood board are not subject to the requirement) must come from certified sustainable forest. Certification must be administered by a third party.

In the UK the BREEAM assessment requires 80% of materials to be responsibly sourced, including the use of recycled materials and BRE's Green guide provided guidance on the use of recycled products.

## **3.6 Green Public Procurement**

### **3.6.1 Austria**

The Austrian act on public procurement (Bundesvergabegesetz, 2006) introduced a legal requirement in public tendering procedures for environmental criteria to be considered on a par with others such as quality, price, cost-effectiveness, running costs, etc. As identified in Section 2 above, this is generally achieved through clauses in the procurement documentation, e.g. technical specification and / or specified environmental criteria. This may include life cycle costing.

The terms of reference should include specifications for the use of environmentally sound products or techniques, if applicable and feasible, by reference to the appropriate European, national, multinational or other eco-labelling standards:

- Based on scientific secured information, or
- Defined and agreed on in an open stakeholder process, and
- Accessible for all potential tenderers.

Specifications on how to conduct procurement procedures are contained in the "Procurement of works, services and supplies - Notices, tenders and award of contract - Procedural standard", the "Guidelines for green public procurement" (IFZ, 2001a). These guidelines include eleven so-called "Check-It" modules, one of which refers to building and construction products (IFZ, 2001b). This specifies that a building should, over its complete life-cycle, meet the following criteria:

- Reduction of energy demand and of operating/maintenance resources;
- Avoidance of transport for construction materials and building components;
- Use of reusable and recyclable materials and components;
- Use of highly durable materials and components;

- Safe recirculation of materials into the natural cycle of materials;
- Protection of natural spaces and space-saving construction.

With special reference to windows the most important criteria for window selection are:

- Environmentally-acceptable frame material
- High insulation levels for the glazing and frames
- No thermal bridges
- Air-tightness
- High levels of light transmission through the glazing.

The guidelines specify as a benchmark, U-values of:

- 1,1 W/m<sup>2</sup>K for double glazing windows (as long as the U-value of the complete window construction does not exceed 1,3 W/m<sup>2</sup>K)
- 0.7 W/m<sup>2</sup>K for triple glazing windows.

In relation to the framing material, according to an analysis of different eco-balances, wood best fits most of the criteria, with wood-aluminium being superior to an aluminium or PVC.

### **3.6.2 Denmark**

Denmark modified legislation in 1995 to incorporate environmental criteria into all public procurement activities (applicable to all levels of government) through the Environmental Protection Act 1994. This requires environmental criteria to be considered on an 'equal footing' with price, quality, etc., similar to Austria. However it is not currently specified how this should be achieved in practice. The mandated preference for eco-labelled products and the restriction of potential suppliers to those with an Environmental Management System is also a general characteristic of green public procurement in Denmark.

Circular 1995 obliges central government institutions to formulate a green procurement policy and to include environmental considerations in the procurement process, including a requirement to purchase energy efficient products. However the currently available product-specific guidelines do not cover windows at present, although they do require eco-labelled products to be given preference.

### **3.5.3 Germany**

In Germany public procurement procedures are regulated by the "official contracting terms for the award of construction performance contracts" (Vergabe- und Vertragsordnung für Bauleistungen (VOB)), which were amended in March 2006. Equivalent regulations also exist at a Laender (regional) level.

These amendments introducing environmental requirements in public tenders to the VOB are virtually

identical to the Austrian public procurement regulations, but unlike in Austria, there is no general provision to take environmental effects into consideration. However but it creates an opportunity to incorporated technical specifications such as eco-labels.

In relation to windows and doors, although the 54 DIN standards (see section 3.3.2 above) are referred to in Part C of the “Official Contracting Terms for the Award of Construction Performance Contracts” (Vergabe- und Vertragsordnung für Bauleistungen (VOB)), which regulate public procurement in Germany, there are no specific guidelines for windows.

However at a municipal level, a growing number of cities have adopted ecological procurement guidelines, including a so-called “grey lists” of materials, that should not be used. Of relevance to window frames, the grey list includes PVC and tropical timber.

### **3.3.1 United Kingdom**

As identified in Section 2 above, the national *Sustainable Procurement Action Plan* (HM Government 2007) and HM Treasury’s *Transforming Government Procurement* (HM Treasury, 2007) provides the framework for sustainable procurement in the public sector in the UK.

Currently, public sector guidance on both mandatory and Best Practice sustainability criteria for a small range of products is available on the government’s sustainable development website, “Buy Sustainable – Quick Wins.” This work will be taken over in due course by the Centre of Expertise in Sustainable Procurement once it is established.

For windows, the 2008 specified mandatory criteria is an energy rating of C or better based on the BFRC window rating scheme, with best practice ratings equivalent to a BFRC rating of B or better. In both cases it also specifies the over-riding criteria of purchasing energy efficient glazing to reduce the amount of energy consumed throughout the life cycle of the window. These criteria will be regularly reviewed and updated regularly.

As noted in the section 2.4.2 above, the “system based” approach in relation to the energy performance of the whole building is increasingly becoming established as a major driving force in the public sector in the UK, with many authorities specifying higher standards than required by Building Regulations. This is normally related to the:

- *Code for Sustainable Homes* (CLG, 2008a), a voluntary standard introduced in 2007 to improve the sustainability of new homes, for new residential buildings and;
- *Building Research Establishment Environmental Assessment Method* (BREEAM) (BRE 2008a), for non-residential buildings, including multi-residential, offices, retail, industrial, schools and courts. It also has a special section covering building fit-out and renovation.

BREEAM Green Guide provides guidance on products and their energy ratings in relation to limiting solar gain / glare and providing adequate natural light and views. There are also sections requiring 80% of materials to be responsibly sourced.

The application of these criteria and guidelines is particularly noticeable at a regional level, where virtually all of the Regional Development Agencies (RDA) are specifying Code Level 3 from the Code for Sustainable Homes and BREEAM Excellent within the contract requirements for construction and development contracts where the RDA is the client.

### **3.5.5 Other Incentives & Barriers**

### Austria

The “Residential-Building-Sponsorship (Wohnbauförderung)” grant scheme is proving to be a key driver in promoting the adoption of energy efficient building practise in Austria. This is awarded at a regional or Länder level and relates the award of a grant to specified energy efficiency criteria.

For example, in the province Carinthia the grant is only issued if the annual heating demand is less than 65 kWh/m<sup>2</sup> (at 3400 Kd/a heating-degree-days and at an area to volume ratio of 0.8 or above) (Kärntner Wohnbauförderungsgesetz, 1997). This requirement also limits the maximum heat transmittance of windows used in Austria. This inevitably affects the choice of windows on the basis of their thermal properties. Also the grant is higher if wood-framed windows are used.

An additional funding scheme, the “Klima:aktiv Haus”, is available through the Federal Ministry for Agriculture, Forestry, Environment and Water Management and the Ministry for Transport, Innovation and Technology for low-energy and passive houses<sup>7</sup>. This restricts the use of windows to those with a heat-transmission value of  $\leq 0.80$  W/m<sup>2</sup>K.

It also includes a clear requirement to exclude PVC in building compounds, e.g. windows, door and shutters. This requirement is also reflected in the procurement criteria for the provincial government of Vienna to refrain from using PVC and tropical wood. Consequently, the tendering criterion for a specific building project prohibited the use of construction materials containing halogen.

### United Kingdom

The Regional Development Agencies are now virtually all incorporating a requirement into their funding agreements for new building projects, that they must achieve Code Level 3 from the Code for Sustainable Homes and BREEAM Excellent, as the formal condition of the project being grant aided.

The Waste & Resources Action Programme (WRAP ) has carried out a considerable amount of research into the types of flat glass suitable for recycling and a number of pilot projects to promote the recycling of window glasses and frames., including projects which established window recycling collection points for use by private individuals and construction and demolition companies.

## **3.6 Summary and conclusions**

- Energy labelling of windows has been introduced in for example in Denmark, Finland, and UK with considerable success. The Nordic Eco-labelling (the Swan) is the first broad labelling system covering a wide range of environmental impacts other than energy related aspects.
- In their Green Public Procurement guidelines, some countries directly apply energy performance-related criteria on fenestration products (windows, doors, skylights, etc.), while a small number of countries also promote eco-labelled products. The desktop studies indicated that currently only few eco-label systems go beyond energy performance and include other environmental performance criteria.
- The development of the European market for windows has experienced significant change over the past three decades, relating to their energy saving performance, with the average U-value being reduced by more than fifty percent to 1.68 W/m<sup>2</sup>K. The main driver for this was the Energy Performance of Buildings Directive (2002).

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<sup>7</sup> Passive houses are defined as buildings with an annual heating demand of equal less 15 kWh/m<sup>2</sup>a at 3400 Kd/a heating-degree-days

- Certain forms of windows exhibiting higher levels of insulation, such as double, triple glazing and Low-E windows require a considerable higher material input for their construction, particularly when considering the material requirements for frames and fittings. The environmental aspects in terms of quantity and types of materials used in the construction sector have so far only played a marginal role in the legislation, as covered under the Construction Products Directive, which is limited to emissions and pollution aspects during the use phase of the products.
- The forthcoming EU revision of the Construction Products Directive (EC Communication, 2008) picked up this weakness and is likely to expand the range of issues covered by the essential requirements, to include life cycle perspective<sup>8</sup>. This specifically refers to the sustainable use of natural resources<sup>9</sup>. It is considered likely that this will flow through to public procurement, but inevitably further guidance will be needed in this area.
- Both the Nordic Swan Scheme (covering Denmark, Sweden, Finland, Norway and Iceland) and the Austrian eco-label scheme lists several environmental criteria, which in principle could serve as a guide to implement compulsory standards for Green Public Procurement of windows, a summary of which can be found in table 3.7 in Appendix D. Both of the presented eco-labelling schemes include a mandatory minimum amount of wooden materials to be used in the windows, and a ban on using certain chemicals in the window and the frame.

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<sup>8</sup> Annex I, Basic works requirements, No 3: *“The construction works must be designed and built in such a way that they will not ... exert an exceedingly high impact over their entire life cycle on the environmental quality nor on the climate, during their construction, use and demolition ...”*

<sup>9</sup> Annex I, Basic works requirements, No 7: *“The construction works must be designed, built and demolished in such a way that the use of natural resources is sustainable and ensure the following:*  
*(a) recyclability of the construction works, their materials and parts after demolition;*  
*(b) durability of the construction works;*  
*(c) use of environmentally compatible raw and secondary materials in the construction works.”*

# 4 Recycled Mineral Construction and Demolition Waste

## 4.1 Product Scope

The primary focus of this chapter is the reuse of recycled mineral material from construction and demolition waste (CDW). In order to keep the scope to a manageable size within the resources of this project, wood, plastics and other non-mineral building materials are not included.

According to the conclusions of the European Council on “*public procurement for a better environment*” from 25 September 2008, the construction sector is among the top ten priority sectors in relation to green public procurement (Council of the European Union 2008). Within the construction sector, the use of recycled mineral CDW can potentially play a key role in the delivery of environmental policy and green public procurement objectives, where:

- Mineral / aggregates used in construction (above-ground construction, road construction and fillings) are among the largest material consumption streams in the EU, with domestic extraction in EU-15 amounting to 7.0 t/capita or 2,600 million tons in 2000, which equates to about 50 % of all the material movements within these countries (Weisz et al. 2007).
- A significant amount of energy could be saved by replacing primary material with recycled CDW. Life cycle analyses show that, for example, concrete containing recycled aggregate has 20 to 30 % less environmental impact than concrete made purely from primary raw materials (Kuemmel, 2000).
- Within Europe, CDW is the largest waste stream by volume. Recycling of CDW can significantly reduce the demands on landfill capacity.
- Furthermore, the revised Waste Framework Directive (2008/98/EC) introduced a recycling target of 70 % for construction and demolition waste (excluding soil and stones and hazardous wastes) to be achieved by the Member States by 2020.

In summary, widespread use of recycled CDW in building and construction can considerably reduce the associated environmental pressures. However, the average recycling rate is estimated to be about 30% of 180 million tons of waste arising annually (FIR, 2004). A requirement or voluntary commitment by public procurers to use a minimum percentage of recycled material in public construction projects could be an efficient measure to further develop the market for recycled material.

However, CDW may often contain pollutants, which if released into the environment through recycling may pose significant environmental and health risks. In order to limit this risk whilst ensuring that increased recycling rates contribute to environmental protection, some Member States have introduced schemes to limit pollutant concentration. These schemes range from mandatory pollutant limits to voluntary quality assurance and labelling schemes.

## 4.2 Markets

In Austria, it is estimated that the total market for mineral material for construction (both primary and recycled material) consists of around 100 million tonnes per year. However due to contamination constraints, only about 30 %, or 30 million tonnes of CDW per year, could potentially be reused

through recycling.

The current demand, however, is much smaller, currently amounting to only 5 million tonnes per year. Whilst the average annual recycling rate across Europe is estimated to be about 30% of the 180 million tons of total waste arisings (FIR, 2004), the maximum which could be recycled at costs below or comparable to primary materials is also estimated to be only some 8 million tonnes per year (Personnel communication Martin Car, BRV, 05.08.2008). A more detailed analysis reveals that a significant amount of recycled material is already used in road construction, though this is not the case in the building and construction sector.

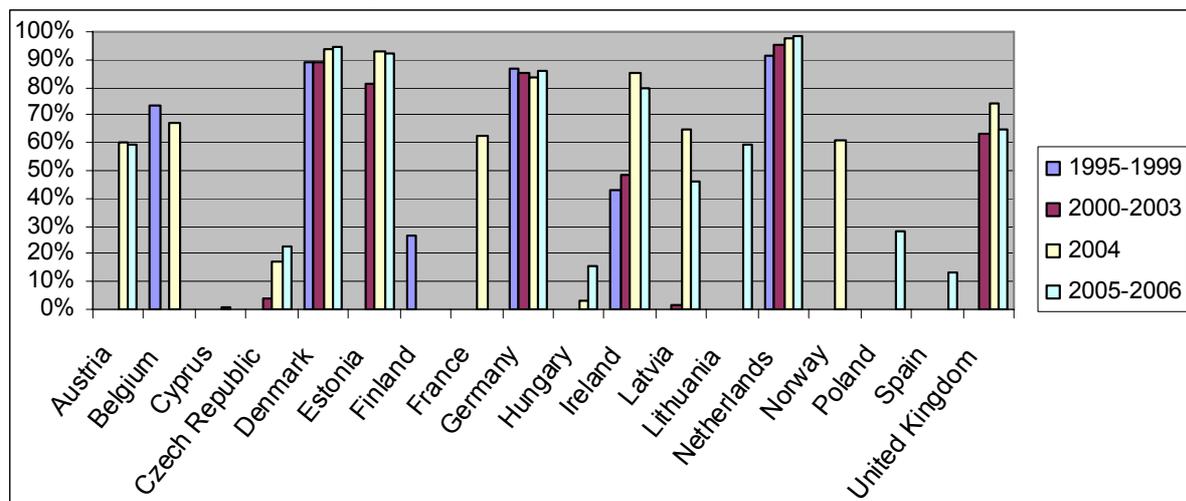
The average annual recycling rate across the European Union is estimated to be about 30% of the total annual CDW arisings (FIR, 2004). However this varies across the different European countries, as indicated in Table 4-1 and Figure 4-1 below, where in Denmark almost all suitable construction and demolition waste is recycled but in Cyprus, Spain or Wales, for example, there would still appear to be considerable scope for further market development.

Table 4-1: Degree of market development in different European countries

	<b>Austria</b>	<b>Denmark</b>	<b>Germany</b>	<b>England</b>	<b>Wales</b>	<b>Scotland</b>
Reference year	2006	2003	2004	2005	2001	1998
Arisings of construction and demolition waste with potential for recycling in million tonnes per year	8	3.8	72.1	74	5.0	8.7
Amount of recycled construction and demolition waste in million tonnes per year	5	3.5	49.6	42	1.6	4.2
<b>Utilization of the supply side market potential in %</b>	<b>63</b>	<b>93</b>	<b>69</b>	<b>57</b>	<b>31</b>	<b>48</b>
Data Source	Car, 2008	Montecinos et al., 2006	Schulz, 2006	DCLG, 2007	OPDM, 2002	Winter et al., 2001

Note: The term "construction and demolition waste" in the different countries may include different waste fractions. Especially the degree to which soil, stones and construction site waste is included or excluded is not the same in the different countries. Therefore, comparisons between countries are indicative only. However, the conclusion that the recycling rate varies greatly from country to country is robust.

Figure 4-1: Recycling of construction and demolition waste in percentage of generated amount in selected EU countries and Norway.



Source: Eurostat and ETC/RWM, 2008 based on national reports and statistics

Significant variation also appears to exist within and between countries as to the type / source of mineral CDW recycled. For example, in Germany 93 % of waste arising from road construction is recycled, whereas only 62 % of waste from building construction and demolition is recycled (Schulz, 2006). However the potential conflict between high recycling rates and high protection of soil and water against pollutants coming from waste materials is currently a matter of intensive discussion in Germany and one of the main reasons why the 'Ersatzbaustoffverordnung' has not yet been adopted – for detail see section 4.4.3. In the UK (excluding Northern Ireland), 25 % of construction materials used is recycled, where the market share had doubled in the last 15 years (WRAP, 2007).

#### **4.2.1 Market trends**

With the exception of Denmark and the Netherlands, where nearly all suitable CDW is recycled, the markets for recycled CDW have changed in recent years. For example, in the United Kingdom, the production of recycled material for building construction has increased by 3.2% since 2003, and 3.7% since 2001. Many pilot projects show that there is significant potential for further extending the use of recycled material from CDW (WRAP, 2004, 2005a, 2006a, b). The government Waste and Resources Action programme (WRAP) business plan 2006-2008 included a target that 1.7 million tonnes of material should be diverted from landfill or avoided from being extracted from primary resources (Aggregain, 2008a).

Use of recycled asphalt as an aggregate in England is predicted to increase by 14% per year over the next ten years. A number of local authorities are starting to utilize recycled asphalt for road maintenance work. The potential has also been identified for increasing the recycling of asphalt back into hot or cold asphalt as recycling methods improve, which will lead to potential environmental and financial savings as a result of lower bitumen use in new and replacement roads (Aggregain, 2008b).

#### **4.2.2 Prices**

The price of recycled CDW varies widely by region and by quality as they reflect the cost of primary materials, which in turn depend on local availability and transportation costs. Usually the price of recycled CDW is lower than the prices of primary materials. In Austria the prices lie between 0 and 24 EUR/t with a median value of 6 EUR/t (BRV, 2008).

#### **4.2.3 Market players**

In most countries the biggest commissioner of construction projects is the public sector and related organisations. Thus public purchasing has a decisive impact on the market for construction materials.

#### **4.2.4 Market barriers**

When looking across different EU Member States (see Fig 4.1), Denmark and the Netherlands recycle almost 100 % of their CDW whereas in other states the recycling rate is much lower. Reasons for lower recycling rates include:

- Abundant supplies of primary mineral materials, increasing the competitive pressure on recycled CDW. This is strongly dependent on transport costs, and therefore is highly site specific. This is further complicated by the fact that the demolition of the old building, the processing of the recycled material and the construction of the new building usually take place at a variety of places, generating varying transport costs. While in densely populated areas the transport distances usually are short, this might be different in the countryside.
- Lower landfill costs for CDW.

- The increasing complexity of construction materials, requiring care to be taken to prevent mixing of different materials, which increases the costs of recovery for recycling.
- Lack of interest in companies to participate in classification or quality assurance schemes for recycled mineral CDW.
- Lack of appropriate specifications and / or quality assurance schemes for recycled CDW.
- The perception that recycled CDW is a waste material. In many cases this is because recycled CDW is still legally defined as a waste. Public procurers refrain from using waste materials for public projects, as if anything goes wrong with the new building they fear being blamed for having used waste as building material. It is felt that purchasers avoid personal responsibility for this by using primary building material instead.

However, there is evidence that some procurers are using recycled material in countries that have introduced quality assurance and labelling schemes, and in some areas there are moves to introduce a minimum share of recycled material for all public construction projects. This is covered in more detail in section 4.5 below.

The following subsections review current classification or rating systems for recycled mineral CDW, quality assurance schemes and public purchase obligations in Austria, with additional information on Denmark, Germany, the United Kingdom and other countries of interest, as appropriate.

### **4.3 European Performance Criteria**

This section summarises the key EU regulations that have implications for the quality and use of recycled mineral CDW in building and construction.

Council Directive (89/106/EEC) (EC, 1989) establishes EU wide minimum requirements on the performance of buildings (and therefore also on building materials). With respect to hygiene, health and the environment the construction work must be designed and built in such a way that it will not be a threat to the hygiene or health of the occupants or neighbours.

Once the revised Waste Framework Directive (European Parliament, 2008) is implemented, certain waste streams shall cease to be waste if it has undergone recovery, including recycling, and complies with specific criteria:

- a. the substance or object is commonly used for specific purposes
- b. a market or demand exists for such a substance or object;
- c. the substance or object fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products; and
- d. The use of the substance or object will not lead to overall adverse environmental or human health impacts.

The criteria shall include limit values for pollutants where necessary and shall take into account any possible adverse environmental effects of the substance or object.

According to the European Commission's 'Handbook on Environmental Public Procurement' (European Commission, 2004), the right to specify materials or the content of a product in public tendering also includes the right to demand a minimum percentage of recycled or reused content where possible. In its Green Public Procurement Training Toolkit (EC, 2008), the Commission also recommends that:

- At least 5 % of construction material should derive from recycled or re-used content

- Recycled material must be accompanied by test documents indicating that they contain no hazardous substances.

#### 4.4 Member State & Non-European Performance Criteria

Performance criteria for recycled CDW can be sub-divided into physical properties (such as particle-size distribution or frost-susceptibility) and chemical properties. The same physical criteria requirements are applied to both recycled CDW and virgin / primary material, while chemical properties for recycled CDW relate to substances or elements, which if found in soil, ground or surface water, could potentially harm the environment.

Key criteria thus relate to possible contamination from recycled mineral CDW and the associated potential to cause pollution during construction and use. In order to ensure that this is minimised, several Member States have defined limiting values in terms of chemical contamination in relation to possible leachate leakage. These often have an associated labelling / classification schemes and / or quality assurance to certify that the recycled end product complies with these limits.

This combination of limiting values for contamination, technical quality, quality assurance and labelling schemes are aimed at ensuring that:

- Only recycled CDW which does not contaminate land or water is put on to the market.
- The resulting building is more sustainable as a result of using recycled CDW.
- Environmental pressure exerted by the economy is reduced.
- The end-of-waste criteria of the waste framework directive (European Parliament, 2008) are met so that the quality assured recycled CDW is not a waste but a product.
- The use of recycled CDW in public buildings is a contribution to GPP.

The section below highlights some of the different approaches to classification and quality assurance in different European countries.

##### 4.4.1 Austria

In Austria, there is a well established market for recycled material for use in road construction. However, there is still considerable resistance to using recycled material in building construction, particularly in the case of public procurement. Even when treated and quality assured, recycled material still carries the label “waste” and individuals responsible for public procurement often fear the negative image of using waste for new buildings and construction and thus refrain from using these materials.

To address this, the Austrian Recycled Construction Materials Association (Oesterreichischer Baustoff-Recycling Verband – BRV), together with the Austrian Recycled Construction Materials Quality Assurance Association (Oesterreichischer Gueteschutzverband Recycling Baustoffe), have issued a series of guidelines on recycled mineral CDW (BRV, 2004, BRV et al., 2007a,b,c) *‘to guarantee the quality of recycled building materials and to assure their quality, assured through quality certification / marks.’*

The guidelines are intended to establish the minimum requirements (regarding the production and use of recycled construction materials and regarding environmental compatibility) and to specify the kind and extent of tests required for recycled mineral CDW. The overall aim is to achieve a quality standard

that corresponds to the proposed application of the recycled materials. Further details on these guidelines, which could be considered exemplary, can be found in Appendix E.

The environmental standards contained within these guidelines can be comprised as follows:

- Maximum contaminant concentration limits, which in turn determine a quality / use classification, as indicated in Table 4-2 below, and
- Maximum content for additional pollutants which could potentially leach from the material. These have to be measured only if there is an indication of possible substances within the material (see **Fejl! Henvisningskilde ikke fundet.** in Annex C). These limiting values are now also required by Government regulations (Lebensministerium, 2006), which cover the use of all recycled mineral CDW in Austria.

The type and concentration of pollutants in the leachate determine which applications the material may be used for (see Table 4-2 and Table 4-3).

Table 4-2: Classification of recycled construction material according to environmental protection criteria

Parameter	Unit	Quality class			
		A+	A	B	C
<b>Leachate</b>					
pH-value		7.5-12.5 <sup>2)</sup>	7.5-12.5 <sup>2)</sup>	7.5-12.5 <sup>2)</sup>	6-13
Electric conductivity	mS/m	150 <sup>1)2)</sup>	150 <sup>1)2)</sup>	150 <sup>1)2)</sup>	300
Chromium <sub>total</sub>	mg/kg dry matter	0.3	0.5	0.5	2
Copper	mg/kg dry matter	0.5	1	2	10
Ammonium-N	mg/kg dry matter	1	4 <sup>3)</sup>	8	40
Nitrite-N	mg/kg dry matter	0.5	1 <sup>3)</sup>	2	10
Sulphate-SO <sub>4</sub>	mg/kg dry matter	1 500	4 500	6 000 <sup>4)</sup>	10 000
KW-Index (hydro carbon index)	mg/kg dry matter	1	3	5	50
1) If the pH-value ranges between 11.0 and 12.5 the limit value of the electric conductivity is 200 mS/m 2) If the value is exceeded a rapid carbonizing according to the standard ON S 2116-3 must be performed and pH-value and electric conductivity determined after carbonization 3) The limit value is regarded as not being exceeded if the arithmetical average of all examinations performed during the last 12 months does not exceed the limit value and if single examinations do not exceed the limit value by more than 65 %. 4) When the Ca/SO-ratio in the leachate $\geq 0.43$ the limit value is 8,000 mg/kg dry matter.					

Source: BRV et al. (2007a).

These quality-related use classifications are then used in conjunction with Table 4-3 below to select the most appropriate material for particular applications.

Table 4-3: Fields of application of recycled construction material according to quality classes (BRV et al., 2007a, b)

Area of application	Hydro-geologically sensitive areas			Hydro-geologically less sensitive areas			On non-hazardous waste land-fill site / restoration of existing structure or inherited damage
	In unbound form without cover layer	In unbound form with cover layer	In bound form	In unbound form without cover layer	In unbound form with cover layer	In bound form	
Class A+:	√	√	√	√	√	√	√
Class A		√	√	√	√	√	√
Class B			√		√	√	√
Class C							√

Source: BRV et al. (2007a, b).

A quality label is assigned to the recycling material after examination has shown that the recycling material meets the requirements of the guideline. This process consists of following steps:

- An initial examination by an independent certification body.
- Regular tests carried out in-house by the producer
- Auditing of the producer's testing regime twice a year by an independent certification body.

However, CDW that has been treated and reprocessed by a certified producer is still legally defined as waste. This is likely to change as a result of the planned revision of the Waste Framework Directive. The scheme is explained in more detail in Appendix E.

#### 4.4.2 Denmark

In Denmark, the use of recycled road surfacing requires no approval - it is accepted through the Danish Environmental Act – Part 5 (cited by WCD, 2005) for use as a sub-base and the paving of roads, paths, public spaces etc., irrespective of whether the surface is waterproofed or not.

However approval is required for permanent or temporary deposits of demolished asphalt. If such deposits of demolished asphalt form part of large building and / or construction works, such as barriers in connection with road or bridge building, they are also subject to approval under the Danish Environmental Protection Act - Part 5 (WCD, 2005, Montecinos and Holda, 2006).

Clean source-separated stone materials, unglazed tile materials and concrete may be used for building and construction works without approval under the Danish Environmental Protection Act - Part 5 and 9. This material used in this context is not subject to a waste tax, provided it is not contaminated (DEPA, 2001, WCD, 2005, Montecinos & Holda, 2006).

In the year 2000 the Danish Ministry of Energy and Environment stipulated Statutory Order No 655 regulating the use of residual waste and soil in building materials. This order allows the use of recycling material for the construction of roads, paths, squares, sound-absorbing walls, ramps, dykes, dams, railway embankments, pipe/cable trenches, refilling floors and foundations if certain leachate values are not exceeded.

These limiting values vary, depending on the potential for penetration of rainwater. Based on a similar system to Austria, recycled mineral CDW is classified on a scale of 1 to 3, but based only on limiting leachate values, where:

- Category 1, which contain only a limited concentration of heavy metals and exert only low leachate values must be used in water sensitive areas;
- Category 3, with relatively high, but still restricted leachate values, can be used in all areas, provided the surface is not porous, i.e. is not subject to rainwater penetration.

*Experience gained so far – supporting and hindering factors*

In Denmark the high recycling rate of construction and demolition waste is achieved due to the following factors:

1. A limited availability of primary materials for building construction, which effectively increases the demand for recycled materials. Generally, the marketing of recyclable construction and demolition waste is organized in line with marketing of virgin materials. Thus, most reprocessing and recycling centres trade in both virgin and recycled materials (Montecinos & Holda, 2006).
2. The use of selective demolition, even although it may be more expensive and time consuming than traditional demolition. However this is offset and made more cost-effective by reduced landfill tax payments, landfill and incineration costs and higher sales prices for recyclable materials. The waste tax is collected upon delivery of the waste to the treatment facilities. The current landfill tax is EURO 50.34 per tonne, however if the waste is processed for recycling, the tax is refunded (WCD, 2006). There is no tax on waste for recycling.

#### **4.4.3 Germany**

In Germany the legal frame for the recycling CDW is provided by the Kreislaufwirtschaftsgesetz (1994) (Act on Closed Loop Economy), supplemented by a series of federal and regional ordinances and norms (Technische Anleitungen).

Until the year 2002 the standard “LAGA 20” (LAGA. 1998) defined the requirements for the recycling of mineral CDW in Germany. In 2002 a revision of the “LAGA 20” was undertaken, introducing higher environmental standards. This revised form, however, was not adopted (KWT-Bau, 2007). An ordinance is planned for the application of mineral recycling material for building construction (Henkes, 2008) aimed at facilitating the use of recycling materials while protecting specifically soil and groundwater. The ordinance specifies which parameters need to be analysed and which limit values must not be exceeded.

Again, similar to Austria and Denmark, these limiting values are used to classify the material in terms of its potential future use, on a scale of 1 to 3, in this instance based on both chemical content and limiting leachate values, where:

- RC-1 material, which has to comply with the most stringent limit values, may be used in most applications, even in hydrologically sensitive areas, and
- RC-3 material, which has to comply with more lenient limit values, is much more restricted. Product analysis has to be performed on a regular basis, partially by certified third parties (Bundesverwertungsverordnung, 2007).

Quality assurance of recycled CDW is governed by voluntary agreements, with the market organised by 4 associations:

- the Baustoffüberwachungsverband Recycling-Baustoffe e.V.

- the Bundesgütegemeinschaft Recycling-Baustoffe e.V.
- the Bundesvereinigung Recycling-Baustoffe e. V. (BRB)
- And as regional association the Qualitätssicherungssystem Recycling-Baustoffe Baden-Wuerttemberg e.V.

The BRB has issued guidance on quality-assured recycling CDW for building and construction, based on existing technical norms. In relation to environmental criteria, only norms for different material types and regions are mentioned. Compliance with this specification must be verified by the producer with third-party testing at least 4 times a year.

#### *Experience gained so far*

As the ‘Ersatzbaustoffverordnung’ has not yet been adopted, there is currently no experience in its implementation. However, under the regime of the original “LAGA 20”, with its lower environmental standards, in 2004 about 70 % of the recyclable mineral CDW (without soil) were actually recycled and 19 % reused, and in the period 1995 to 2004 the amount of CDW that went to landfill fell from 60 % to 11 % (KWT-Bau, 2007).

The discussion continues on the relative importance of water and soil protection versus closing material cycles. The outcome of this discussion will determine, how stringent the environmental criteria of recycling CDW are defined.

#### **4.4.4 United Kingdom**

The UK Waste and Resources Action Programme (WRAP) in conjunction with the Highways Agency and the Quarry Products Association, established a Quality Protocol for Aggregates in 2004, with a revised edition released in 2005 (WRAP, 2005b). The Protocol has two main purposes, to:

- Identify the point in the recycled material ceases to be classified as waste. Thus, downstream users avoid the costs of complying with Environmental Permitting legislation. Possible stigma associated with the use of these materials is removed, which in the past was thought to have led to low levels of utilisation of secondary materials; and
- Give adequate assurance that recovered aggregate products conform to standards common to both recycled and primary products.

One of the key aspects of this is the quality assurance process to ensure that the product meets the definition of “inert waste” as defined in the Landfill (England & Wales) Regulation 2002. This states that waste is inert if:

- (a) It does not undergo any significant physical, chemical or biological transformations;
- (b) It does not dissolve, burn or otherwise physically or chemically react, biodegrade or adversely affect other matter with which it comes into contact in a way likely to give rise to environmental pollution or harm to human health; and
- (c) The total leachability and pollutant content and the ecotoxicity of its leachate are insignificant and, in particular, do not endanger the quality of any surface water or groundwater.

The WRAP Quality Protocol for Aggregates places a responsibility on the producer of recycled CDW to:

- Define acceptance criteria in order to ensure that all incoming waste which is not inert is rejected. This is achieved by specifying limits on the concentration of contaminants or foreign material in the material.
- Establish a factory production control system in accordance with the norms for recycled construction material issued by the British Standards Institute (such as BS EN 13 242 and PD 6682-2). Following initial type testing the producer is responsible for process control.
- Prove that there is a demand / market for his product, which must meet the end-of-waste criteria specifications defined in [www.aggregain.org.uk/specifier/index.html](http://www.aggregain.org.uk/specifier/index.html).
- Test aggregate composition weekly, including organics and grading, although not necessarily through a third party. Further parameters may be tested to either decide or illustrate suitability for a particular end use.
- Provide test results, test procedures and outline details of the factory production control manual (WRAP, 2005b), when requested.

WRAP's web-page, ([www.aggregain.org.uk/specifier/index.html](http://www.aggregain.org.uk/specifier/index.html)), also provides guidance for purchasers in specifying the appropriate class of recycled CDW for each particular application.

All in all, the use of recycled aggregates has steadily increased in the UK over recent years, due at least in part to the efforts of WRAP and Aggregain. Although it is too early to estimate the contribution of WRAP's Quality Protocol, since its introduction in 2004 there has been over 20,000 downloads of the protocol documents and several thousand hard copies have been distributed. The majority of the 500 recycled aggregate producers in the UK now satisfy its requirements (J.Barritt, personal communication, 31<sup>st</sup> October 2008), thus, prospects for the protocol are extremely encouraging.

#### 4.4.5 Other Countries

##### *European & Non-European*

In 1990 the International Recycling Federation (FIR) was founded as an association to promote joint efforts to advance recycling of construction and demolition waste.

Another organisation concerned with quality assurance of recycled CDW is the European Quality Association for Recycling. Table 4-4 lists its member organisations.

Table 4-4: Members of the European Quality Association for Recycling

Country	Member Associations	Number of additional member companies
Austria	Oesterreichischer Güteschutzverband Recycling-Baustoffe	
Bosnia-Herzegovina		1
Czech Republic	Asociace pro rozvoj recyklace stavebnich materialu v CR (ARSM)	
France		1
Germany	Bundesgütegemeinschaft Recycling-Baustoffe e.V.	3
Ireland		1
Italy	Bauschutt-Konsortium Suedtirol	
Netherlands		2
Switzerland	Abbruch, Aushub und Recycling Verband Schweiz (ARV)	1

Source: [www.euqar.com](http://www.euqar.com).

##### *Switzerland*

Having first issued guidance on the quality of recycling material for building construction in 1992, Switzerland is among the countries with most experience in this field. Currently the regulation is composed of two basic elements:

1. A normative guideline on the minimum specification for recycled CDW for building construction specified by a public authority (BAFU, 2006) and
2. Voluntary guidelines on quality-assured recycled CDW, leading to the issue of a quality label (ARV, 1998).

Both guidelines require that the quality of the recycled material is tested by the producer, with third party tests required at least once a year per product, and every 20,000 cubic metres of recycled CDW produced. The producer's test procedures must also be audited by third party.

### *Netherlands*

In the Netherlands, where primary building material is scarce, there almost 100 % of mineral CDW is recycled. However the soil and hydro-geology of the Netherlands are particularly sensitive to pollutants and the Dutch Building Materials Decree (Sdu Uitgevers, 1999) was therefore introduced to limit the environmental impact of all building materials. For both primary, secondary<sup>10</sup> and recycled materials, the Decree specifies:

- Technical and environmental criteria for all building materials, which may come into contact with rain water, surface water or groundwater. 'Clean soil' is defined by maximum concentration levels for pollutants. Limiting leachate values (considering 15 metals and 6 anionic substances) and limiting concentrations of 20 other organic substances are also defined.
- An obligatory quality assurance system to ensure adherence to the above standards. This includes testing methods and third party validation of testing processes (Eikelboom et al., 2000).

### *Italy*

The National Association of Bioecological Architecture (ANAB) has introduced a voluntary labelling scheme which guarantees the quality of building materials. This label is issued based on life cycle analyses and the building material fulfilling following criteria, that it:

- Is preferably made from renewable and recycling materials.
- Is technically fit for the intended application.
- Does not contain or release substances that are harmful to people and the environment.
- Is produced in an energy efficient way; it does not require a big amount of energy during construction, use and recycling.
- Has a low environmental impact, based on its production, construction, use and recycling phase.
- Has a very low level of radioactive emissions (ANAB, 2008).

Compliance with these criteria is certified by ICEA (Institute for the Ethical and Environmental Certification Italy) based on regular inspections and measurements. The label is valid (illustrated in

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<sup>10</sup> Note: Secondary materials includes waste quarrying material that is re-processed.

Figure 1 in Appendix E) for two years from the certification date. 10 companies are currently certified as producers of materials for sustainable architecture in Italy (ANAB, 2008).

## **4.5 Green Public Procurement**

Technical and environmental specifications, supported by appropriate quality assurance systems, in general provide the basis in Europe for the use of recycled CDW whilst protecting the environment. This section looks at the impact of GPP on the use of recycled mineral CDW and the extent to which these standards are used in GPP specification.

### **4.5.1 Austria**

The Austrian act on public procurement (Bundesvergabegesetz, 2006) requires that purchased services must comply with environmental regulations and must be provided in an environmentally friendly way. This can be implemented either by including environmental technical specifications in the description of the requested services or by setting firm award criteria that are linked to complying with certain environmental standards.

These guidelines are reflected in the standard terms of reference for public building projects (BMWA, 2007, Baumeisterverband, 2005, FSV, 2008) and the Austrian List of Building Materials (OIB, 2007)). In relation to recycled mineral CDW, products must meet the specification included in the 'Guidelines for Construction Materials made from Recycled Demolition Waste' (BRV, 2004, BRV et al., 2007a, b, c). This includes a requirement for all recycled material purchased to be quality assured.

There is, however, no obligation to use recycled materials for public buildings. However some regional governments have issued recommendations to prefer recycled material over primary material in public building projects (personnel communication Martin Car, BRV, 05.07.2008). IFZ (2008) recommends that at least 25 mass % of the shell of a building are made from recycled or recovered material.

### **4.5.2 Denmark**

As the market for recycled mineral CDW and the regulations for limiting any associated environmental risk are so well established in Denmark, it has not proved necessary to develop special guidelines or targets in relation to public procurement of this product group in Denmark.

### **4.5.3 Germany**

There are a whole series of technical and environmental standards which must be considered when specifying construction material for public procurement in Germany (SLG, 2006). In relation to recycled mineral CDW, it is assumed that the Bundesverwertungsverordnung will become the basis for public procurement (and also private purchasing) once this ordinance has been adopted.

### **4.5.4 United Kingdom**

As part of the on-going process of promoting sustainable public procurement in the UK, a new Centre of Expertise in Sustainable Procurement has been established within the Office of Government Commerce, which is responsible for providing cross-departmental support on all aspects of government procurement, to help deliver this by providing product-specific guidelines and information.

Public sector guidance on both mandatory and Best Practice sustainability criteria for a small range of products is currently available on the government's sustainable development website, "Buy Sustainable – Quick Wins." While the scope of work includes water heaters and showers, at present it does not

cover the use of recycled mineral CDW.

In the interim, different public sector organisations are using the existing guidelines for public procurement contained in the:

- *Code for Sustainable Homes* (CLG, 2008a), a voluntary standard introduced in 2007 to improve the sustainability of new homes, for new residential buildings and;
- *Building Research Establishment Environmental Assessment Method* (BREEAM, 2008a), for non-residential buildings, including multi-residential, offices, retail, industrial, schools and courts. It also has a special section covering building fit-out and renovation.

The BREEAM assessment scheme works on a scoring basis, where points are gained for different environmental aspects of the building design and includes a requirement for at least 80% of the products used to be “responsibly sourced”. This is based on the level and scope of certification achieved by the material suppliers / manufacturers, related to identified compliance schemes for each product group and supply chain Environmental Management Systems. In relation to recycled materials, reference is made to the *Calculating and declaring recycled content in construction products, “Rules of Thumb” Guide* (WRAP, 2008).

BREEAM Green Guide also rates some 250 construction elements with respect to their life cycle environmental impact. The BRE website also provides guidance<sup>11</sup> on recycled products, e.g. the use of recycled CDW in bricks. However currently it does not make specific reference to recycled aggregates.

Public procurement guidelines may also refer to the WRAP Quality Protocol for Aggregates (WRAP, 2005b) as basis for purchasing recycling material. A public procurer who wishes to use the protocol is required to check whether the producer is certified for the use they require.

A more direct measure to stimulate the market for recycling material is to specify minimum content of recycled CDW within project tender document, as that proposed by WRAP. In one of its guidelines WRAP recommends that public purchasers set an outcome-based requirement in any contract specification – such as ‘10 % of the materials value of the project derive from recycled content’ (WRAP, 2005c).

This method is finding increasing take-up among many regional and local authorities, e.g. the public sector-led regeneration project in St Austell, Cornwall included a requirement for 25 % of all bulk materials to be from recycled or reclaimed sources.

The Environment Agency (EA), in its flood defence and other capital projects specifies requirements for materials recycling. These were initially set at 50% but have since been increased to 60% because of the success of contractors in meeting the requirement. Experience has led the EA to believe that the use of recycled materials can deliver cost savings in certain instances (Aggregain, 2008c).

The Highways Agency, on the A38 trunk road scheme in Devon, used recycled road surfacing in situ as part of the resurfacing works for a 12 km stretch of carriageway, which resulted not only in a saving in use of primary aggregates but also a 70% saving in asphalt and the associated energy used in extraction, processing and transport. The scheme also avoided considerable pollution and congestion due to the significant reduction in transport of materials to site.

A further exemplary measure is the Mayor of London’s launch of a green procurement code where both corporate and public purchasers have signed up to purchase goods containing recycled materials where possible (European Commission, 2004).

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<sup>11</sup> [www.bre.co.uk/rbp/page.jsp?d=1](http://www.bre.co.uk/rbp/page.jsp?d=1)

#### 4.5.5 Switzerland

In Switzerland roughly one third of the building construction projects are commissioned by public authorities. (Stadt Zuerich - Amt fuer Hochbauten, 2007). KBOB an institution for the co-ordination of federal construction management in Switzerland has issued a recommendation for public procurers concerning the use of concrete made from recycled minerals. It is recommended to purchase concrete made from recycled minerals when technically appropriate and available at the same price as concrete from primary material within a radius of 25 km (KBOB, 2007).

#### 4.5.6 Other Incentives

As identified above, landfill tax in many countries provides an added incentive to recycle CDW, particularly if it is possible to do this on-site, where, for example an old building is being demolished to make room for a new building. These are already helping to divert CDW from landfill and stimulate recycling in some European countries.

In addition to landfill levies, taxes on the extraction of primary material are have been employed in some countries to further stimulate recycling of mineral CDW. A study by the European Environment Agency, which analysed the effects of a specific tax on primary rock, gravel and sand (aggregates tax) in Czech Republic, Italy, Sweden and the United Kingdom (EEA, 2008), showed that the rate of tax varied considerably between the 4 countries, increasing the price of the aggregates by between 2% and 20 % (see Table 4-5). However only in the United Kingdom has this revenue from tax been specifically used to encourage recycling. The other objectives in the different countries are shown in Table 4-5 below.

Table 4-5: Context of tax on primary rock, gravel and sand (aggregates tax in 4 European countries)

		Czech Republic	Italy	Sweden	United Kingdom
Objective of tax	Raise revenue	X			
	Preserve the landscape	X	X	X	
	Compensate for environmental externalities		X		X
	Conserve resources			X	
	Reduce demand for aggregates				X
	Encourage Recycling				X
Tax rate in EUR per tonne		0.1	0.2 – 0.3	1.43	2.4
Tax as % of aggregate price		2 – 3 %	4 %	12 %	20 %

Source: EEA (2008).

In Sweden, a shift from gravel to crushed rock consumption has been observed since introduction of the tax, though it has not been possible to establish any clear link to the tax.

However analysis of the market reaction to the aggregates tax in the United Kingdom showed that a modest substitution with untaxed secondary materials has occurred, resulting in an increase in the recycling rate.

The aggregates tax also reported some disadvantages, including:

- The complexity of the administration process,
- Regional variation in the supply of primary material is not reflected in the tax level,
- Trade distortions arise if there are differences in the tax rate or the existence of taxes between neighbouring countries.

## 4.6 Summary and Conclusions

### *Extent of coverage of energy efficiency and other environmental performance criteria in legislation, standards and labelling*

While the energy efficiency of buildings and energy-related products is subject to a whole raft of regulations at both the EU and Member State level, there are no common regulations on the classification or labelling of construction materials to indicate the energy required to produce it to the procurer. This applies to both primary and recycled construction material.

With respect to other environmental performance criteria, a number of Member States have introduced limit values for the contents and/or leachate concentration of pollutants. This is necessary as construction and demolition waste may contain pollutants such as heavy metals or hydrocarbons.

The environmental specification of recycled materials for use in building construction would appear to vary between being based on binding:

- Leachate-limit-values for a core set of parameters, as in Germany,
- Both chemical content and limiting leachate values for a more extended set of parameters, as in Denmark or in the Netherlands,
- Limiting leachate values for a small number of pollutants (see Table 4-2), with an extended number of parameters to be measured only if there is an indication of contamination (see **Fejl! Henvisningskilde ikke fundet.**), the approach adopted in Austria. This approach may limit the cost of chemical analysis.

### *Extent of coverage of energy efficiency and other environmental performance criteria in GPP*

In many Member States there are general recommendations to take environmental criteria into account in public procurement, however there are few specific requirements to use recycled material in public building projects. An exception is the UK where some public procurement recommendations require at least 10 % of the material used in any construction project to be recycled material.

If mineral recycled material is used in public projects in Austria, Denmark, Germany, the Netherlands and the UK it has to fulfil certain technical and environmental specifications, such as limited pollutant contents. However in the UK, the environmental specification is not mandatory but rather applied on an individual organisation / authority basis, generally following the recognised BRE and / or WRAP guidelines.

In order to further ensure that recycled CDW is safe for the environment and human health and is of sufficient quality, many countries have established a form of certification or rating scheme.

In the European countries studied, two generic approaches to establishing a quality assurance system were identified:

- An *obligatory approach*, such as the Dutch Building Materials Decree. This introduces stringent limit values for all building materials and compliance is strictly controlled by third party laboratories.
- A *voluntary approach*, such as the WRAP Quality Protocol in the UK, which does not include a requirement for third party testing / verification.

There are advantages and disadvantages to both approaches:

- With an *obligatory approach*, the procurer has a high level of certainty that the recycled material will satisfy all necessary technical and environmental criteria. The increased analysis and administration costs of these systems, however, increase the price of the recycled material and reduce its competitive position relative to primary material, thereby potentially reducing the amount of recycled CDW used.
- Under a *voluntary approach*, in-house testing procedures may be less rigorous than those used by third party bodies. However, the reduced costs of complying with the quality assurance scheme may increase the number of producers participating, thus increasing the amount of recycled CDW supplied to the market. This can be particularly important where primary materials are readily available and the market is thus highly competitive.

The choice of approach will therefore vary from country to country, depending on the availability of primary material, etc. For some countries, the optimum may lie somewhere in the middle, with a voluntary system that includes third party certification, backed up by state control, such as the Austrian quality label 'Recycling'.

However, the optimum design of any certification and associated quality assurance scheme will inevitably be influenced by the local characteristics of the building materials industry in each county, and in particular, the price differential between recycled and primary materials.

#### ***Effect of legislation, standards and labelling on the market***

Quality assurance and certification / rating schemes that set technical and environmental specifications mean that EU Member States can ensure that recycling materials are fit for purpose, without the potential to pollute the environment. Effective testing and certification can ensure that potential purchasers have confidence in the material they procure.

In the UK, the WRAP Quality Protocol has proved very popular amongst producers and the majority of recycled material produced is compliant with the protocol. For example, in the United Kingdom, the production of recycled material for building construction has increased by 3.2% since 2003, and 3.7% since 2001.

#### ***Effect of GPP on the market***

With the exception of Denmark and the Netherlands, in all other European countries there seem to be considerable potential to increase the use of recycled CDW.

In most European countries, public institutions are a major client in the construction market and thus have the greatest potential to influence the market. Increased use of recycled material in public projects can significantly reduce barriers for other purchasers as well. When public purchasers are committed to take up as much recycled material as is technically, economically and environmentally feasible, the full market potential of construction material from recycled CDW could be activated.

#### ***Barriers***

The *negative image* of using material which has been classified as waste is perhaps the strongest barrier against the increased use of recycled mineral CDW. Quality assurance systems improve this image, but additional measures, such as regulations on a minimum share of recycled materials seem may be necessary. In the UK, compliance with the WRAP Aggregates Protocol actually removes the waste definition from the material and further encourages the use of recycled material. This approach is consistent with the 'end-of-waste' criteria specified in Article 6 of the new Waste Framework Directive (EC, 2008).

*Competition with primary materials* is a further key market barrier, as discussed elsewhere in this chapter. This is strongly dependent on transport costs, and therefore is highly site specific. This is further complicated by the fact that the demolition of the old building, the conditioning of the recycling

material and the construction of the new building usually take place at a variety of places, generating varying transport costs. While in densely populated areas the transport distances are usually short, this might be different in the countryside.

*Complexity of building construction*, which increases the efforts needed to properly clean and condition recovered materials in preparation for recycling, is a technical barrier against the increased material use. This is especially true for the construction of walls in low energy buildings.

Finally, a significant barrier against use of quality assurance system in other member states is the considerable effort to establish such a system. Any positive image of recycled CDW built up by certification / quality assurance systems and third party certification, could also be dismantled by a single free-rider who provides substandard material.

In relation to the possible introduction of an energy labelling scheme for recycled CDW, the effort required to assess the embedded energy in the product could be extensive. In particular, the necessity to treat every batch of CDW differently (e.g. coming from different demolition sites) might make the energy balance almost impossible.

### ***The scale of potential savings***

Generally speaking, the actual cost-benefit balance of using recycled CDW as the basis for construction materials instead of using primary material depends heavily on local conditions. However, extrapolating Austrian figures to the EU as a whole, it is estimated that roughly an additional 200 million tonnes per year of pollutant-free CDW could be recycled in the EU and sold to generate revenue of roughly 1.2 billion Euros per year. This would result in 200 million tonnes per year of primary material saved, and a major reduction of waste going to landfill. Note that this estimate includes only cases where the recycled material can be provided at a lower cost and lower energy uptake than primary materials.

### ***Other incentives***

Other incentives that can help to drive the market are:

- Landfill taxes, which help divert CDW from landfill; and
- A tax on the extraction of primary materials applied in the Czech Republic, Italy, Sweden and the United Kingdom, have been proved to further stimulate the market for recycling.

### ***Other Environmental Aspects***

In addition to the material specific criteria for the use of recycled, public procurers should also consider the:

- Environmental impacts associated with the processing of recycled material
- Transport distances involved
- Energy efficiency of the resulting building
- Ease of dismantling / demolition to facilitate further recycling.

### ***Current Best Practise***

Elements of best practise in quality assurance can be found in all countries investigated, Denmark, Austria, the Netherlands, Germany and the UK. Denmark has a strong obligatory framework whilst in the UK and in Austria there is a good mix of voluntary registration and strong testing standards. However, it is generally not possible to identify a single best practice; the optimum design of a quality assurance system depends on local characteristics.

### ***Future developments***

Pressure to use more recycled CDW will very much depend on the development of the global resources market. If the global demand for material resources continues to grow at current rates, significant effort will be required to close the materials loop and use materials more efficiently. Although the market for mineral construction material is primarily local (transport costs being the main driving force), developments in the global markets of other materials, such as metals and fossil fuels, could also have a significant effect.

The national implementation of the 'end-of-waste' criteria specified in Article 6 of the new Waste Framework Directive (EC, 2008) will also have a big influence of the recycling market. Once the national legislation / regulation in each member state succeeds in making a clear-cut distinction between high quality recycled material and waste, this could potentially have a dramatic effect, both in lowering the costs and improve the image of recycling material.

#### ***4.6.1 Recommendations***

Given the benefits of an increased use of recycled mineral CDW as construction material, that is

- Reduced depletion of primary resources
- Reduced demand on landfill
- Reduced energy demand, associated with extraction, processing & transport

There is a strong case for increasing the amount of recycled mineral CDW in public procurement. It still remains open to what degree to pursue this objective and what would be the most efficient way of achieving this goal. However, instruments are likely to include:

- General recommendation on the use of products with recycled content
- Targets stating a minimum percentage of recycled materials purchased
- Specifying an obligatory minimum content of recycled material in a product.

As a minimum, a positive improvement would be if every EU Member State introduced a system of:

- Stringent limits for different chemicals and leachate potential
- A quality label attached to the certification / quality assurance system which verifies that these limits are met
- Third party certification as further independent verification method.

Examples from the Netherlands, Switzerland and Austria would indicate that these systems can be introduced in the whole of the EU.

## 5 Conclusions

This concluding chapter brings together some key findings for the three product groups, identifying the common threads. After reviewing the use of performance criteria and rating (energy related and non-energy related) in procurement, it addresses possible areas of future action and highlights other measures that could be used to further stimulate the market for energy efficient and environmentally sustainable products.

### 5.1 Performance criteria and rating in procurement practice

Legislation and / or national action plans exist in all four countries requiring the public sector to take environmental considerations into account in their procurement procedures. There is evidence of this being taken up already in a number of countries at both a regional and local level. For example in the United Kingdom each of the government departments are now required to provide an audit on the level of green procurement and benchmark comparisons are made to encourage action.

In all of the four countries reviewed, current GPP guidance is already using the various national eco-labelling / rating systems in existence to specify the recommended products performance levels. This is encouraging the market to develop in response to this demand.

Energy labelling is already proving to be an effective means of influencing the market for more sustainable products, as illustrated by the growth in efficiency labelling of domestic appliances, which has succeeded in raising consumer awareness and concern and has stimulated the uptake of better performing products. This in turn has encouraged manufacturers to actively use the labelling system to gain a competitive edge. The success is demonstrated by the extension of labelling schemes into the non-domestic sector, and includes products that form part of the components (e.g. fixtures and fittings) of a building.

The combination of energy labelling and national building regulations, which incorporate the requirements of the Energy Performance of Buildings Directive, has been effective in raising the energy efficiency standards of individual building components. In all of the countries examined, building regulations now specify the minimum energy efficiency and energy-related criteria for water heaters and windows. This change in policy has prompted one major trade association, BSRIA, to report that this has sent “shock waves” through the market and has led to a strong trend towards the use of more energy efficient products and building models.

Several of the national eco-labelling schemes already incorporate a wider set of environmental criteria, e.g. greenhouse gas emission levels relating to water heaters and chemical content of preservatives and protective coatings for window frames.

In the case of recycled mineral construction and demolition waste, there is a rating system based on acceptable levels of contamination in all four countries, which relate to specific (re)uses as an aggregate-replacement material, e.g. in backfill, concrete or road surfacing.

The public sector, particularly at a regional and local level, is also using voluntary codes to raise the standard of environmental building design relating to both the energy performance of the finished building and other environmental aspects, such as water demand and use of recycled materials. Voluntary codes or standards on sustainable construction, which set standards above those required by national building regulations, are also using labelling / rating systems to identify the required level of product performance. The voluntary codes and labelling standards have been supportive in overcoming the stigma associated with buying waste construction materials. The labels and standards provide

greater certainty to buyers of these recycled materials in the market place.

## 5.2 Overview of performance criteria applied to the three product groups

### *Energy Related Criteria*

A comparison of the different energy performance criteria in relation to the rating systems, standards and associated labelling schemes currently used in the four countries of Austria, Denmark, Germany and the UK would indicate that:

- In the case of both water heaters and windows, minimum efficiency standards and / or product-specific rating systems currently exist in three of the four countries studied;
  - For water heaters, the metrics used in current energy efficiency standards and rating systems are based on various measures of steady-state efficiency. Consistency and standardisation of approach could be improved if Member States were encouraged to adopt the 24-hour tapping metrics now proposed by the EU in Mandate M326 in an effort to harmonise testing standards. This would appear to be consistent with current best practice in America, Asia and Australia. A common set of standards would enable the consumer to compare products on a similar basis, and the manufacturer to produce one set of labelled products suitable for all European markets;
  - For windows, the thermal efficiency metrics are based on varying combinations of heat loss, solar gain and air-tightness, depending on the country in question, with heat loss being common in three countries. However the consideration of solar gain may be of almost equal importance not only in the Mediterranean Member States, where summer temperatures increase the use of air conditioning, but with climate change and the associated potential for warmer summers, this may also be true of the more northern countries. The development of a common set of metrics covering both heat loss and solar gain, on which ratings or standards could be based, would be a big improvement on the current situation;
- Other energy-related aspects of water heaters, which can affect energy demand in a building are:
  - Tank and pipe insulation, which is of particular relevance to instantaneous and storage electric water heaters;
  - Better use of controls, such as thermostat settings and advanced controls for condensing boilers.

The research also shows that in at least one country, the UK, a recent market assessment would indicate that the use of an energy efficiency rating and associated labelling scheme for water heaters has helped to transform the market and increase the demand for higher rated units.

### *Non-energy related Criteria*

In relation to other existing performance criteria, there is considerable variation in the extent and the consistency of coverage across both the product groups and the countries reviewed. For water heaters, identified criteria relate to environmental and health and safety aspects, and are summarised in table 5.1 below.

**Table 5.1 Water Heaters: Other Performance Criteria**

<b>Environmental Criteria</b>	<b>Health &amp; Safety Criteria</b>
<ul style="list-style-type: none"><li>• Maximum levels of greenhouse gas emissions (CO &amp; NO<sub>x</sub>) associated with gas &amp; oil-fired heaters</li><li>• Maximum levels of particulate emissions associated with gas &amp; oil-fired heaters</li></ul>	<ul style="list-style-type: none"><li>• Avoidance of Legionella bacteria by stipulation of minimum water storage temperature at 60°C</li></ul>

If the minimum water temperature in relation to Legionella can be reduced by 5 or 10 degrees, this could also have a significant effect on the energy performance of the hot water system in a building.

Although currently covered to some degree under a voluntary scheme in the UK, water consumption, in terms of water loss during the period of draw down until the water runs hot and flow levels through instantaneous showers, is becoming another issue of concern.

In relation to both windows and recycled mineral CDW, the identified criteria for consideration relate more specifically to:

- **Sustainable use of resources through:**
  - Use of sustainably-managed renewable resources, such as timber in window frames,
  - Reduction of demand for primary/virgin construction materials
- **Reduction of waste sent to landfill through:**
  - Increased use of recycled product (recycled mineral CDW)
- **Avoidance of possible ground contamination and water pollution associated with:**
  - Potentially contaminated product-waste arisings in end-of-life disposal (windows)
  - in-use contamination, through use of recycled product containing hazardous substances (recycled mineral CDW)

The findings for each product group are summarised in Tables 5.2 and 5.3 below.

**Table 5.2 Windows: Other Performance Criteria**

Resource Use	Waste Arisings	Pollution Avoidance
<ul style="list-style-type: none"> <li>• Use of wood from sustainably managed forests</li> <li>• Exclusion of tropical hardwoods</li> </ul>	<ul style="list-style-type: none"> <li>• Labelling of plastic frames for recycling</li> </ul>	<ul style="list-style-type: none"> <li>• Limits on maximum concentrations of certain chemicals in protective coatings of frames to avoid ground / water pollution</li> <li>• Limits on maximum concentrations of certain chemicals in preservatives used in wood frames to avoid ground / water pollution</li> </ul>

**Table 5.3 Recycled C&D Waste: Other Performance Criteria**

Resource Use	Waste Arisings	Pollution Avoidance
<ul style="list-style-type: none"> <li>• Minimum recycled content in construction projects to reduce demand for virgin / primary materials</li> </ul>	<ul style="list-style-type: none"> <li>• Minimum recycled content in products to encourage increased uptake of recycled product</li> </ul>	<ul style="list-style-type: none"> <li>• Maximum allowed concentrations of certain organics in recycled product</li> <li>• Maximum allowed concentrations of certain chemicals in recycled product</li> <li>• pH value</li> </ul>

Judging by the experience of countries with high recycling rates for construction and demolition waste, setting quality criteria for recycled construction materials and putting in place quality assurance systems seem to be an effective way to establish the market and to gain acceptance for the use of waste-derived construction materials.

### 5.3 Possible areas for future action

Based on the study findings, there is a need for more consistent practical guidance on product selection in GPP. Using a standard set of rating criteria and publicised through a labelling system or a benchmarking scheme would help the procurer to compare the performance of individual products within the product groups.

Concerning energy related labelling, regulations and standards, the literature research indicates that existing labelling schemes and performance standards would benefit from more regular review to ensure they keep abreast of advances in technology and changing environmental requirements, e.g. new climate change targets.

With respect to environment-related performance requirements, except for some provisions in the European Eco-Label and in a handful of national schemes, there is no evidence of any consistent standards or guidelines which take into account the life cycle aspects of products, in terms of:

- Embedded energy and water (i.e., used in the production/ manufacturing /processing stages)
- Resource use (natural and mineral) and
- End-of-life disposal and possible waste

While methodologically challenging, taking the above into account would help raise awareness of these issues and provide suitable metrics for a more consistent and comprehensive comparison of products.

On a more general note, use of life-cycle costing in public procurement would help to further optimise purchasing decisions, with a potential 'side benefit' of reducing environmental impacts.

Concerning guidance to practitioners, much information is already available through national sources or at the EU level, such as the Green Public Procurement (GPP) Training Toolkit of European Commission: [http://ec.europa.eu/environment/gpp/toolkit\\_en.htm](http://ec.europa.eu/environment/gpp/toolkit_en.htm)

However, it would appear that there is much less information on how all the guidance is actually applied in the practice. To that end, continued support for experience transfer and information exchange among procurement practitioners could be a promising avenue to facilitate broader implementation of GPP.

## 5.4 Other measures of market stimulation

To support the expansion of GPP a number of wider measures used in combination with labelling or benchmarking schemes could be encouraged. Three key types of potential supporting measures are described below:

### *Fiscal Incentives*

Fiscal incentives can be used to further stimulate the market, particularly when there is an economic downturn, as at present. These forms of incentive were identified in the study in at least two of the four countries reviewed. For example, in the UK, 100% tax relief is offered to businesses on capital expenditure on energy-efficient products within the year of expenditure, which would appear to be having a positive influence on both the consumer and the market. This particular scheme uses the national SEDBUK labelling system to indicate acceptable levels of energy efficiency, which must be met as part of the eligibility criteria.

### *Grants*

As with fiscal incentives, grants are also used with effect in some countries, particularly to further stimulate the uptake of energy efficient products, e.g. the Wohnbauförderung (Residential-Building-Sponsorship) grant scheme for energy efficient buildings in Austria and the Energy Savings Trust and Carbon Trust grant schemes in the UK.

### *Voluntary Codes*

Voluntary codes, which set standards higher than those required by the national building regulations or codes, are also proving a very effective way of stimulating the market for energy efficient and environmentally sustainable products. In the examples reviewed, they tend to use product labelling / rating schemes to measure the different energy-related performance properties of specific product groups / building components.

All in all, recent initiatives at the EU level to establish targets for GPP for priority products are likely to

stimulate the market for environmentally preferred goods and services. Gradually introducing provisions for mandatory GPP in certain areas could provide further impetus, although the political viability of such an initiative at the present time remains to be seen.

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# Appendix B: Glossary of Terms & Abbreviations

## Chapter 2: Water Heaters

### *Auxiliary Power*

Power provided by an alternative source, usually as a back-up.

### *Back-Up Systems*

Power supplies that are activated if the main source of power fails.

### *Combination Boilers*

Boilers that provide both space heating and water heating services.

### *Condensing Boilers*

A boiler that captures water vapour normally discharged to the atmosphere. Because this water vapour is hot and contains energy, condensing boilers are considered to be more efficient than standard boilers.

### *Cylinder Thermostat*

This type of thermostat detects the temperature of water and activates the boiler if it below the preset temperature.

### *Dedicated Heaters*

Appliances that provide sanitary hot water and have no space-heating function.

### *Ignition Arrangement*

Mechanism deployed to ignite the oil or gas to fire the water heater / boiler, e.g. spark plug or pilot flame.

### *Instantaneous Heater*

An appliance that heats water on demand.

### *Least Life Cycle Costing (LLCC)*

A methodology that seeks to identify an option that has the least financial cost when considering both the purchase and operation stages.

### *Primary Water Heaters*

Appliances that provide the main source of hot water for a dwelling.

### *Sanitary Hot Water*

water used for bathing or washing (clothes, dishes etc).

### *Seasonal Boiler Efficiency*

Refers to the energy efficiency of the boiler over different seasons, which may differ at different levels of utilisation. For example, the boiler may be highly efficient when heating large quantities of water in the winter but less efficient when heating lower quantities in the summer.

### *Secondary / Supplementary Water Heater*

A heater that are not the primary source of hot water for the dwelling but have a supplementary role, usually supplying just one room or location.

### *Standing losses*

Radiation and convection losses incurred when the boiler is not firing.

### *Steady-State Combustion Efficiency*

A measure of how efficiently a water heater / boiler converts fuel to heat, once the heater has warmed up and is running steadily.

### *Storage Heaters*

An appliance that heats water in larger quantities ready for use at later times.

### *Tapping Cycles*

Patterns of hot water demand or draw-off during the period stated

### *Thermal Efficiency*

A measure of the efficiency of converting a fuel into energy or useful work.

### *Thermostat*

A device used to regulate the temperature of water or air.

## **Chapter 3: Windows**

### *CE Marking*

CE Marking on a product is a manufacturer's declaration that the product complies with the essential requirements of the relevant European health, safety and environmental protection legislation that contain the essential requirements and/or performance levels to which the products must conform.

### *Composite Frames*

Composite frames may combine materials to obtain aesthetics of one material with the functional benefits of another. Composite window frames consist of composite wood products, such as particle board and laminated strand lumber. There are vinyl-wood and aluminium-wood composites as well.

### *Double or Triple Glazing*

It is better to have two or three panes of glass with an air or gas space between them in order to decrease heat loss through the windows.

### *Eco-Balances*

Eco-balance involves the environmental impact input/output data to identify, quantitatively measure the environmental impact of products.

### *Embodied Energy*

Embodied energy refers to the quantity of energy required to manufacture, and supply to the point of use, a product, material or service.

### *Energy Performance Label*

Energy performance labels are easy to understand to determine how well a product will perform in terms of energy efficiency. For windows it is to cover functions of insulation, keep out wind, and resist condensation.

### *Finish*

Finishes such as varnishes, glazes or water repellents (usually paraffin wax or related material, resin or drying oil) are used to form a protective coating to wooden frames.

### *Thermal Performance*

Thermal performance of the building envelope, both in terms of improved insulation and air-tight construction, plays a key role in minimising energy use for heating and cooling and hence in reducing carbon emissions. Thermal performance includes factors such as thermal bridges as well as effects of solar gain.

### *U-Value*

The U-value is a measure of heat loss. It is expressed in  $W/m^2K$ , and shows the amount of heat lost in watts (W) per square metre of material (for example wall, roof, glazing, and so on) when the temperature (K) is one degree lower outside. The lower the U-value, the better the insulation provided by the material.

### *Laminated Glass*

Laminated glass is a sandwich of two or more glass sheets with one or more interlayers, typically of polyvinyl butyral (PVB) or resin. In case of breakage, the interlayer holds the fragments together and continues to provide resistance to the passage of persons or objects (particularly suitable for shop-fronts, balconies, stair-railings, roof glazing).

### *Fire Resistant Laminates*

Fire-resistant glasses assembled using two or more intumescent interlayers, which expand in the event of fire. Fire-insulating glass contains inflammable gas and prevents not only the transmission of flames and smoke but also of heat to the other side of glazing. Fire-resistant glasses are classified according to their performance rating (duration of resistance to fire and type of insulation).

### *Tinted Flat Glass*

Normal float-clear glass into whose melt colorants are added for tinting and solar-radiation absorption properties, reducing heat penetration in buildings. Production is the same as in float glass production.

## **Chapter 3: Recycled Mineral Construction and Demolition Waste**

### *Aggregates*

Mineral materials, such as sand or stone, used in making construction materials.

### *Bulk/apparent Density*

Mass to volume ratio of a grainy material in a pile or in the usual transport container (as opposed to the mass to volume ratio of the single particles)

### *Construction & Demolition Waste*

Residues of building materials arising during construction, rehabilitation and demolition of a building, which the owner wants to get rid of.

### *Eluate*

The solution obtained by a laboratory leaching test (as defined by directive 1999/31/EC)

### *Frost-Susceptibility*

sensitivity of a material to be destroyed by frost

### *Heat Resistance and Flowability of Sand*

Ability of taking up heat without the sand grains starting to stick together

### *Limit Values*

Maximum or minimum allowed value of a specific property of a material. Here mostly: the maximum allowed concentration of a certain pollutant in a material or its eluate.

### *Leachate*

Liquid (mostly an aqueous solution) having been in contact with a solid and solved the soluble components of this solid.

### *Mineral Material*

Inorganic material excepting elementary metals and their alloys.

### *Particle Size Distribution*

A grainy material is separated into fractions of different particle sizes by standardised screening. The relative masses of these fractions show the particle size distribution.

### *Primary Resources*

In principle primary resources are all means of the nature taken or used by humanity in order to meet its needs. In this report primary resources means primary materials that are materials taken from nature by humanity.

### *Quality Assurance*

System which makes sure that predefined quality criteria are met

### *Recycled Materials*

Materials having been subject to a recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes

### *Recycled Minerals*

Inorganic materials (without metals) having been subject to a recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes.

### *Selective Demolition*

Demolition of a building in a way that the different building materials are as far as possible taken from the building in different phases, so that a maximum of sorted material is achieved.

### *Source-Separated*

Material which has become waste, separated at the site of its main use.

### *Virgin Materials*

Materials taken from nature = primary materials

## Appendix C: Additional Material on Water Heaters

Table C-1: 2004/05 Stock and Sales of Water Heating Products in Selected Countries

	Austria		Denmark		Germany		UK		EU22 <sup>††</sup>		
	000's	%	000's	%	000's	%	000's	%	000's	%	
<b>Existing Stock<sup>†</sup></b>	<u>4,283</u>	<u>100%</u>	<u>1,664</u>	<u>100%</u>	<u>50,134</u>	<u>100%</u>	<u>37,024</u>	<u>100%</u>	<u>236,516</u>	<u>100%</u>	
District heating	74	2%	212	13%	441	1%	0	0%	2,606	1%	
Linked to Boiler	1,378	32%	643	39%	15,071	30%	20,598	56%	87,301	37%	
Dedicated Units	Solar Thermal	159	4%	36	2%	587	1%	7	0%	1,661	1%
	Elec. Inst.	81	2%	12	1%	10,600	21%	12,189	33%	26,784	11%
	Elec. Storage	2,396	56%	752	45%	19,832	40%	2,905	8%	84,707	36%
	Gas Inst.	186	4%	6	0%	2,464	5%	1,018	3%	29,688	13%
	Gas Storage	9	0%	3	0%	1,139	2%	307	1%	3,769	2%
<b>Sales</b>	<u>250</u>	<u>100%</u>	<u>79</u>	<u>100%</u>	<u>2,306</u>	<u>100%</u>	<u>7,397</u>	<u>100%</u>	<u>17,188</u>	<u>100%</u>	
'Combi' Boilers	17	7%	1	1%	120	5%	1,100	15%	4,481	26%	
Indirect Cylinder	78	31%	33	42%	685	30%	0	0%	2,316	13%	
Dedicated Units	Elec. Storage	140	56%	43	54%	815	35%	151	2%	5,905	34%
	Elec. Inst.	6	2%	1	1%	610	26%	1,418	19%	2,403	14%
	Gas Storage	8	3%	1	1%	40	2%	4,717	64%	1,849	11%
	Gas Inst.	1	0%	0	0%	36	2%	11	0%	234	1%

**Notes:** <sup>†</sup>Reflects number of properties with equipment installed, except for Germany, which reflects number of products. <sup>††</sup>refers to products, not dwellings. <sup>†††</sup>EU22 excludes Cyprus, Luxembourg & Malta.  
**Source:** Adapted from VHK (2007).

Table C-2: EU25 Apparent Consumption of Water Heaters & Boilers

Year	Electric instantaneous		Electric Storage		Gas Instantaneous & Storage		Total	
	Mill. Units	Million EUR	Mill. Units	Million EUR	Mill. Units	Million EUR	Mill. Units	Million EUR
2004	4.3	437	15.7	607	4.1	1,295	31.0	7,019
2005	5.3	433	20.2	708	4.4	1,310	29.9	7,442
2006	4.4	577	20.9	900	4.6	1,405	37.0	8,143
2007	5.1	455	29.1	1,277	4.6	1,345	45.7	8,056
Growth 2004-07	18%	4%	86%	110%	13%	4%	47%	15%
% of Total in 2007	11%	6%	64%	16%	10%	17%	100%	100%

**Notes:** Apparent consumption is equal to total production plus imports minus exports. Market Values are in 2007 Euros. † Estimate, based on average production value. †† No data available EUROSTAT.  
**Source:** Adapted from PRODCOM Data.

Figure C-1: EU Electric Water Heater Market 2004-05

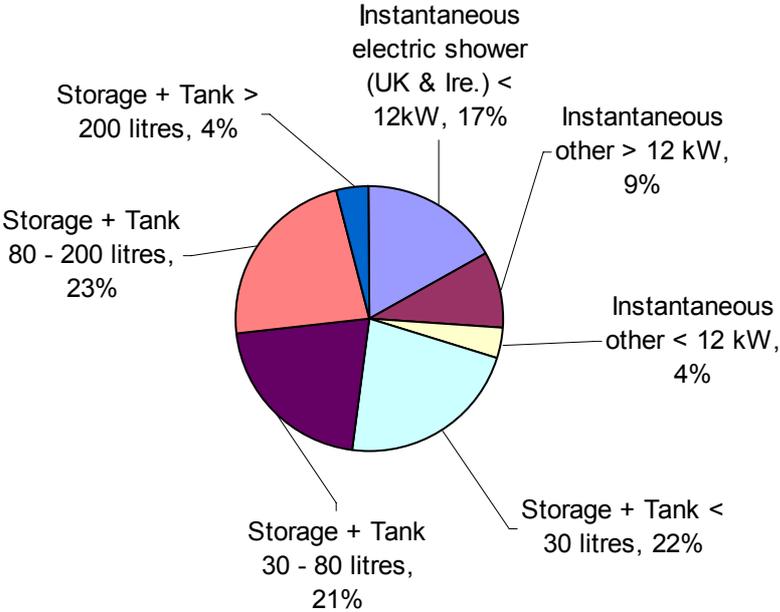


Figure C-2: EU Gas-fired Water Heater Market 2004-05

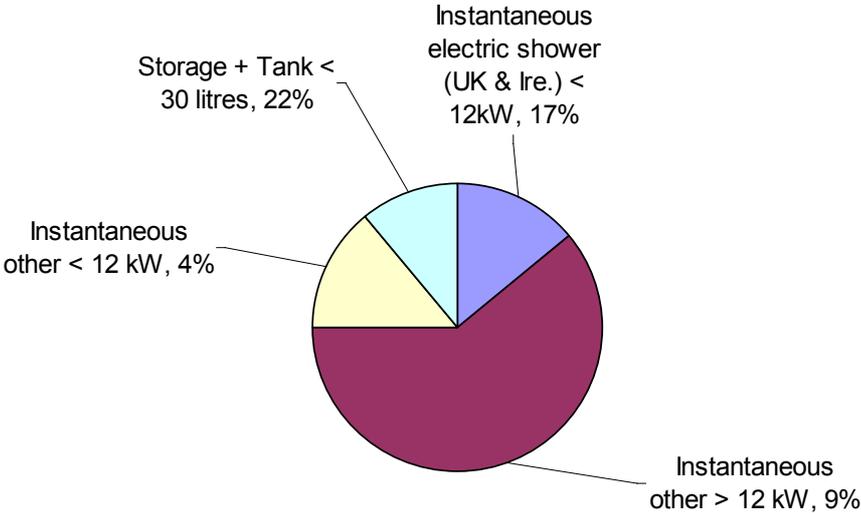


Table C-3 Product Categories & Tapping Cycles

Category	Profile (EN Tapping)	Max Flow Rate (l/min)	Max tapping Req'd (l)	24 hr Demand	No of Cycles / 24 hrs	Description
XXS	1c	2	2	2.1	18	Sink without dishwasher
XS	1b	4	5	2.1	16	Average sink
S	1	5	9	2.1	11	Large sink / small shower
M	2	6	24	5.85	23	Average shower
L	3	10	62	11.7	24	Bath
XL	4	10	76	19.1	30	Large Bath
XXL	5	16	107	24.5	30	Simultaneous bath / shower
3XL	N/A	48	215	46.8	23	Collective / non residential small
4XL	N/A	96	430	93.6	23	Collective / non residential large

## EN Standards List

- (i) EN 26: Gas Fired Instantaneous Water Heaters
- (ii) EN 89: Gas Fired Storage Water Heaters
- (iii) EN 13203-1: Gas Fired Water Heaters Performance Assessment (< 70 kW & 300l)  
This applies to all gas-fired appliances producing domestic hot water of less than 70 kW and with less than 300 litre-capacities. It sets out both qualitatively and quantitatively the delivery performance of water heaters for a variety of uses.
- (iv) EN 13203-2: Gas fired Water Heaters Energy Use  
This also applies to all gas-fired appliances producing domestic hot water of less than 70 kW and with less than 300 litre-capacities. It sets out the methodology for assessing the energy performance of the heaters.  
  
It defines a number of daily delivery programmes for domestic hot water use (re mandate M324), together with corresponding test procedures, enabling the performance of different gas-fired water heaters to be compared and matched to the needs of the end-user.
- (v) EN 50440: Efficiency of Domestic Electric Storage Water Heaters  
This is similar to EN 13203-2 but for electric heaters and is based on differing daily delivery programmes or tapping cycles of mandate M324. However there are some differences in the methods of measurement and it has yet to be seen whether any resulting error is within acceptable limits.
- (vi) EN 12897: Specification for Indirectly Heated, Closed Storage Water Heaters
- (vii) EN 15332: Energetic Assessment of Hot Water storage Tanks
- (viii) EN-EIC 60379: Methods of Measuring Performance of Electric Water Storage Heaters.

Table C-1-1: Energy and Cost Savings from purchase of Least Life Cycle Cost Water Heaters

<b>Heater Size</b>		<b>Savings relative to business-as-usual</b>	
<b>Category</b>	<b>Maximum Draw Off</b>	<b>Cost</b>	<b>Energy Use</b>
	<b>(Litres)</b>	<b>(Percentage Savings)</b>	
XXS	1.8	0.5	4
XS	5.4	14	14
S	9	17	29
M	24	21	23
L	62	30	32
XL	75	27	37
XXL	107	35	45
XXXL	192	24	28
XXXXL	384	42	45

**Notes:** LLCC options as specified by VHK (2007). Options should be considered representative and savings are indicative only.

**Source:** Adapted from VHK (2007).

# Appendix D: Additional Material on Windows

## EN Standards List

- (i) EN ISO 12567-1:2000 Thermal performance of windows and doors - Determination of thermal transmittance by hot box method - Part 1: Complete windows and doors (ISO 12567 1:2000)
- (ii) EN ISO 10077-2:2003 Thermal performance of windows, doors and shutters - Calculation of thermal transmittance - Part 2: Numerical method for frames (ISO 10077-2:2003)
- (iii) EN ISO 12567-2:2005 Thermal performance of windows and doors - Determination of thermal transmittance by hot box method - Part 2: Roof windows and other projecting windows (ISO 12567-2:2005)
- (iv) EN 12412-4:2003 Thermal performance of windows, doors and shutters - Determination of thermal transmittance by hot box method - Part 4: Roller shutter boxes
- (v) EN 12412-2:2003 Thermal performance of windows, doors and shutters - Determination of thermal transmittance by hot box method - Part 2: Frames
- (vi) EN ISO 10077-1:2006 Thermal performance of windows, doors and shutters - Calculation of thermal transmittance - Part 1: General (ISO 10077-1:2006)
- (vii) EN 14220:2006 Timber and wood-based materials in external windows, external door leaves and external doorframes - Requirements and specifications
- (viii) EN 14221:2006 Timber and wood-based materials in internal windows, internal door leaves and internal doorframes - Requirements and specifications
- (ix) EN 12608:2003 Un-plasticized polyvinylchloride (PVC-U) profiles for the fabrication of windows and doors - Classification, requirements and test methods

**Table 3.2 Performance standards for windows**

ÖNORM B 5300:2002-02-01	Windows - General requirements
ÖNORM B 5305:1992-07-01	Windows - Maintenance
ÖNORM B 5306:1990-12-01	Window; terms with definitions
ÖNORM B 3013:1993-07-01	Wooden raw profiles for windows - Requirements and test specifications
ÖNORM B 3710: 2004-04-01	Flat glass in building - Terms with definitions for types of glass and glass products
ÖNORM B 3710:2004-04-01	Flat glass in building - Terms with definitions for types of glass and glass products
ÖNORM B 3803:2006-05-01	Protection of timber used in buildings - Coatings of dimensionally stable wooden outdoor building components - Minimum requirements and testing
ÖNORM B 5315-1:1993-05-01	Wooden windows - Examples for the construction of casement windows, bottom-hinged and side/bottom hung sash windows - Single windows
ÖNORM B 5315-2:1993-05-01	Wooden windows - Examples for the construction of casement windows , bottom-hinged and side/bottom hung sash windows - Composite windows
ÖNORM B 8110-6 Bbl 1: 2008-08-01	Thermal insulation in building construction - Part 6: Principles and verification methods - Heating demand and cooling demand - Supplement 1: Single family house - Examples for validation of the calculation of the heating demand
ÖNORM EN 107:1981-09-01	Methods of testing windows; mechanical tests
ÖNORM EN 12207:2000-02-01	Windows and doors - Air permeability - Classification
ÖNORM EN 12208:2000-02-01	Windows and doors - Watertightness - Classification
ÖNORM EN 1279: 2002-11-01	Glass in building - Insulating glass units
ÖNORM EN 14220:2007-02-01	Timber and wood-based materials in external windows, external door leaves and external doorframes - Requirements and specifications
ÖNORM EN 477:1996-01-01	Un-plasticized polyvinylchloride (PVC-U) profiles for the fabrication of windows and doors - Determination of the resistance to impact of main profiles by falling mass
ÖNORM EN 479:1996-01-01	Un-plasticized polyvinylchloride (PVC-U) profiles for the fabrication of windows and doors - Determination of heat reversion
ÖNORM EN 513:1999-10-01	Un-plasticized polyvinylchloride (PVC-U) profiles for the fabrication of windows and doors - Determination of the resistance to artificial weathering

**Source:** Austrian Standards Institute

**Table 3.6 Blauer-engel Window related markings and labels**

Technical / quality markings	Name	Granting institution	Awarding criteria
	German marking of conformity (Uebereinstimmungszeichen)	German Institute for Structural Engineering (Deutsches Institut für Bautechnik, DIBt) and certified bodies	Compliance with either the technical rules of the Construction Products List according to the Building Regulation Law, or with harmonized European standards
	CE conformity marking	e.g. the Institute for Windowing (Institut fuer Fenstertechnik, IFT)	Regulation Law, or with harmonized European standards
	RAL quality label/windows (RAL Gütezeichen/Fenster)	RAL German Institute for Quality Assurance and Labeling (RAL Deutsches Institut für Guetesicherung und Kennzeichnung)	Compliance with quality standard guidelines issued by the RAL Four guidelines on windows, insulated glazing, sealing profiles, liquid-tight joints)
	Blue Angel (Blauer Engel)	RAL German Institute for Quality Assurance and Labeling (RAL Deutsches Institut für Guetesicherung und Kennzeichnung)	n.a.
	Forest Stewardship Council	Forest Stewardship Council mandating certifying bodies	Ten principles and 56 associated criteria applying to all tropical, temperate and boreal forests and to plantations and partially replanted forests

# Appendix E: Additional Material on Recycled Mineral Construction & Demolition Waste

The Austrian Recycled Construction Materials Association (Oesterreichischer Baustoff-Recycling Verband – BRV) together with the Austrian Recycled Construction Materials Quality Assurance Association (Oesterreichischer Gueteschutzverband Recycling Baustoffe) have issued a series of guidelines on the quality of CDW for recycling (BRV, 2004, BRV et al., 2007a,b,c) ‘to guarantee the quality of recycled building materials and to assure their quality based on the issuance of quality certifications/marks for recycled construction material.’

The guidelines are intended to set the regulatory requirements (regarding the production and use of recycled construction materials and regarding environmental compatibility) as well as to specify the kind and the extend of tests for recycled building materials. The aim is to reach a quality standard which meets the requirements corresponding to the future use of recycled building materials.

As these guidelines may be exemplary for other EU Member states their core rules shall be shown in some detail.

Every recycling material for building construction is designated according the scheme shown in **Fejl! Henvisningskilde ikke fundet. E-1**

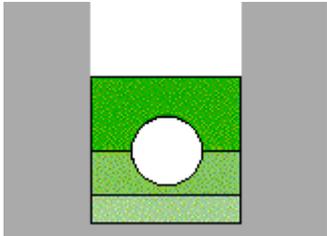
**Table E-1: Designation scheme for recycled building construction material**

	Material designation	Grade	Grading Curve Field	Quality class
Example	RMH	III	0/32	A+

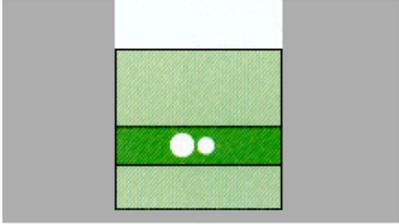
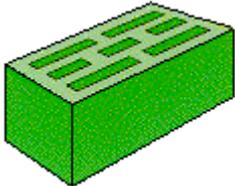
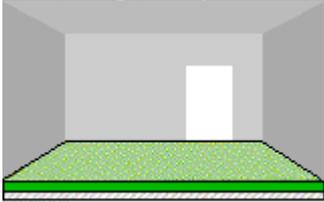
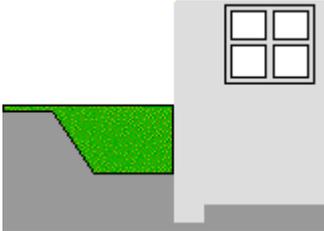
Source: BRV, et al. (2007a).

Table shows the material designations, the origins of the corresponding materials, their fractions and their proposed use.

**Table E-2 Designation, origin and application of recycled material for building construction**

Name of Recycling Material	Origin	Recycling Material Fractions	Use
A) Recycled material resulting from demolition of above ground construction <sup>12</sup>			
RMH Recycled mineral waste resulting from demolition of above ground constructions (mineralische Hochbaurestmassen)	Demolition of industrial plants and general buildings 	Mineral building construction residues – concrete, brick, natural stones 	trench fillings, backfill for buildings, sports field construction 
RS	Demolition of industrial	Recycling sand	Bedding of cables and pipes

<sup>12</sup> Recycled construction material in this category are made from properly sorted waste resulting from the demolition of suitable above-ground structures and construction parts or from pure materials entirely constructed from waste resulting from demolition of above-ground construction. They mainly consist of concrete, bricks and natural stone.

Name of Recycling Material	Origin	Recycling Material Fractions	Use
Recycled sand	plants and general buildings 		
RZ Recycled brick sand; recycled granular brick (Ziegelbruch)	Brick production Demolition 	Recycled brick sand Recycled brick chippings 	Additive for the production of masonry material or cement; stabilisation, drainage strata, fillings, roof greening, landscaping 
RHZ Recycled brick sand resulting from above – ground constructions; recycled granular brick resulting from above ground constructions (Hochbau/Ziegelbruch)	Demolition of homes and buildings 	Recycled above- ground brick sand, Recycled above- ground granular brick (with a brick share > 33 %) 	Additive for the production of masonry material or cement; stabilisation, drainage strata, fillings, floor pavement 
RH Recycled above-ground construction sand, recycled granular materials from above-ground construction (Hochbauabbruch)	Demolition of industrial plants and buildings 	Recycled above- ground brick sand, Recycled above- ground granular brick (with a brick share < 33 %) 	Stabilised fillings, trench fillings, backfill for buildings, sports field construction, landscaping, road construction in agriculture and forestry 
<b>B) Recycled material resulting mainly from road construction</b>			
RA Recycled crushed granular asphalt (Asphaltaufbruch)	Road construction	Recycled crushed asphalt granulate	Material for all layers in road construction
RB Recycled crushed granular concrete (Betonabbruch)	Road construction, bridges, industrial buildings	Recycled crushed concrete granulate (mostly concrete)	Material for all layers in road construction, additive to concrete production, high quality trench filling, drainage strata
RAB Recycled crushed granular concrete/ asphalt mix (Asphalt/Betonabbruch)	Road construction, bridges, parking areas	Recycled crushed asphalt/concrete mix-granulate (as- phalt and concrete)	Material for road construction

Name of Recycling Material	Origin	Recycling Material Fractions	Use
RM Recycled crushed mixed granular material consisting of concrete and/or asphalt and no more than 50 % stone (natural and/or recycled) (Mineralische Restmassen)	Road construction	Recycled crushed granulate from asphalt, concrete and natural stones	Material for road construction
RG Recycled crushed mixed granular material consisting of concrete and/or asphalt and more than 50 % stone (natural and/or recycled)	Road construction	Recycled crushed granulate from asphalt, concrete and natural stones	Material for road construction
C) Other			
RFM Material for trench fillings, capable of flowing and self-compacting (Fließfähiges, selbstverdichtendes Künnettenfüllmaterial)	Demolition of industrial plants and general buildings	Material for trench fillings, capable of flowing and self-compacting consisting of recycled crushed material	Trench fillings, cavity fillings, backfillings

Source: BRV et al. (2007a,b,c), BRV (no year).

The grade of the recycling materials (see Table E-3) is defined by following criteria on civil engineering and material composition properties

- Grain- and/or particle-size distribution
- Frost-susceptibility
- Resistance against fragmentation
- Water absorption, water content
- Frost-dew resistance
- Bulk / apparent density
- Specific heat resistance and flowability (for recycled sand only)
- Maximum content of foreign materials (bitumen and mineral materials not part of the definition as shown in Table E-2)
- Maximum content of impurities of non-harmful waste and of organic impurities
- Mixing ratios and minimum content of binding agents (for certain material designations).

The grade in turn defines the fields of application of the recycling material from the civil engineers point of view (see **Fejl! Henvisningskilde ikke fundet.** for an example).

The grading curve field defines the required grain- or particle-size distribution (see **Fejl! Henvisningskilde ikke fundet.** for an example).

The quality class is defined by criteria which are relevant to environmental protection (see Table 4-2 in the main text and Table E-5 below) and define the fields of application of the recycling material from the environmental point of view (see Table 4-3 in the main text).

**Table E-3: Grading categories for mineral recycled construction material**

Category	Definition	Additional Definition
Grade I	Frost-proof and frost resistant building materials for unbound base courses and sub-base courses and for the construction of hydraulically and bituminous bound bases	
Grade II	Frost-proof and frost resistant building materials for unbound sub-bases and hydraulically bound base courses	
Grade III	Building materials for hydraulically bound base courses, agricultural and forestry road construction, parking areas, noise protection embankment, fillings, filling materials for roadside ditches, subsoil improvement.	With defined grading curve
Grade IV		With a defined maximum grain size

Source: BRV et al. (2007a,b).

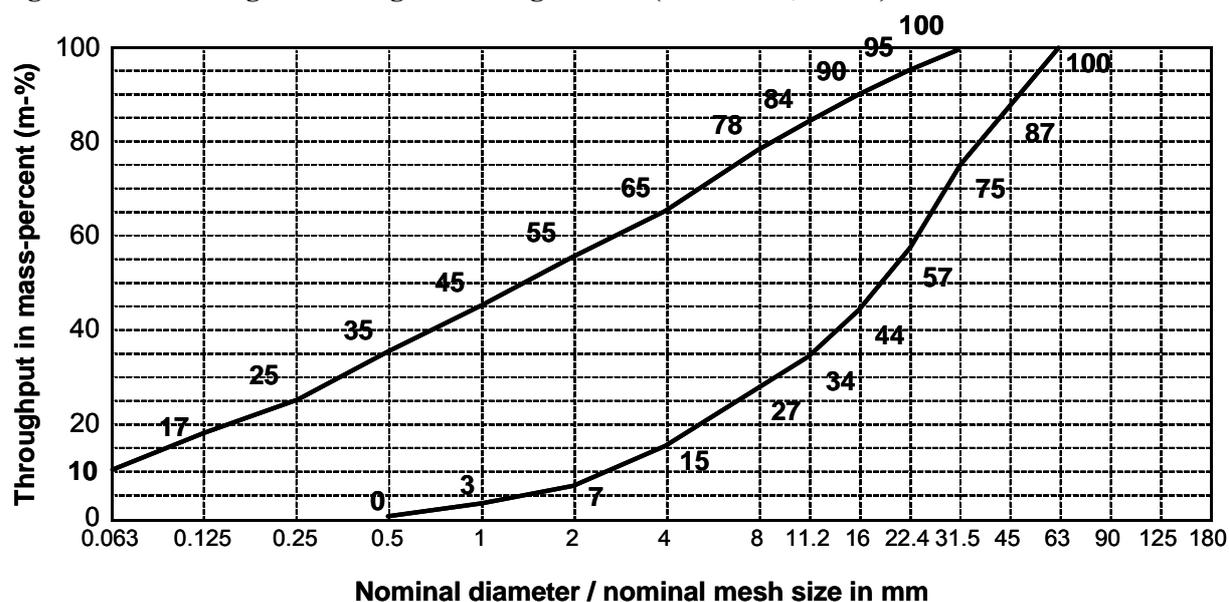
**Table E-4 Fields of application of recycled construction material from the civil engineers point of view – example RMH**

Construction material			RMH	
Grade			III	IV
Use	Hydraulically bound construction methods	Bricks and hollow blocks	-	-
		Concrete	???	-
		Light-weight concrete	???	-
		Screed and screed in bulk format	???	-
		Ground improvement / stabilization	???	-
	Unbound construction methods	Bulks	√	?
		Filling of utility trenches and covering of cables	√	?
		Bedding materials for cable areas	?	-
		Backfilling and covering of structures	√	?
		Cover layers and spread layers in sports structures	?	-
		Substrates for planting purposes (aggregate)	?	-
		Construction materials used for waste site constructions	√	?
	Drainage materials	???	-	
	Flowing self-thickening filling material		???	???

1) brick content must be submitted; √ = suitable; ? = qualification must be confirmed; ??? = additional tests are required to confirm the qualification; - = not suitable

Source: BRV et al. (2007a).

Figure E-1: Grading curve range 0/32 for grade III (BRV et al., 2007a)



Source: BRV et al. (2007a).

Table E-5: Classification of recycled construction material according to environmental protection criteria which have to be measured only if there are indications, based on the provenance of the material, of a possible contamination during use

Parameters	Unit	Class A+	Class A	Class B
<b>Eluate at a liquid to solid ratio (L/S) of 10</b>				
Antimony	mg/kg dry matter	0.006	0.06	0.1
Arsenic	mg/kg dry matter	0.5	0.5	0.5
Barium	mg/kg dry matter	20	20	20
Lead	mg/kg dry matter	0.5	0.5	0.5
Cadmium	mg/kg dry matter	0.04	0.04	0.04
Molybdenum	mg/kg dry matter	0.5	0.5	0.5
Nickel	mg/kg dry matter	0.4	0.4	0.6
Mercury	mg/kg dry matter	0.01	0.01	0.01
Selenium	mg/kg dry matter	0.1	0.1	0.1
Zinc	mg/kg dry matter	4	4	18
Chloride	mg/kg dry matter	800	800	1000
Fluoride	mg/kg dry matter	10	10	15
Phenol index	mg/kg dry matter	1	1	1
Dissolved organic carbon (DOC) [1]	mg/kg dry matter	500	500	500
Total dissolved solids TDS [2]	mg/kg dry matter	4 000	4 000	8 000
<b>Total content</b>				
Significant Carbohydrate (CH) content is only permitted on condition that this originates from primary construction materials and from oil contamination.				
Arsenic	mg/kg dry matter	20	30	30
Lead	mg/kg dry matter	30	100	100
Cadmium	mg/kg dry matter	0.5	1.1	1.1
Chromium total	mg/kg dry matter	40	90	90
Copper	mg/kg dry matter	30	90	90

Parameters	Unit	Class A+	Class A	Class B
Nickel	mg/kg dry matter	30	55	55
Mercury	mg/kg dry matter	0.2	0.7	0.7
Zink	mg/kg dry matter	100	450	450

[1] May be investigated if own pH value or alternatively where L/S = 10 l/kg and pH value 7.5 to 8.0.  
[2] The values for totally dissolved solids (TDS) can be used instead of sulphate and chloride. However, sulphate must be determined in any case.

Source: Lebensministerium (2006).

The quality label as shown in Figure E-2 is assigned to specific recycling material after a process of examinations has shown, that the recycling material meets the requirements of the guideline. The examination process consists of following steps:

First examination: it is checked by an independent certification institution if the requesting company has the necessary means for assuring the quality of the recycling material under investigation. The material itself is tested, graded and classified once per facility, once per kind of granulate (according to Table E-2) and once per delivered aggregate.

Internal control comprises

- visual inspection of every load,
- daily visual inspection of processing and storage
- weekly inspection of grain size-distribution
- bi-weekly measurement of pH-value, electrical conductivity, chromium and copper
- monthly inspection/analysis of flowability, content of foreign materials and impurities
- External surveillance – the whole test-programme twice a year by an independent certified institution.

Figure E-2: The Austrian quality label for recycled construction material



Source: BRV et al. (2007a).

The Topic Centre has prepared this report for the European Environment Agency (EEA) under its 2008 work programme as a contribution to the EEA's work on policy analysis and assessment.

### **Project team**

David Legg, Environment Agency England and Wales (ETC project manager)  
Pawel Kazmierczyk, European Environment Agency (EEA project manager)  
Carol Wilson, Environment Agency England and Wales  
Philipp Schepelmann, Wuppertal Institute, Germany  
Marton Herczeg, European Topic Centre on Resource and Waste Management  
Hubert Reisinger, Umweltbundesamt, Austria

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European Topic Centre on Resource and Waste Management  
Højbro Plads 4  
DK-1200 Copenhagen K  
Phone: +45 72 54 61 60  
Fax: +45 33 32 22 27  
Email: [etc@etc.mim.dk](mailto:etc@etc.mim.dk)  
Website: <http://waste.eionet.eu.int>