European Commission

JRC SCIENCE AND POLICY REPORTS

Green Public Procurement Criteria for the design, construction and management of Office buildings

(Draft) Technical background report and criteria proposal

Nicholas Dodd, Elena Garbarino, Oliver Wolf (JRC-IPTS)

December 2014

Joint Research Centre

European Commission
Joint Research Centre
Institute for Prospective Technological Studies

Contact information
Nicholas Dodd
Address: Edificio Expo. c/ Inca Garcilaso, 3. E-41092 Seville (Spain)
E-mail: jrc-ipts-office-buildings@ec.europa.eu
Tel.: +34 954 488 728
Fax: +34 954 488 300

https://ec.europa.eu/jrc
http://ipts.jrc.ec.europa.eu

Table of contents

List of Tables

List of Figures

1 INTRODUCTION

Public procurement constitutes approx. 19% of overall Gross Domestic Product (GDP) in Europe (EC, 2011) – and thus has the potential to provide significant leverage in seeking to influence the market and to achieve environmental improvements in the public sector.

To reduce the environmental impact of public purchasing, it is important to identify and develop green public procurement (GPP) criteria for products, services and works which account for a high share of public purchasing combined with a significant improvement potential for environmental performance.

The construction and refurbishment of buildings in an energy and resource efficient way is an important policy objective for Europe. The recast *Energy Performance of Buildings Directive* [1], the *Renewable Energy Directive* [2] and the *Energy Efficiency Directive* [3] together set out requirements for buildings that contribute towards ambitious EU targets for energy efficiency and renewable energy generation by 2020. Moreover, these policy instruments also require the public sector, in the first place through the procurement of refurbishment and new-build projects by central government, to lead the way in delivering efficiency improvements and in deploying cleaner forms of energy generation. The Roadmap to a Resource-Efficient Europe [4] highlighted the significant impact of construction on natural resources. This is further emphasised in the Commission's Communications *Towards a Circular Economy* [5] and *Resource Efficiency Opportunities in the Building Sector* [6] which outline future policy initiatives to address construction and demolition waste.

The development of GPP criteria for the design, construction and management of office buildings aims therefore at helping public authorities to ensure that office buildings projects are procured and implemented in order to deliver environmental improvements and with reference to the European policy framework for energy and resource efficiency. In order to identify the most significant improvement areas an analysis is required of the environmental impacts of office buildings. It also requires an understanding of commonly used procurement processes for office buildings and the actors involved in delivering successful projects.

For this reason, the European Commission has developed a process aiming at bringing together both technical and procurement experts to develop a broad body of evidence and to develop in a consensus oriented manner, a proposal for criteria which promise to deliver substantial environmental improvements.

Green Public Procurement (GPP) is a voluntary instrument. The criteria are divided into selection criteria, technical specifications, award criteria and contract performance clauses. For each set of criteria there is a choice between two ambition levels:

- The *Core criteria* are those suitable for use by any contracting authority across the Member States and address the key environmental impacts. They are designed to be used with minimum additional verification effort or cost increases.
- The *Comprehensive criteria* are for those who wish to purchase the best products available on the market. These may require additional verification effort or a slight increase in cost compared to other products with the same functionality.

This Technical Report provides the technical background information and further details on the reasons for selecting the GPP criteria for office buildings. Together with this technical report, the GPP criteria for office buildings are also provided, supported by a guidance document that provides orientation on how to effectively integrate these GPP criteria into the procurement process. These documents represent the latest updated version of the GPP criteria for the office buildings project.

Publically available information related to the development of the GPP criteria for office buildings can be found at (http://susproc.jrc.ec.europa.eu/buildings/index.html) hosted by the Institute for Prospective Technological Studies IPTS.

1 Directive 2010/31/EC of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (recast)

2 Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources

3 Directive 2012/27/EU of the European Parliament and of the Council of 25th October 2012 on energy efficiency

4 Communication COM (2011) 571 final

5 Communication COM (2014) 398 final

6 Communication COM (2014) 445 final

1.1 Scope and definitions of office buildings

This GPP criteria set addresses the procurement process for office buildings, including their design, site preparation, construction, servicing and ongoing management. For the purposes of the criteria, the product group "Office buildings" shall comprise buildings where mainly administrative, bureaucratic and clerical activities are carried out. An office building is, moreover, defined as being:

> *"A building which contains administrative, financial, technical or bureaucratic activities as core representative activities. The office area must make up a significant majority of the total building's gross area. The building may also comprise other type of spaces, like meeting rooms, training classrooms, staff facilities, or technical rooms".*

Buildings constituting offices will fall under the specific planning use classes within Member States. The definition of ''significant'' can vary by Member State, but is generally within a range of 50-80% of the building. The GPP criteria do not cover parking areas that are located outside of the building's physical footprint or curtilage. Major renovations of office buildings are also addressed within the scope of the criteria. Such renovations are defined by the Energy Performance of Buildings Directive 2010/31/EU as instances where:

> *a) the total cost of the renovation relating to the building envelope or the technical building systems is higher than 25 % of the value of the building, excluding the value of the land upon which the building is situated; or*
>
> *(b) more than 25 % of the surface of the building envelope undergoes renovation.*

The proposed GPP criteria contain recommendations that apply to both the renovation of existing buildings and the construction of new buildings. They are structured in order to broadly reflect the distinct sequence of procurement activities that tend to form part of a project:

- Preliminary scoping and feasibility;
- Detailed design and applications for permits;
- Strip-out, demolition and site preparation works;
- Construction of the building or major renovation works;
- Installation of energy systems and the supply of energy services;
- Completion and handover;
- Facilities management.

Energy services are defined according to Directive 2006/32/EC on energy end-use efficiency and energy services as:

> *The physical benefit, utility or good derived from a combination of energy with energy efficient technology and/or with action, which may include the operations, maintenance and control necessary to deliver the service, which is delivered on the basis of a contract and in normal circumstances has proven to lead to verifiable and measurable or estimable energy efficiency improvement and/or primary energy savings.*

For the purpose of the GPP criteria of office buildings the procurement of energy services is primarily concerned with the provision of the supply of low or zero carbon emission energy to an office building by, as defined by Directive 2006/32/EC, energy service companies (ESCO's) or energy performance contracting (EPC).

Facilities management is defined according to EN 15221 [7] as:

> *'[the] integration of processes within an organisation to maintain and develop the agreed services which support and improve the effectiveness of its primary activities'*

7 EN 15221 series, *Facility management*, October 2006 version

For the purpose of the GPP criteria 'primary activities' refer to operation of the office building with main area of relevance within EN 15221 being 'Space & Infrastructure' which encompasses the activities relating to the management of accommodation, workplaces, technical infrastructure and ICT systems.

In general, the criteria focus on an office building as a system rather than individual components. It should be noted that separate GPP criteria are available that can be used for the procurement of various building components. Components of relevance for which there exist EU GPP criteria [8] include:

- Thermal insulation,
- Wall panels,
- Combined Heat and Power (CHP) systems,
- Water-based heating systems,
- Indoor lighting,
- Taps and showerheads,
- Toilets and urinals,
- Hard Floor coverings.

1.2 Market analysis

Office building data in EU-28 are not official and rarely harmonised between countries. In the preliminary background report, a detailed market analysis was carried out for office buildings across Europe[9]. Aggregated market data was presented. It should however be remembered that limitations in the transparency of the EU statistics and lack of data in general resulted in a number of assumption having to be made. In order to supplement and update this data, a review has been made of selected reports by the property market analysts BNP-Paribas, DTZ, Jones Lang La Salle and Savills.

The non-residential building stock accounts for approximately 25% of the total floor area, and of this proportion 23% is represented by office buildings (approximately 6% of the total building stock floor area) [10]. The majority of these consist of large office buildings, mainly erected before 1975 and concentrated in moderate climatic zones. These comprise Austria, Belgium, Czech Republic, Denmark, France, Germany, Hungary, Ireland, Luxembourg, Netherlands, Slovakia, Slovenia and UK. .

The construction sector is split into two main categories: buildings and civil engineering work. The data presented in Figure 1.1 shows that "*production for construction*" in Europe was in 2013 at its lowest level during the last 14 years because of the ongoing economic downturn [11]. The office sector has been one of the first to show some tentative signs of recovery, as illustrated by Figure 1.2 which shows trends in development completions, and there have also been signs of a reduction in office vacancy rates [12]. However, due to intensive fiscal austerity policies adopted by some countries, it has to be expected that direct investment and subsidies from governments and public authorities to promote green buildings will be limited in the coming years.

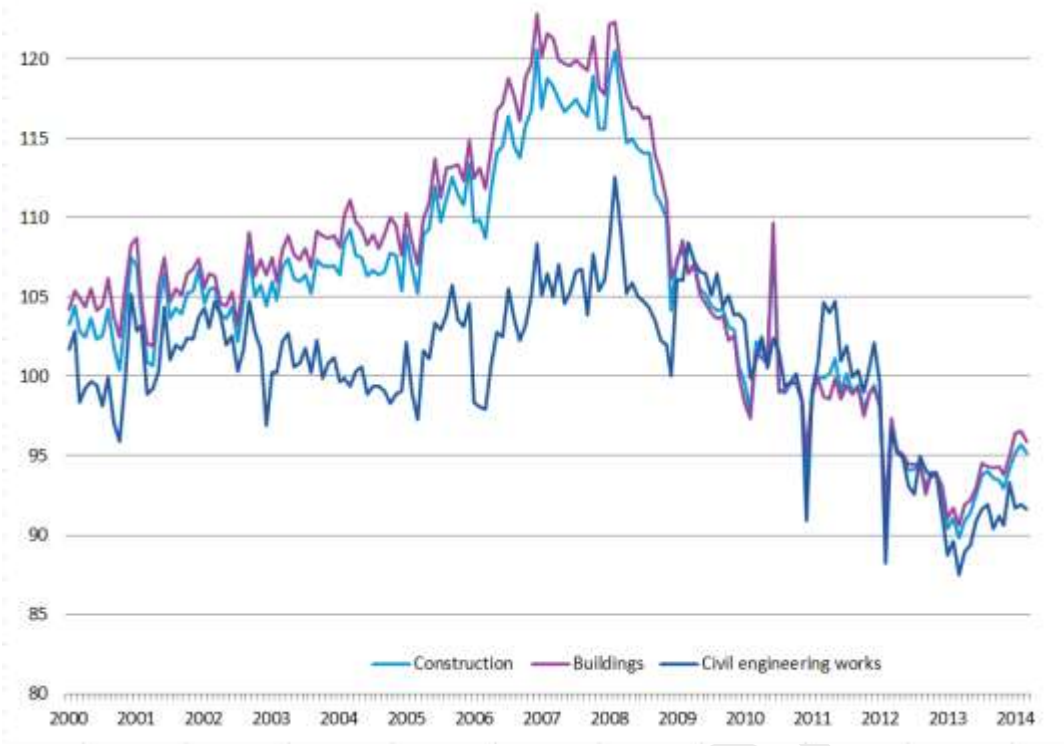
8 See http://ec.europa.eu/environment/gpp/eu_gpp_criteria_en.htm

9 European Commission, *GPP Office buildings: Economical and market analysis*, JRC-IPTS 2011
http://susproc.jrc.ec.europa.eu/buildings/docs/market%20and%20economic%20analysis.pdf

10 Building Performance Institute Europe, *Europe's buildings under the microscope*, October 2011

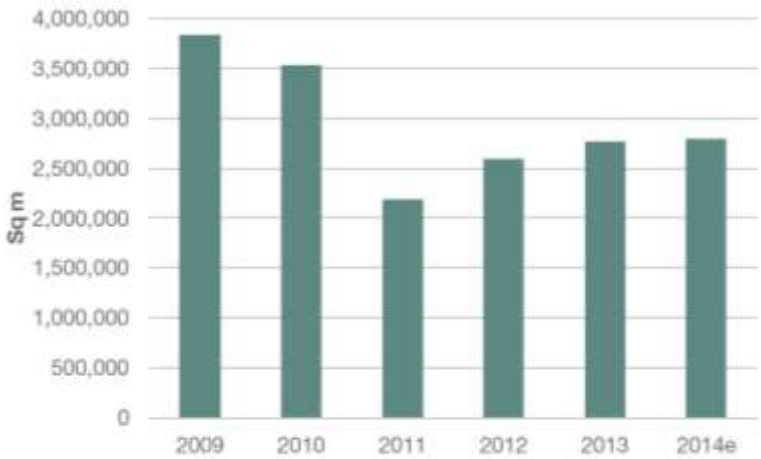
11 Eurostat (2014). *Construction production (index)* overview, Available online at
http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Construction_production_(volume)_index_overview

12 Savills, *Market report: European offices*, March 2014



Source: Eurostat (2014)

Figure 1.1 Index of price adjusted construction output, EU-28, 2000-14



Source: Savills (2014)

Figure 1.2: Office development completions in Europe

Public sector activity

Public construction activity was, until the onset of the economic downturn, an important factor in the market. Prior to the downturn EU-27 expenditure in construction and housing accounted for 1.4% of GDP (3.0% of government expenditure). Often public authorities try to fight economic downturns through public investments which, for example, can include public construction procurement. However, the possibilities to do so depend on budgetary constraints. Indicative figures for the percentage of office buildings attributed to central government and municipalities for some EU-27 countries include Germany (20%), France (30%),

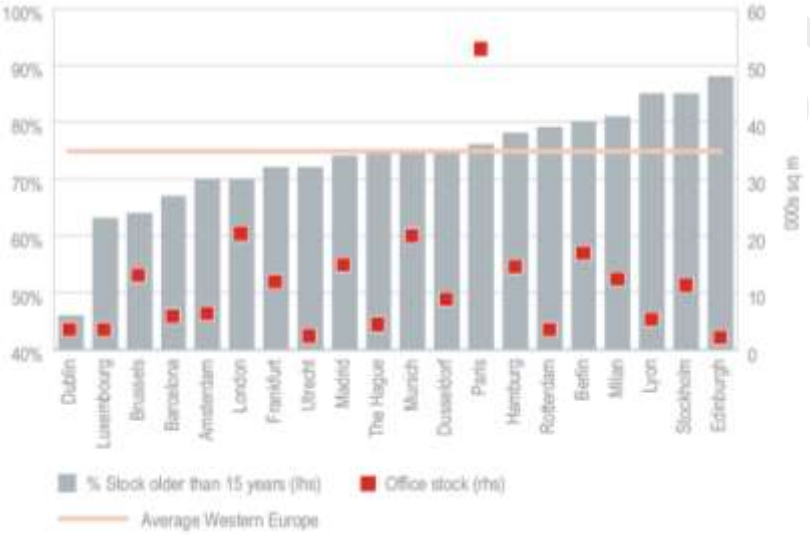
Austria (17%) and Finland (11%). These proportions are expected to fall in the future as cuts in the public sector lead to a rationalisation in the stock and more efficient space utilisation in the retained stock.

As a result, following the EU's debt crisis, some countries have followed intensive fiscal austerity policies and EU's Finance Ministers approved a comprehensive rescue package worth almost a trillion dollars aimed at ensuring financial stability across Europe by creating the European Financial Stability Facility. Only when economic recovery occurs and the crisis of confidence is over, will the amount of money spent on both construction and environmental policy will be the one observed in the years before the financial crisis. Moreover, it can be seen that subsidies from governments to promote green buildings have been reduced, so even though environmental policies have not lost relative importance, their importance has reduced in absolute budgetary terms.

The increasing importance of renovation

As can be seen in Figure 1.3, the majority of Europe's office building stock is dated. For example, in Germany 59% of the stock dates from between 1950 and 1990 and in the UK 22% dates from before 1960. With the continued economic downturn there has been on average a lower rate of replacement of offices across Europe, cited as being between 1% and 3%[13]. This means that as the building stock ages the cost of maintaining this stock will increase for both investors and occupiers.

As a result of the economic crisis an increased focus has been observed on better use of existing building assets, and this is reflected by a wider trend in EU office markets for major renovations instead of new-build projects. A trend has also been noted towards more efficient use of space, with reductions in both office footprints and space per workstation [14].



Source: Jones Lang La Salle (2013) lhs=left axis rhs=right axis

Figure 1.3. Proportion of office building stock older than 15 years across Western Europe

1.3 The environmental impacts of office buildings

Broad evidence for the life cycle environmental impacts of office buildings across the different European climatic zones indicates that energy use during their occupation is related to the most significant impacts[15]. In detail, for the purpose of the project, one generic office building with flexible parameters and with a life span ranging over 50 years was analysed by means of an LCA. One of the main outcomes is referred to the energy consumption during the use phase. Of the primary energy used during occupation the most significant contributors tend to be lighting, heating, cooling and ventilation. Their relative importance can be seen to vary according to the age of the building, its thermal insulation as well as the climatic zone in which the building is located. This highlights the importance of taking into account the overall energy performance of a building,

13 Jones Lang La Salle

14 DTZ

15 European Commission, *GPP Office buildings: Technical Background report*, JRC-IPTS 2011

which could include the potential to generate cleaner energy. In Figure 1.4 an example of the total energy consumption evaluation for different buildings located in different climatic zones has been reported.

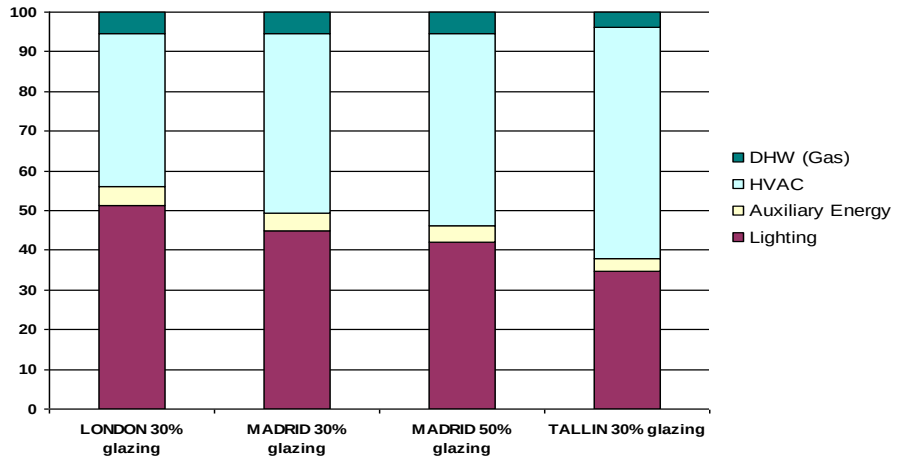


Figure 1.4. . Energy consumption distribution of an office building during the use phase [16]

The Energy Performance of Buildings Directive has led to the adoption of stricter regulations on energy use at Member State level[17]. Office buildings have, as a result, become more energy efficient and the significance of space heating, particularly in northern Europe, has tended to reduce. Space heating requirements are, however, still significant in older office buildings, which may therefore be candidates for major renovation. Cooling has become more significant, particularly in warmer climates, because of the increased use of computers and the installation of larger IT servers which generate waste heat. Intelligent lighting controls have allowed for lighting systems to become more responsive to occupancy and daylighting levels, thereby saving electricity. The thermal efficiency of the building fabric, building orientation and façade configurations, water use, together with a buildings depth and layout, all play a role in influencing heating, cooling, lighting and ventilation requirements in existing buildings[18].

As office buildings have become overall more energy efficient, this has at the same time resulted in an increase in the importance of environmental impacts associated with their construction. The use of more energy intensive insulation materials and façade systems in order to meet higher energy efficiency standards has, for example, tended to increase the overall environmental impact of the construction materials used [19].

The production of construction materials and products is responsible for the next most significant environmental impacts. These relate to the resources used to manufacture products and process materials as well as emissions arising from material extraction and energy used in their processing, also termed embodied energy. Resource use is also related to the amount of waste generated during product manufacturing, construction on-site and demolition processes, which can make up a significant proportion of the overall material flows on a construction site. This highlights the importance of designing and specifying for resource efficiency, with the most significant building elements to address being the floors, roof, structure and external walls.

A further factor to consider is the lifespan of the building, which is also sometimes referred to as its service life, and related to this its functionality as a healthy working environment. The longer the lifespan of the main structural elements of the building, the lower their associated life cycle environmental impacts, assuming that the overall energy performance is also prioritised as part of the overall approach during the service life.

Other human factors can also influence the service life. For example, a healthy and attractive working environment can contribute to a longer service lifespan and minimise the need for renovations. For example,

16 DHW, Domestic Hot Water; HVAC, Heating, Ventilation and Air Conditioning

17 European Commission, *Energy efficiency: Buildings*, DG Energy, http://ec.europa.eu/energy/efficiency/buildings/buildings_en.htm

18 Baker,N & K,Steemers (1999) *Energy and environment in design: A technical design guide*, Taylor and Francis.

19 Rawlinson, S & D,Weight, *Embodied carbon*, Building Magazine, p-88-91, 12th October 2007

evidence shows that in a healthy building the workforce is more productive and there are less illness-related absences [20].

The key environmental areas to be addressed, as well as the key life cycle environmental impacts, are summarised below. Based on the background evidence analysed during the criteria development process, the overall GPP approach and focus for office buildings has also been summarised.

Key Environmental Areas in Office Buildings life cycle and Key Environmental Impacts

Key environmental areas

- Primary energy consumption and associated greenhouse gas emissions during use of the building
- Depletion of natural resources, embodied energy and emissions associated with the manufacturing of building materials
- Waste generation during site preparation. construction, use and demolition of the building
- Deterioration in indoor air quality due to emissions of hazardous substances from building products and the intake of particulate air pollution from the external environment
- Water consumption during use of the building

Key life cycle environmental impacts:

- The following key environmental impact categories along the product life cycle are: global warming potential, acidification, eco-toxicity, human toxicity, eutrophication, abiotic resource depletion, and water consumption.

Proposed EU GPP Office Buildings approach

- Design and construction to achieve high energy efficiency standards and low associated CO_2 emissions
- The installation of low or zero CO_2 energy technologies to reduce energy use and CO_2 emissions
- Design and specification to reduce the embodied impacts and resource use associated with construction materials
- Design, specification and site management to minimise construction and demolition (C&D) waste and to use building products or materials with a high recycled or re-used content
- Specification of fit-out and finishes that minimise hazardous emissions to indoor air
- Ventilation design in order to ensure healthy air and minimise the intake of external air pollution
- Specification and installation of water saving technologies
- Installation of physical and electronic systems to support the ongoing minimisation of energy use, water use and waste arisings by facilities managers and occupiers

20 Useable Buildings Trust, *PROBE post occupancy study series*, Building Services Journal 1995-2002, http://www.usablebuildings.co.uk/

1.4 GPP criteria for office buildings

For better readability of this document, a list of the proposed GPP criteria for office buildings with a brief description of the contents is summarised below. Not all of the criteria will be relevant for all projects and forms of contracts. Unless otherwise noted in brackets the criteria areas are relevant to both Core and Comprehensive criteria.

GPP criterion	Brief Description
Criteria related to the ability of the tenderer	
Competencies of the project manager and the design team	*Experience and expertise in:* - *Energy efficient building fabric and services design and commissioning* - *Specification of resource efficient construction* materials. - *Use of multi-criteria building assessment and certification schemes,*
Competencies of the lead construction contractor, specialist contractors and/or property developers	*Experience and expertise in:* - *Energy efficient building fabric and services design and commissioning* - *Procurement of resource efficient construction* materials. - *Implementation of demolition site waste management plans*
Criteria related to different environmental aspects of the building	
Energy-related criteria	
Energy performance	
Minimum energy performance	*- Achieving Cost-Optimal performance with rewards of a further reduced energy consumption as award criterion*
Commissioning of building energy systems	*- By reference to EN, ISO or equivalent standards for systems*
Quality of the completed building fabric	*- Thermal imaging (Core) and air tightness testing (Comprehensive)*
Lighting	
Lighting control systems	*- Requiring features not addressed in national energy calculation methodologies*
Commissioning and handover of lighting control systems	*- Manual, training and Building Energy Management System interface*
Building Energy Management System (BEMS)	
BEMS installation	*- Intelligent systems and data collection*
Commissioning and handover of the BEMS	*- By reference to EN, ISO or equivalent standards for systems* *- Manual, training and use of user interface*
Low or zero carbon energy sources	
Energy supply systems	*- Highly efficient or renewable sources with rewards for a higher share of sustainable supply sources as award criterion*
Commissioning of energy supply systems	*- Connection and commissioning*
Heating systems including CHP	*- Reference to EU GPP criteria for CHP and water-based heaters*
Facilities energy management	
Reporting on energy use	*- Monthly data collection and reporting*
Performance-based energy contracting	*- Limits on energy consumption associated with lighting, heating, cooling, ventilation and auxiliary power*
Resource efficient construction	
Life cycle performance	
Performance of the main building elements	*- Two options based on EPDs and/or LCA results*
Construction product recycled content	
Incorporation of recycled content	*- 15% (Core) and 30% (Comprehensive)*
Wood sourcing	
Legal sourcing of wood construction materials	*- Due diligence along the supply chain*
Waste management plans	
Demolition waste audit and management plan	*- 55% (Core) and 70% (Comprehensive) by weight* *- Structure and fit-out elements* *- Hazardous waste risk assessment* *- Bill of quantities and methods for recycling and re-use* *- On-site monitoring and accounting*
Site waste management plan	*- 11 tonnes (Core) and 7 tonnes (Comprehensive) per 100 m^2 floor area*

Other environmental criteria	
Recycling facilities	
Recyclable waste storage provision	- *Designation of space in the design* - *Detailed plans of facilities*
Waste management system	- *Basic segregation systems with monitoring and reporting of arisings*
Water saving	
Water saving installations	- *Link to other EU GPP criteria sets*
Quality of the office environment	
Thermal comfort conditions	- *EN 15251 or equivalent*
Daylighting and glare	- *Daylight Factor and glare (EN 12464)*
Air quality	
Ventilation and air quality	- *Clean air intake and filtration (EN 13779)*
Selection of fit-out materials and finishes	- *Testing to minimise emissions of VOC's, SVOC's and carcinogens*
Air quality testing	- *In-situ sample testing for VOC's, formaldehyde and particulates*

1.5 Applicability of the Green Public Procurement criteria for office buildings

Designing and procuring an office building with a reduced environmental impact, whether it be new-build or a major renovation, is a complex process. Considering the complexity of the office building procurements, a guidance document has been developed to provide procurers with orientation on how to effectively integrate the GPP criteria for office buildings into the procurement process (see Section 3).

The process of constructing a new office building or carrying out a major office renovation consists of a distinct sequence of procurement activities with related contracts. This sequence of procurement can have a significant influence on the outcome. This is because each type of contract brings with it distinct interactions between the procurer, the building design team, the contractors and the future occupants and facilities managers. Moreover, they each have advantages and disadvantages in seeking to procure an improved environmental performance.

Depending on the procurement route adopted, some of these contracts may be awarded to the same contractor but in most cases they are let separately. Some contracts may be integrated in a design and build (DB) or a design, build and operate (DBO) arrangement, with the detailed design process, the main construction contract, the installation or provision of energy services and even facilities management all potentially co-ordinated by one contractor.

It is therefore important to identify the main points in the sequence of procurement activities where GPP criteria should be integrated. To this end these criteria are accompanied by a guidance document which provides general advice on how and when GPP criteria can be integrated into this process. It also suggests, based on experience from different projects across the EU, how the procurement sequence could be managed in order to achieve the best results.

Depending on the ambition level of the project and the experience of the contracting authority, not all of the GPP criteria included in this criteria set will be relevant. Moreover, depending on the preferred procurement sequence criteria may be best addressed at specific stages. Some activities may be let as separate contracts requiring their own criteria.

The strategic objectives and targets of the project should be determined at the outset of the project with reference to the GPP criteria set. The optimum stages for integration of GPP criteria should be evaluated during discussions to determine the procurement route. In all cases it is recommended that GPP criteria are integrated into both internal planning and the procurement sequence at as early a stage as possible in order to secure the desired outcomes and achieve the best value for money.

2 GPP CRITERIA AREAS

This section provides the technical evidence and rationale for each of the proposed GPP criterion. The criterion proposals are grouped into the following broad criteria areas:

- Project team competencies
- Energy-related criteria
- Resource efficient construction criteria
- Other environmental criteria
- Office environmental quality criteria

For each criteria area technical and market evidence is presented and discussed. Draft criteria proposals are then proposed, split into Core and Comprehensive technical specifications, Award criteria and (where appropriate) Contract Performance Clauses.

2.1 Project team competencies

The selection criteria have been specified to encompass the range of competencies and expertise that would be required to deliver an environmentally improved office building. These reflect the need for experience in specific technical areas as well as in the successful management of technical innovation in this field.

The first criterion is proposed to focus on the project manager and the design team, who have a critical role to play in selecting, modelling, specifying and integrating solutions to meet environmental criteria. Working alongside the design team, the role of the project manager is also identified as being significant in managing technical innovation. Given the increasing prevalence of building environmental assessment schemes, experience and expertise in applying them to projects is also judged to be of value in managing a design teams' response to a range of environmental criteria.

The second criterion is proposed to focus on the main building contractor and possible specialist contractors. This is because, depending on the nature of the project, it may also be necessary to procure the services of specialist contractors. These could include, for example, the demolition of buildings already on a site or an Energy Service Company (ESCo) providing building renovations and/or low or zero carbon energy supply technologies. The competency of property developers and investors that lead bids could also be addressed.

Selection criteria on the competencies of the project manager and design team

Core criteria	**Comprehensive criteria**
SELECTION CRITERIA	
A1. Competencies of the project manager and design team *These criteria may form part of a pre-selection procedure for the lead contractor or where the services of a design team are procured by the contracting authority.* The project manager, architect, consultant and/*or* design team consortium shall have relevant competencies and experience in each of the following areas for which they would be responsible under the contract *(select as relevant to the specific contract):* - The project management of building contracts that have delivered improved environmental performance; - Energy efficient building fabric and services design for new-build or renovation projects (*select as appropriate*),	**A1. Competencies of the project manager and design team** *These criteria may form part of a pre-selection procedure for the lead contractor or where the services of a design team are procured by the contracting authority.* The project manager, architect, consultant and/*or* design team consortium shall have relevant competencies and experience in each of the following areas for which they would be responsible under the contract *(select as relevant to the specific contract):* - The project management of building contracts that have delivered improved environmental performance; - Energy efficient building fabric and services design for new-build and/or renovation projects (*select as*

including if available measured energy demand data per m^2 from completed projects including heating, cooling, lighting, hot water and auxiliary equipment; - The specification and design of renewable and/or high efficiency energy generation equipment; - Installation of Building Energy Monitoring Systems (BEMS), communication of how they work to building managers and their use to diagnose energy use patterns in buildings; - Water efficient services design, including measured water demand per employee from completed projects; - Bioclimatic architecture and passive design to achieve good thermal and visual comfort, natural air purification etc; - Assessment of building environmental performance using multi-criteria building assessment and certification schemes, - The specification, procurement and installation of low environmental impact construction materials. To include reference to EPDs in compliance with ISO 14025 or equivalent **Verification**: Evidence in the form of information and references related to previous contracts in which the above elements have been carried out. This shall be supported by CVs for personnel who will work on the project.	*appropriate*), including if available measured energy demand data per m^2 from completed projects including heating, cooling, lighting, hot water and auxiliary equipment; - The specification and design of renewable and/or high efficiency energy generation equipment; - Installation of Building Energy Monitoring Systems (BEMS), communication of how they can be used to building occupiers and their use to diagnose energy use patterns in buildings; - Water efficient services design, including measured water demand per employee from completed projects; - Bioclimatic architecture and passive design to good thermal and optical comfort, natural air purification etc; - Assessment of building environmental performance using multi-criteria building assessment and certification schemes, - The specification, procurement and installation of low environmental impact construction materials. To include reference to EPDs in compliance with ISO 14025 or equivalent. - The use of holistic assessment tools in the design and specification of environmentally improved buildings including LCC and LCA. Comparative studies in compliance with ISO 14040 and ISO 14044.or equivalent **Verification**: Evidence in the form of information and references related to previous contracts in which the above elements have been carried out. This shall be supported by data from post-occupancy surveys. This shall be supported by CVs for personnel who will work on the project.

Selection criteria on the competencies of the lead construction contractor, specialist contractors and/or property developers

Core criteria	**Comprehensive criteria**
SELECTION CRITERIA	
A2. Competencies of the lead construction contractor, specialist contractors and/or property developers *These criteria may form part of a pre-selection procedure for the lead contractor or where specialist contractors are to be procured e.g. demolition, ESCO's.* The construction contractor and/or property developer shall have relevant competencies and experience in the completion of building contracts that have been shown to have delivered improved environmental performance. In the case of design and build or DBO contracts, criterion A1 will also be relevant to the design team employed. Relevant areas of experience shall include (as appropriate to the project and the selected GPP criteria): - Energy efficient building fabric and services design for new-build or renovation projects (*select as appropriate)*, including if available measured energy demand per m^2	**A2. Competencies of the lead construction contractor, specialist contractors and/or property developers** *These criteria may form part of a pre-selection procedure for the lead contractor or where specialist contractors are to be procured e.g. demolition, ESCO's.* The construction contractor and/or property developer shall have relevant competencies and experience in the completion of building contracts that have been shown to have delivered improved environmental performance. In the case of design and build or DBO contracts criteria A1 will also be relevant to the design team employed. Relevant areas of experience shall include (as appropriate to the project and the selected GPP criteria): - Energy efficient building fabric and services design, including if available measured energy demand per m^2 from completed projects including heating, cooling, lighting,

from completed projects including heating, cooling, lighting, hot water and auxiliary equipment. This will have been applied in the context of new-build and/or renovation projects (select as appropriate); - The installation, commissioning and ongoing operation/maintenance of renewable and/or high efficiency energy generation equipment; - The installation of Building Energy Monitoring Systems (BEMS) and communication of how they work to building managers; - The installation of water efficient services, including if available measured water demand per employee from completed projects; - The procurement, installation and verification of low environmental impact construction materials. Supply chain management to ensure compliance with building assessment and certification systems and in order to support modelled resource efficiency strategies; - The successful implementation of demolition and site waste management plans in order to minimise waste arisings. Selection and knowledge of off-site treatment options. **Verification:** Evidence in the form of information and references related to relevant contracts in the last 3 years in which the above elements have been carried out. This shall also be supported by CVs for personnel who will work on the project and their relevant project experience.	hot water and auxiliary equipment. This will have been applied in the context of new-build and/or renovation projects (select as appropriate); - The installation, commissioning and (as relevant) ongoing operation/maintenance of renewable and/or high efficiency energy generation equipment; - The installation of Building Energy Monitoring Systems (BEMS) and communication of how they work to building managers; - The installation of water efficient services, including if available measured water demand per employee from completed projects; - Functioning passive design features to achieve low energy use and good thermal and optical comfort, etc; as evidenced by post-occupancy studies; - The procurement, installation and verification of low environmental impact construction materials. Supply chain management to ensure compliance with building assessment and certification systems and in order to support modelled resource efficiency strategies; - The successful implementation of demolition site waste management plans in order to minimise waste arisings. Selection and knowledge of off-site treatment options. **Verification:** Evidence in the form of information and references related to previous contracts in the last 3 years in which the above elements have been carried out. This shall be supported by evidence and data from: – Third party auditing, – Post-occupancy auditing, – LCA/LCC analysis and/or – Data collection from monitoring This shall also be supported by CVs for personnel who will work on the project and their relevant project experience.

Supporting notes:

- The evaluation of consultants, design teams and contractors requires an experienced evaluation panel. It may be appropriate to bring in external expertise, which may include appointment of a project manager, and the setting up of a panel with the knowledge and experience to judge the experience of competing contractors. The lists included in selection criterion 1 and 2 are indicative and should be adapted to the project and the procurement stage.
- In the reform of the Public Procurement Directives [21] [22] (published in the Official Journal 28th March 2014 and requiring transposition by Member States within 24 months), it is explicitly stated (Art. 66 of Directive 2014/24/EU) that the organisation, qualification and experience of staff assigned to performing the contract (where the quality of the staff assigned can have a significant impact on the level of performance of the contract) can be a criterion for awarding a contract. They can therefore be cited in addition to selection criteria. For complex contracts such as building contracts it can usually be expected that the quality of the project managers, design team, specialist consultants and contractors can have a significant impact on the performance of the project.

21 Directive 2014/24/EU of the European Parliament and of the Council of 26 February 2014 on public procurement and repealing Directive 2004/18/EC

22 Directive 2014/25/EU of the European Parliament and of the Council of 26 February 2014 on procurement by entities operating in the water, energy, transport and postal services sectors and repealing Directive 2004/17/

2.2 Energy related criteria

The main focus of the proposed energy criteria are on the overall primary energy demand of an office building. Lighting systems are an important contributor to energy-related environmental impacts and so, if these are not addressed within the national energy calculation methodology of a Member State, lighting criteria are additionally proposed. Once an efficient building has been designed, the potential contribution of low or zero carbon energy technologies should be addressed.

For each criteria area, overall technical specifications setting performance requirements are proposed. Recognising the importance of monitoring, testing and commissioning to ensure that a building's completed performance is comparable with the expected design performance, associated technical specifications and contract performance clauses are also proposed. These would require the building fabric to be tested and for building systems to be installed and commissioned correctly.

With regards to commissioning, a single technical specification is proposed requiring functional performance testing for the following sub-systems, which in most building designs will be interlinked:

- Heating, cooling and ventilation (HVAC),
- Lighting controls,
- Building Energy Management System (BEMS),
- Low and Zero Carbon energy technologies.

In each case, tenderers would have to comply with a technical specification requiring testing and there would be a contract performance clause requiring them to report the results and, in the case of the building fabric, to propose remedies if problems are identified. Specific contract performance clauses are proposed for each sub-system.

2.2.1 Energy performance

2.2.1.1 Performance requirements: minimum energy performance

2.2.1.1.1 Background technical discussion and rationale

The preliminary technical background reports for the office building product group indicated that primary energy use during the occupation of a building - also referred to as the use phase - is associated with the most significant environmental impacts. These impacts are mainly attributed to greenhouse gas emissions from the consumption of electricity and natural gas for heating, cooling, ventilation, lighting and hot water. The balance of heating, cooling and lighting energy use varies depending on the climate zone in which the building is located.

For the main energy performance criterion for office buildings, the potential to set Core and Comprehensive technical specifications for both new-build and major renovated offices is considered in the following sections:

Setting of minimum performance requirements at Member State level

The energy use of office buildings is regulated at Member State level by building regulations and ordinances that set minimum performance requirements. These are usually expressed in terms of kWh/m^2 of primary energy or carbon dioxide emissions per m^2 [23]. In some Member States these requirements are divided into requirements for heating and cooling, such as in Italy. These minimum performance requirements can in most cases be readily equated to Energy Performance Certificate ratings, which must be provided for all new and existing buildings that are sold on the property market.

Member States are furthermore required to calibrate their minimum energy performance requirements against what is termed the 'cost-optimal' performance. The cost-optimal performance is calculated following a comparative methodology described in Commission Delegated Regulation No 244/2012. The methodology sets out a minimum set of variables to be considered that influence a buildings energy use as well as the factors and assumptions to be included within a financial appraisal. This methodology is essentially a

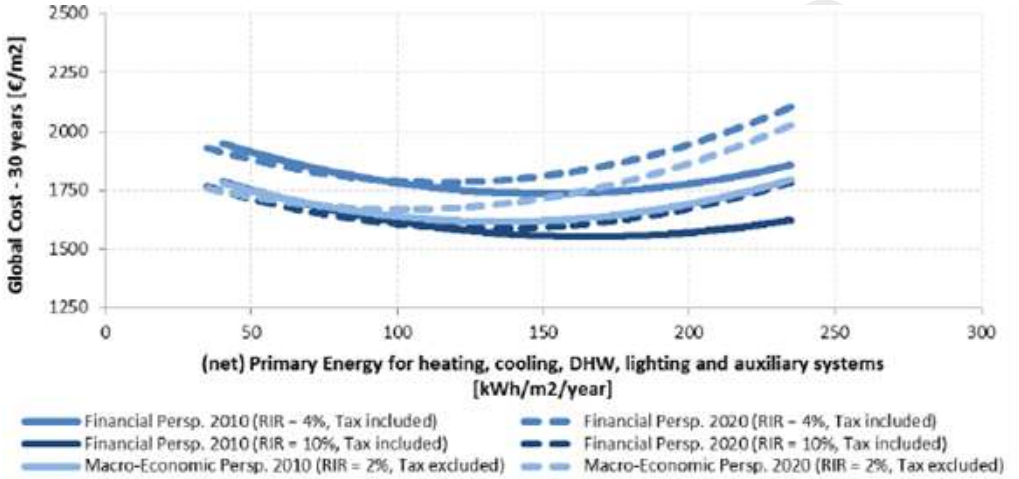
23 Concerted Action EPD (2011) *Implementing the Energy Performance of Buildings Directive*, Intelligent Energy Europe programme

simplified Life Cycle Costing exercise as it cash flows the long term benefits of the primary energy saving measures.

For public buildings the Regulation stipulates a 30-year time period for the appraisal. The discount rate is not stipulated but for public sector projects would be assumed to usually include sensitivities of 3.5%, 7% and 10%. Member States are required to then ensure that any gap between their national minimum requirements and the cost-optimal level is reduced by the time of their latest next review in 2015-6. The minimum shall in general not then be 15% greater than the cost-optimal level.

Modelling of cost-optimal levels of performance for new-build office buildings

A comprehensive modelling exercise has been carried out for DG ENER by a consortium led by Ecofys. This provides an indication of cost-optimal levels of performance for office buildings across the EU [24]. Geographical climate zones were defined in order to take into account of variations in primary energy requirements across the EU expressed in terms of heating and cooling days. A model was then used to simulate a reference office building to which 189 combinations of building envelope, heating and cooling strategies were applied in each climate zone. The cost-optimal performance for each variant was calculated based on an investment period of 30 years with discount rates of 2%, 4% and 10% applied. An indicative example of the modelled variation in the cost optimality curve is illustrated by Figure 2.1). The results were then segmented into notional performance classes expressed in kWh/m^2. The modelled results for new-build and refurbished office buildings for the four climate zones at 2010 and (projected) 2020 prices are summarised in Table 2.1 and Table 2.2)



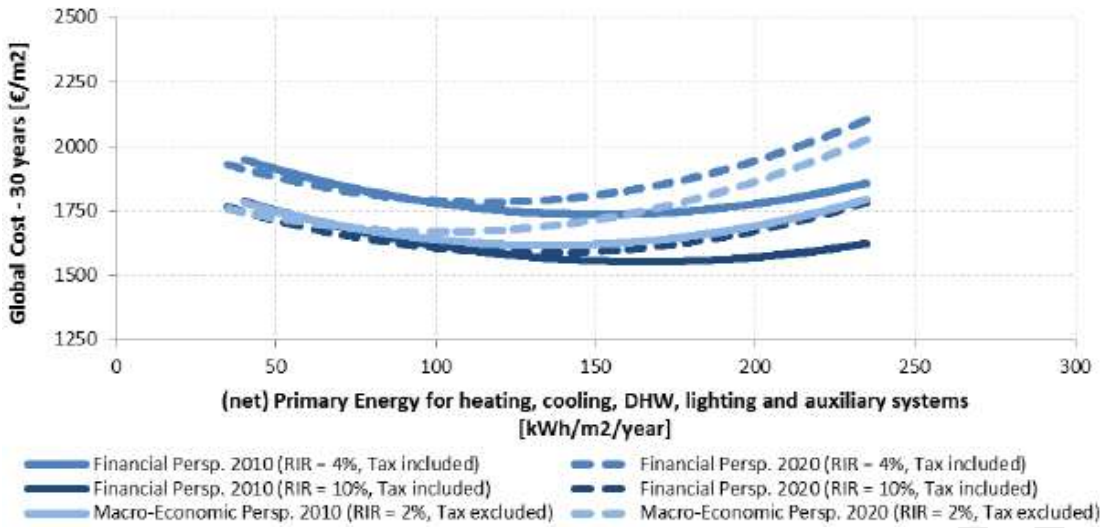
Source: Ecofys (2013)

Figure 2.1: Modelled changes in cost optimality curves between 2010 and 2020 for a new office building in Paris, France

Table 2.1: Cost-optimal new office building stock modelling results for the four EU climate zones

Climate zone (selected city)	2010 results (kWh/m^2)		2020 Cost-optimal performance (kWh/m^2)
	Cost-optimal performance	Performance class for top 20% of the building variants	
Catania	120	30 - 45	80
Paris	170	30 - 45	100
Budapest	160	45 - 60	90
Stockholm	160	60 - 75	100
Source: Ecofys (2013)			

24 Ecofys Germany et al, *Towards nearly zero energy buildings: Definition of common principles under EPBD*, Report for the European Commission, 14th February 2013.



Source: Ecofys (2013)

Figure 2.2: Modelled changes in cost optimality curves between 2010 and 2020 for a new office building in Paris, France

Table 2.2: Cost-optimal existing office building stock modelling results for the four EU climate zones

Climate zone (selected city)	2010 Cost-optimal performance (kWh/m²)	2020 Cost-optimal performance (kWh/m²)
Catania	120	90
Paris	170	100
Budapest	160	110
Stockholm	170	80
Source: Ecofys (2013)		

In order to cross-check the findings of the Ecofys study with cost-optimal modelling in Member States a review of the current status of Member State minimum requirements and cost optimality comparisons for the four main climate zones of the EU was carried out. Data for the same countries analysed in the Ecofys study could not be compiled because of variations in the reporting by Member States. The results are summarised in Table 2.3 below.

The data illustrates that the variation between the current minimum national requirements and the cost-optimal can be significant. It is also notable that in most cases a 20 year term was used for the appraisal and in some cases a high discount rate, suggesting that the cost optimum performance for a public building over 30 years and at indicative public sector borrowing rates for infrastructure (3.5%) could, depending on the combination of measures used and their cost, be lower than the figures reported.

Table 2.3: Example outputs from cost-optimal reporting by Member States

Country	Office building type	Current minimum requirement (kWh/m²)	Cost-optimal level (kWh/m²)	Variation from the cost-optimal level calculated	Financial assumptions (term and discount rate)
Spain	New-build	49 - 97.3	46.8 - 103.5	-6.0 to +41.4%	20 year term at 7%
	Renovation	52.1 – 85.4	42.7 – 103.0	-16.0 to +77.0%	
UK	New-build	87 - 155	89 - 163	-4%	20 year term at 3.5%
	Renovation	-	-	-	
Denmark	New-build	32.5 – 103.0	-	+31.2%	20 year term at 3.0%
	Renovation	113.2 – 231.9	-	-6.6% to +3.7%	
Finland	New-build	152 - 161	130.0 – 160.0	+3.9 to +12.6%	20 year term at 6.0%
	Renovation	136	122	+11%	
Hungary	New-build	101	84	+20.2%	20 year term at 5.0%
	Renovation	199 - 256	156 - 227	+27.6% to +12.8%	
Source: *Member State reports submitted to DG ENV as of 2013, see: http://ec.europa.eu/energy/efficiency/buildings/implementation_en.htm*					

Modelling cost-optimal levels of 'nearly zero energy' performance for office buildings

Under the recast Energy Performance of Buildings Directive 2010/31/EU Member States are additionally required to prepare national plans to ensure that all new buildings are 'nearly zero energy' by 2020. This is defined in Article 2(2) as:

> *'…a building that has a very high energy performance, as determined in accordance with Annex I. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources,'*

Of particular relevance to GPP is an early target date for nearly zero energy public buildings of 2018. The national plan should set requirements for primary energy use expressed in kWh/m² per annum. Intermediate requirements shall be set for 2015. It is understood that fifteen Member States have already set intermediate targets, expressed either in kWh/m² or as EPC levels. Only three Member States are understood to have set targets for major renovations.

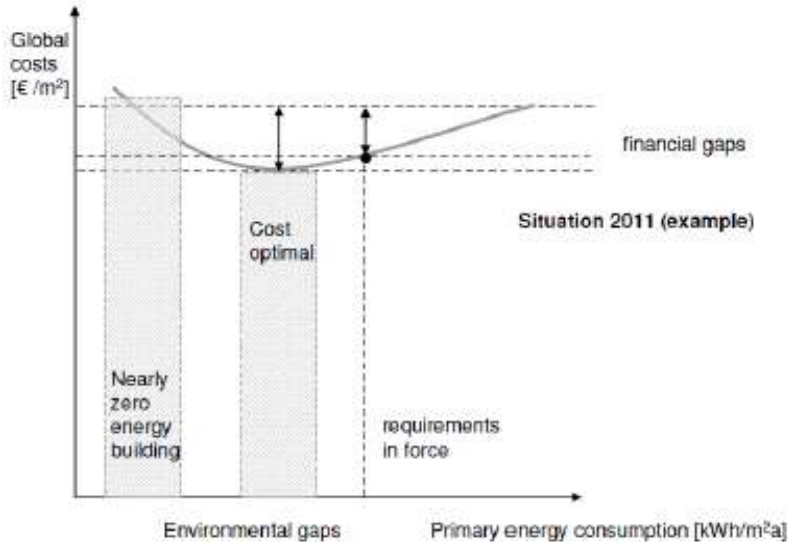
The Ecofys consortium study for DG ENER highlights that a gap is likely to exist in practice between cost-optimal levels of performance in each Member State and nearly zero energy performance requirements, as illustrated in Figure 2.3. Experience suggests that the extent of this gap will depend on:

- Industry experience and skills in the cost effective delivery of new designs and specifications,
- The cost of high performance components, reflecting their availability and the maturity of the supply chain,
- Energy and carbon pricing levels for both consumers and generators of energy.

It is therefore possible that, if these factors improve, the gap would close and nearly zero energy buildings would move closer to, or even achieve, cost-optimality.

In the case of Public-Private projects the assumptions underlying Life Cycle Costing are likely to vary, with higher discount rates anticipated to be used for private sector borrowing. The open market property valuation of an office building with a higher EPC rating may also be a factor to consider, with early evidence from the property market suggesting that energy efficient buildings may receive a higher valuation or command higher rents[25].

25 European Commission, *Energy performance certificates in buildings and their impact on transaction prices and rents in selected EU countries*, Report prepared by BIO Intelligence Services and IEEP,19th April 2013



Source: Ecofys et al (2012)

Figure 2.3: Indicative illustration of the potential gap between cost-optimal and NZE performance

This financial gap was recognised in a study carried out by AECOM and Europe Economics for the UK Government in support of Zero Carbon targets for non-residential building to be achieved by 2019 [26]. Modelling of office buildings to identify a cost effective approach was based on three stepwise improvements from the 2006 Building Regulations:

1. 'Advanced Energy Efficiency' measures: Those measures considered to represent the remaining cost effective measures possible to implement for an office building.
2. 'Carbon Compliance' measures: Low or zero carbon technologies that are possible to install on the building and which provide useful energy.
3. 'Allowable solutions': The balance of carbon emissions reductions from new investment in energy technologies installed off-site e.g. shared biomass heating network, wind turbines.

The study appraised the costs of selected improvement scenarios for large, medium and small offices. The aim was to explore cost effective level at which the Carbon Compliance threshold could be set relative to a 2006 baseline for the performance of an office building. These scenarios considered different mixes of efficiency measures and technologies. The Net Present Value (NPV) was calculated for each scenario. Only one scenario gave a positive Net Present Value (NPV) in the Impact Assessment [27], equating to a positive outcome from an EPBD Cost-Optimality calculation. The performance thresholds that could be cost effectively achieved for each scenario are summarised in Table 2.4.

Table 2.4: Thresholds for energy efficiency and carbon compliance per office building type

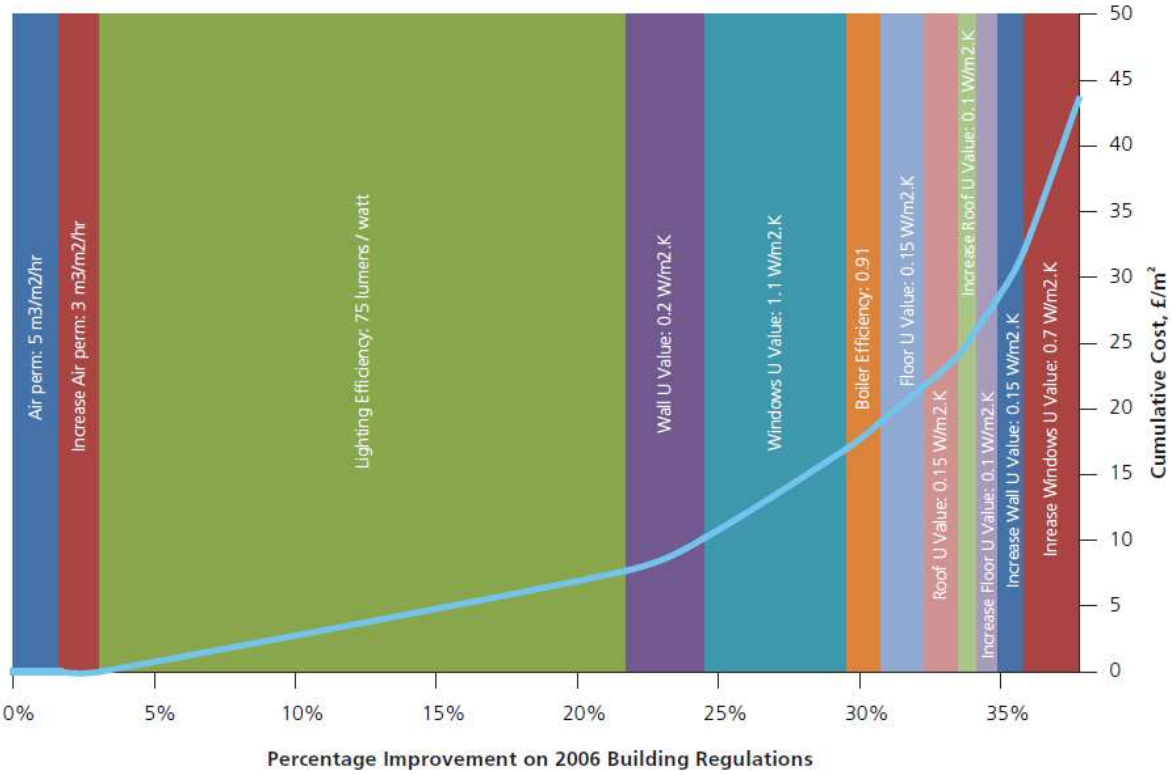
Building type	2006 baseline (kg CO_2/m^2)	Energy efficiency improvement threshold	Carbon compliance improvement threshold	
			2016	2019
Large city centre HQ	-	21%	22%	28%
Medium speculative	-	21%	23%	27-30%
Small office	18.7	38%	39%	39-53%

Source: DCLG (2009)

26 DCLG, *Zero carbon for new non-domestic buildings: Impact assessment*, November 2009

27 Net Present Value (NPV) is the value generated by an asset over a specified period of time. During this time,period the cash flow generated by the asset is discounted annually by a fixed rate usually equivalent to the cost of capital. A positive NPV indicates that a project will retain its Present Value and/or deliver a return on the initial capital invested over the specified period of time.

Abatement curves for the combinations of different measures show that a point of inflexion occurs past which it becomes significantly more expensive to achieve carbon emissions reductions (see the example in Figure 2.4). Hence the proposal from the UK government that further carbon reductions beyond 'carbon compliance' could then be achieved by investing in off-site infrastructure at much reduced costs in €/tonne of CO_2 abated – so-called 'allowable solutions'.



Source: DCLG (2009)

Figure 2.4: Cumulative costs for achieving Energy Efficiency threshold: Small office scenario

Modelling the cost and benefit of energy efficient major renovations

With the majority of the existing EU office building stock having an EPC performance in the range of D to G a major renovation generally provides the opportunity to significantly improve energy performance. The decision to retain and renovate an existing building or to demolish and/or construct a new building may, however, be finely balanced in terms of the costs and environmental benefits depending on the nature of the construction.

It is therefore important to first appraise whether, given the physical form and structure of the existing building, the building's environmental performance can be improved sufficiently in order to meet a contracting authority's requirements. A renovation may also provide the opportunity to make improvements in how an asset is utilised. For example, through the improved internal use of space or the remodelling of layouts and services to better control daylighting and ventilation.

For instance, certain features of a building such as heat loss from structural elements (so-called 'thermal bridging') may preclude a cost effective level of improvement when compared to the minimum local requirements or criteria set by a contracting authority. On the other hand, given the emerging market for energy efficient building renovation, novel approaches to the renovation of common office building forms may be brought forward by designers and contractors.

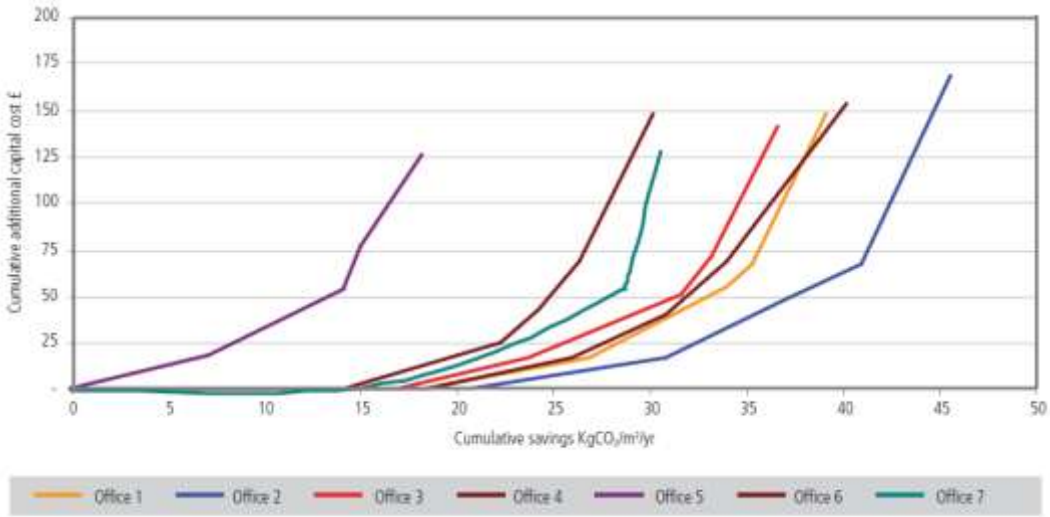
Examples from the UK compiled by WRAP illustrate the improvement potential [28]. Hampshire County Council's Elizabeth II office complex was subjected to a major renovation in 2007-2009 [29]. The original

28 WRAP, *Refurbishment case studies: Offices*, UK http://www.wrap.org.uk/node/12619

29 WRAP (2012) *Refurbishment Resource Efficiency Case Study: Elizabeth II Court, Winchester*

building was subject to significant thermal fluctuations during the year, making for an unpleasant and expensive to operate building. An appraisal showed that for 50% of the cost of the demolition and new-build option a 50% reduction in CO_2 emissions could be achieved. Moreover a 70% increase in occupancy was achieved in the finished renovation, giving a reduction in CO_2 emissions per Council desk space.

Because of the wide range of building ages and forms that may be found across the EU it is difficult to generalise about the cost and potential for energy efficient renovation. Instead analysis has tended to focus on comparing the cost of packages of measures to reference or example office building typologies. Studies carried out in 2009 and 2012 by the Investment Property Forum illustrate the possible variation in the cost uplift to achieve reductions in primary energy consumption and improvements in EPC performance using seven and four modelled office scenarios respectively [30]. The findings are summarised in Figure 2.5 and Table 2.5.



Source: Investment Property Forum (2009)

Figure 2.5: Additional costs to reduce primary energy consumption (7 office scenarios, 2009)

Table 2.5: Additional costs to achieve EPC improvements (four office scenarios, 2012)

EPC performance	Example 1: Naturally ventilated, Pre-1940	Example 2: Narrow plan, air conditioned, early 1990's	Example 3: Deep plan air conditioned, 2002	Example 4: Deep plan air conditioned, 2006
Baseline EPC	E	G	F	E
Market EPC+	D	F	F	E
Additional capital costs over and above market renovation costs				
E	-	0.3%	1.0%	-
D	-	1.7%	1.9%	1.0%
C	0.8%	14.6%	12.6%	12.8%
B	14.1%	37.3%	44.7%	45.7%
A	40.0%	-	-	-

Source: Investment Property Forum (2012)

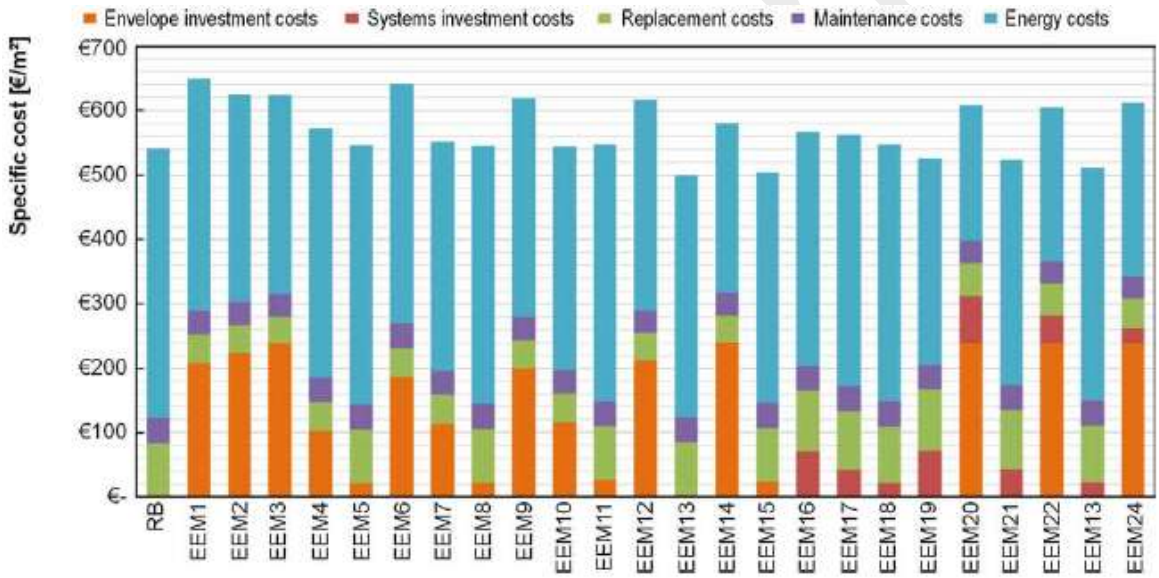
The 2009 study concluded that making improvements in the private sector with a total additional cost increase of greater than +5% on the cost of a Category A market renovation (quoted as €840-1200/m^2 at 2009 prices) may be prohibitive because of sharply increasing costs and negative Internal Rates of Return (IRR's). This broadly equated to a reduction of between 42% and 51% in primary energy use. IRR's were calculated for individual improvement options to a vacant building with a discount rate of 7%.

30 Investment Property Forum, *Costing energy efficiency improvements in existing commercial buildings*, UK, January 2009 and July 2012

It is notable that major improvements that would be expected to deliver the significant reductions in energy use, namely the upgrading of windows to double or triple glazing (+€127/m^2 and +€252/m^2 respectively), the addition of internal or external wall insulation (+€26m^2 internal and +€200 m^2 external) and chilled beam cooling (€168-184/m^2) incur very high additional costs that mean they may not recoup their costs over the lifetime of the renovation (on the basis of 10-30 year lifespans for the improvements analysed). They may still, however, compare favourably if a comparison is to be made with a demolition and re-build scenario, as illustrated in the previously given UK example.

These findings are broadly supported by a separate peer reviewed modelling exercise undertaken for REHVA (the Federation of European Heating, Ventilation and Air conditioning Associations) defined in its overall approach by the use of reference building [31] and application to an office building typology [32]. Twenty four packages of Energy Efficiency Measures (EEM's) were modelled and compared with a defined Reference Building (RB), with measures ranging from simple improvements to the building fabric and automatic lighting control systems to the more costly measures such as the installation of external insulation and solar photovoltaic arrays (see Figure 2.6).

The cost optimal EEM suggested a reduction of approximately 16% in primary energy consumption achieved by installing an automatic lighting control system, with a lifecycle cost reduction of 7.6%. The most significant potential reduction in primary energy consumption of 59% was achieved with improvements to the building's insulation and installation of a solar photovoltaic array on the roof. The lifecycle cost increase was estimated to be 18%. However, the modelling indicated that these measures would not pay for themselves over a reference period of 30 years at 2013 prices and at a 4% discount rate.



Source: Becchio, C et al (2013)

Figure 2.6: Life cycle cost comparison of a Reference Building (RB) in Italy with Energy Efficiency Measures (EEM's)

The IPF study and REHVA analysis differ in their assumptions as to the overall costs of renovation. REHVA considered the energy improvements in isolation and the ongoing life cycle cost of running the building. The IPF study was based on the assumption that improvements form part of a 'market renovation' package equivalent to a 'Category A' fit out and that these would be made either whilst the building was occupied or upon 'vacant possession'. Although Category A has no formal definition in the EU it can be understood to include major internal improvements such as suspended ceilings and floors together with new centralised

31 Corgnati.S.P, Fabrizio.E, Filipi.M and V,Monetti, *Reference buildings for cost-optimal analysis: Method of definition and application*, Applied Energy, 102 (2013) p-983-993

32 REHCA Task Force 'Reference buildings for energy and cost-ptimal analysis' – see also Becchio.C, Corgnati.S.P, Fabrizio.E and V,Monetti, *The cost optimal methodology applied to an existing office in Italy*, REHVA Journal, October 2013.

heating and cooling plant and associated services. More recent market commentary for Germany by EC Harris [33] suggests that for a public sector Category B renovation the typical budget might be in the range of €400-600/m^2 which is more in line with the assumptions used in the REHVA analysis, which suggested costs of €520/m^2.

Based on an analysis of office renovations by Davis Langdon an assumption can be made that a Category A fit out would require a 30-35% increase in the budget [34] and would extend the economic life of a building by approximately 15-20 years This would approximate to €532-800/m^2 for a public sector office building, potentially making some of the more costly improvement packages identified in both studies more difficult to justify, even if a lower discount rate of 3.5% was to be used. On the other hand energy efficiency improvements carried out as part of a major renovation may, over the life cycle of the building, be more cost effective because they make use of labour and access that is already on-site carrying out works e.g. building façade repairs require scaffolding and/or gantries.

2.2.1.1.2 Revised criteria proposal

Core criteria	**Comprehensive criteria**
TECHNICAL SPECIFICATIONS	
B1. Minimum Energy performance The modelled primary energy performance of an office building shall meet the following requirements: ○ New-build: If the national minimum requirement is less than Energy Performance Certificate (EPC) class C, then the performance shall be one class better than the minimum requirement, ○ Major renovation: A minimum Energy Performance Certificate class of D *unless heritage restrictions apply* in which case a minimum class of E. In either case the resulting performance shall not be less than the cost optimum primary energy demand for a *public sector office building* expressed in kWh/m^2 as calculated according to the methodology in Commission Delegated Regulation No 244/2012. *An award criterion may then be set to encourage further cost effective improved performance in primary energy use (see criterion B8).* **Verification:** The Design team *or* the Design & Build tenderer *or* the DBO tenderer shall submit information demonstrating that the building design to be submitted to the local building control for permitting complies with the GPP requirements. This shall consist of the predicted energy performance of the building according to the national calculation methodology applicable where the building is situated. A cost optimality calculation shall additionally be provided following the stated methodology. The calculations shall be verified by either a competent authority or building assessor certified to use the methodology.	**B1. Minimum Energy performance** The modelled primary energy performance of an office building shall meet the following requirements: ○ New-build: - If the national minimum requirement is less than Energy Performance Certificate (EPC) class B, then the performance shall be one class better than the minimum requirement, *or* - If the national minimum requirement is Energy Performance Certificate (EPC) class A or B, then the performance shall be a minimum of 75 kWh/m^2 ○ Major renovations: Performance to the national minimum requirement for new-build properties that was in force in 2002, *unless heritage restrictions apply in which case a minimum EPC class of D shall apply*. In all cases the combinations of measures used to achieve this performance shall result in a positive Net Present Value when the Cost-Optimal calculation methodology for a *public sector office building* is calculated according to the methodology in Commission Delegated Regulation No 244/2012. For major renovations a dynamic model compliant with EN 15603 shall be used together with input data reflecting surveyed construction details of the building. *An award criterion shall then be set to encourage further cost effective improved performance in primary energy use (see criterion B8) and, where the building achieves the 2018 nearly zero energy requirement for the Member State, further contributions by low and zero carbon energy technologies (see criterion B9).* **Verification:** The Design team *or* the Design & Build tenderer *or* the DBO tenderer shall submit the following information demonstrating that the building design to be submitted to the

33 EC Harris, *Office fit out costs can have an impact on profitability*, Market insight: Germany, Summer 2011

34 Davis Langdon, *Cost model: Office refurbishments*, June 2012

	local building control for permitting complies with the GPP requirements. This shall consist of the predicted energy performance of the building according to the national calculation methodology applicable where the building is situated. A cost optimality calculation shall additionally be provided following the stated methodology. The calculations shall be verified by either a competent authority or building assessor certified to use the methodology.
AWARD CRITERIA	
B8. Minimum Energy performance requirements *This criterion supplements and encourages further performance improvements over and above the requirements of criterion B1.* The procurer shall award points according to the modelled improvement in the energy performance of the building in excess of those in criterion B1. This could relate to the EPC rating or could be in gradations of improvement of 15 kWh/m^2. **Verification:** Please refer to the verification for criterion B1.	**B8. Minimum Energy performance requirements** *This criterion supplements and encourages further performance improvements over and above the requirements of criterion B1.* The procurer shall award points according to the modelled improvement in the energy performance of the building *either*: ○ In proportion to how close the proposed design approaches the Member States national Nearly Zero Energy requirements in kWh/m^2 or, *if these are not defined,* ○ On the basis of a comparison of design proposals that, depending on the prevailing national minimum requirements, have a primary energy demand: i) Renovations: Up to 100 kWh/m^2 ii) New-build: Up to 60 kWh/m^2 The points could be awarded in gradations of improvement of 15 kWh/m^2. In all cases the combinations of measures used to achieve this performance shall result in a positive Net Present Value when the Cost-Optimal calculation methodology for a *public sector office building* is calculated according to the methodology in Commission Delegated Regulation No 244/2012. **Verification:** Please refer to the verification for criterion B1.

Summary rationale:

- With introduction of the need for Member States to compare their minimum performance requirements for office buildings against cost-optimal levels there can be significant variations between the two values. The cost-optimal performance is usually calculated only for the private building scenario, potentially making the target less strict.
- It is therefore proposed as one option for the Core criterion that the cost-optimal performance shall apply if it is stricter than the national minimum performance requirement.
- Alternatively, and reflecting the potential for significant variation between national minimum and cost-optimal performance, a minimum improvement of one EPC rating is proposed if the national minimum is less than C. This recognises that improvements from C to B or A tend to become significantly more costly and with diminishing returns.
- This combination of requirements is repeated for the Comprehensive criterion because there is limited data on which to indicate the extent to which new buildings placed on the market in some cases exceed national minimum requirements.
- Specific technical specifications are proposed in each case for major renovations. Evidence suggests that, unless there are heritage restrictions on the building fabric improvements that can be made, a

minimum EPC class of D is generally feasible for a modest increase in budget. An alternative option of the cost-optimal performance is also proposed, applicable in cases where this is stricter than the national minima.

- For major renovations a different option is proposed for the Comprehensive criterion, with performance required in line with the national minimum in force in 2002. This would ensure, based on a notional replacement rate of 2% per annum of the office building stock (taking into account the economic downturn), that the renovated building would then fall broadly within the best 15-20% of the building stock. The cost (and extent of the renovation) would be constrained by a requirement to demonstrate a positive net present value in a cost optimality assessment.
- In addition, for renovations it is proposed to require the use of a detailed energy model with survey data inputs. The latter is intended to ensure that potential problems with the existing building stock such as thermal bridges are taken into account in the modelled performance.
- Given that there appears to be a practical limit to how far an office building can progress towards a 'nearly zero energy' performance – in terms of both cost and on-site technology - it is proposed that an award criterion is used to invite potential contractors to bring forward advanced performance specifications on a competitive basis.
- Nearly Zero Energy can be defined in terms of Member State requirements, where these have been established at the time of publishing the ITT, or based on modelled figures for simplified EU climatic zones. Upper performance levels have been defined based on the cost-optimal levels projected by Ecofys et al (2013) for 2020. Past these levels, low or zero carbon energy technology is likely to be required, which is addressed by a separate criterion.
- In both options for the Comprehensive award criterion, it is proposed that instead of being cost-optimal the measures shall achieve a positive Net Present Value, reflecting the approach taken by the UK in their policy Impact Assessments. This would allow measures to be implemented that lie further up the improvement curve illustrated in Figure 2.3.

2.2.1.2 Commissioning of building energy systems

2.2.1.2.1 Background technical discussion and rationale

Evidence from the monitoring of building projects from design through to handover and operation suggests that the performance of the building services – i.e. the Heating, Ventilation and Cooling (HVAC) systems – is an important factor to control in the overall management of energy use. The increasing complexity of these systems means that on the one hand they can be used to intelligently control and respond to the buildings HVAC needs whilst on the other hand, if not commissioned and operated correctly, they can lead to higher energy use.

UK association CIBSE defines commissioning as *'the processes of bringing the systems into operation; their regulation; the setting up of associated control systems; plus the recording of the final settings and the state of the final system performance'*. The IEA's Energy Conservation in Buildings and Community Systems Annex 40 recognised the importance of properly function HVAC systems and developed tools to support the commissioning process[35]. They highlight the importance of 'Functional Performance Testing' in commissioning HVAC systems, an approach which is reflected to some extent in the EN standard 12599 for the handover of building ventilation systems . US standards organisation ASHRAE has also recently published a new commissioning standard 202 which specifically addresses the commissioning process and includes a number of areas highlighted by ECBCS Annex 40 [36]. The importance of incorporating requirements for commissioning is, moreover, highlighted by experience from innovative projects, including those certified to existing building certification schemes [37].

Evidence from surveys of buildings commissioned in the US suggests based on findings from a database of 643 buildings that energy-related commissioning problems can increase energy use by approximately 15%

35 International Energy Agency (2004) Commissioning tools for improved energy performance, ECBS Annex 40

36 ASHRAE, *ASHRAE publish first standard focussed on the commissioning process*, 26th September 2013, https://www.ashrae.org/news/2013/ashrae--ies-publish-first-standard-focused-on-commissioning-process

37 Turner, S.C. *Commissioning design/build projects*, ASHRAE Journal, October 2012

[38]. A low energy buildings programme by the Carbon Trust in the UK revealed that 40% of the building developers involved did not meet their low energy goals because of problems that could have been addressed by better commissioning. This is particularly understood to be the case where energy saving technologies such as heat pumps have been introduced. In several cases, systems have not performed according to modelled expectations - as demonstrated by findings from monitored projects in programmes such as EnOB in Germany [39].

2.2.1.2.2 Revised criteria proposal

Core criteria	**Comprehensive criteria**
TECHNICAL SPECIFICATIONS	
D2. Installation and commissioning of building energy systems Depending on the procurement route this may also apply to systems installed by a third party energy services contractor (see Section E). The following systems shall be designed, installed and commissioned in conformance with the agreed designs and specifications: - Heating, cooling and ventilation (HVAC) - Low and Zero Carbon energy technologies - Building Energy Management System (BEMS) - Lighting controls Each system shall be subjected to functional performance testing, including measurement of performance. HVAC systems shall be in conformance with EN12599 or equivalent and, as relevant to other systems installed, other applicable EN, ISO or national standards, or their equivalent. **Verification:** The main construction contractor or the DBO contractor shall describe and commit to carrying out a functional performance testing routine in order to ensure that the systems perform within design parameters.	**D2. Installation and commissioning of building energy systems** Depending on the procurement route this may also apply to systems installed by a third party energy services contractor (see Section E). The following systems shall be designed, installed and commissioned in conformance with the agreed designs and specifications: - Heating, cooling and ventilation (HVAC) - Low and Zero Carbon energy technologies - Building Energy Management System (BEMS) - Lighting controls Each system shall be subjected to functional performance testing, including measurement of performance. HVAC systems shall be in conformance with EN12599 or equivalent and, as relevant to other systems installed, other applicable EN, ISO or national standards, or their equivalent. **Verification:** The main construction contractor or the DBO contractor shall describe and commit to carrying out a functional performance testing routine in order to ensure that the systems perform within design parameters.
CONTRACT PERFORMANCE CLAUSE	
D5. Installation and commissioning of building energy systems *Depending on the procurement route, this may also apply to systems installed by a third party energy services contractor (see Section E).* The following systems shall be installed and commissioned in conformance with the agreed designs and specifications: - Heating, cooling and ventilation (HVAC) - Low and Zero Carbon energy technologies - Building Energy Management System (BEMS) - Lighting controls Each system shall be subjected to functional performance testing as described in the successful tender, including measurement of performance.	**D5. Installation and commissioning of building energy systems** *Depending on the procurement route, this may also apply to systems installed by a third party energy services contractor (see Section E).* The following systems shall be designed, installed and commissioned in conformance with the agreed designs and specifications: - Heating, cooling and ventilation (HVAC) - Low and Zero Carbon energy technologies - Building Energy Management System (BEMS) - Lighting controls Each system shall be subjected to functional performance testing as described in the successful tender, including measurement of performance.

38 Lawrence Berkeley National Laboratory, Building Commissioning: A Golden Opportunity for Reducing Energy Costs and Greenhouse Gas Emissions, Report prepared for the Californian Energy Commission, USA, July 21st 2009

39 EnOB, *Research for energy optimised building*, Germany http://www.enob.info/en/analysis/analysis/details/workplace-satisfaction-and-comfort/

Verification: The main construction contractor or the DBO contractor shall provide a copy of the survey report or certificate confirming that testing of the building services has been carried out and providing data showing that the services perform within design parameters.	**Verification:** The main construction contractor or the DBO contractor shall provide a copy of the survey report or certificate confirming that testing of the building services has been carried out and providing data showing that the services perform to within design parameters.

Summary rationale:

- Evidence suggests that if HVAC systems are not correctly commissioned, this can lead to increased energy consumption, particularly when low carbon energy technologies are introduced into designs.
- Commissioning routines have been developed that aim to diagnose problems before the building is used. So-called 'functional performance testing' can help in ensuring that the building's systems are more thoroughly tested before occupation, potentially avoiding additional energy use and costly interventions later on.
- A requirement is proposed for all buildings that a functional performance testing routine is carried out before occupation, with reference to EN 12599 which provides a routine for the functional checking of the installation and measuring of performance. This would be included as a contract performance clause.

2.2.1.3 Quality of the completed building fabric

2.2.1.3.1 Background technical discussion and rationale

In order to guarantee a high performing low energy building, it is important to ensure that the completed building fabric has a low level of air infiltration (i.e. it is air tight and does not leak air) and minimal thermal bridges where heat can be conducted through the buildings structure from outside to inside (or vice versa). This should be addressed at the design stage by careful detailing of the external fabric and at the construction stage by ensuring quality and precision on-site. For example, the Passivhaus standard developed in Germany and now promoted across the EU places a strong emphasis on minimising thermal bridges during design and construction, followed by post-construction testing [40].

Thermal imaging using a special camera can be used to identify breaks in the integrity of a building's insulation. It can be used to assess the quality of workmanship in installing insulation and in detecting any failure in the building fabric such as an ingress of moisture. In some Member States such as the UK and Ireland accredited details are specified which provide designers and builders with construction details that minimise thermal bridging but in general limited guidance is provided across the EU [41]. Only Denmark is understood to currently legally require thermal imaging to test construction quality [42]. In Italy there is understood to be a certification scheme for construction details.

The UK PROBE series of building post-occupancy surveys during the 1990's identified uncontrolled air infiltration as a common problem in new-build completions [43]. The study series identified the following problems:

- Gaps in the building fabric around roof eaves, the cills and reveals of window and door frames, at junctions in the structure and between light and heavyweight cladding:
- Motorised windows and dampers intended for summer ventilation without adequate seals;
- Unnecessarily high volumes and hours of mechanical ventilation, often without heat recovery;
- Reception areas that suffered high levels of infiltration.

40 Passipedia, *Thermal bridges*, Passivhaus Institut, http://www.passipedia.org/passipedia_en/basics/building_physics_-_basics/heat_transfer/thermal_bridges#what_defines_thermal_bridge_free_design

41 Asiepi (ASsessment and Improvement of the EPBD Impact), *An effective Handling of Thermal Bridges in the EPBD Context*, Final Report of the IEE ASIEPI Work on Thermal Bridges, 31st March 2010

42 Asiepi (ASsessment and Improvement of the EPBD Impact), *Analysis of Execution Quality Related to Thermal Bridges*, 18th October 2009

43 PROBE, *Final report 4: Strategic conclusions*, Report to DEFRA (UK Government), August 1999, http://www.usablebuildings.co.uk/Probe/ProbePDFs/SR4.pdf

Whilst thermal imaging is a technique that can be used to locate breaks in the fabric insulation where there may be air infiltration a 'blower door' (fan pressurisation) test, whereby the building is sealed and pressurised, is required to quantify the level of air infiltration into a building. Best practice for air infiltration (also referred to as air leakage) is stated to be in the range of 1.5-3 $m^3/(h.m^2)$ at 50 Pascals of air pressure [44] with lower end of the range represented by the Passivhaus standard. High performance may be more difficult and costly to achieve for major renovations so performance equating to a naturally ventilated building may be more appropriate, indicatively in the range of 5-8 $m^3/(h.m^2)$ at 50 Pascals of air pressure. The EN standard 13829 provides a method for carrying out this test. It should be noted that comparability of standards is an issue because some Member States express standards as air changes and at differing air pressures [45].

Recognising the importance of air tightness, at least 11 Member States now require some form of testing of the integrity of the building fabric at national or regional level, with Denmark, Ireland, France and the UK setting minimum requirements in their building regulations [46]. The most common form of testing is the blower door test.

Credit is given in the BREEAM building certification schemes (see ENE 6 Commercial 2009) for careful attention to fabric performance of avoidance of air infiltration. Within the as-built performance measures 'comprehensive thermographic inspection' is identified in order to confirm:

- Continuity of insulation in accordance with the construction drawings,
- Avoidance of excessive thermal bridging,
- No air leakage paths through the fabric (except through intentional openings).

Recognising the need within the construction industry for improvements in detailing and, in particular, quality control on-site, Hannover City Council in Germany implemented an innovative quality control programme on phases of its demonstration EXPO 2000 urban extension. This included requirements for on-site inspections coupled with testing of the fabric integrity. The programme reported significant improvements in quality control and the level of compliance as phases of construction progressed [47]. The lessons learnt were then applied across the city of Hannover and may therefore be particularly relevant to public authorities or consortia procuring a series of buildings through a framework.

2.2.1.3.2 Revised criteria proposal

Core criteria	**Comprehensive criteria**
TECHNICAL SPECIFICATIONS	
F1. Quality of the completed building fabric The building fabric and its construction shall be designed in order to ensure a high standard of air tightness. The design air tightness shall be 4 $m^3/(h.m^2)$ at 50 Pascals for new-build and 8 $m^3/(h.m^2)$ at 50 Pascals for major renovations. Upon completion of the building, the lead contractor shall test the quality of the finished building fabric and its construction according to EN 13829 or equivalent in order to ensure that the design performance has been achieved. **Verification:** The tenderer shall provide a commitment to carry out, upon completion, testing of the airtightness of the building fabric and to address any defects that may arise.	**F1. Quality of the completed building fabric** The building fabric and its construction shall be designed in order to ensure continuity of insulation and a high standard of air tightness. The design air tightness shall be 2 $m^3/(h.m^2)$ at 50 Pascals for new-build and 5 $m^3/(h.m^2)$ at 50 Pascals for major renovations. Upon completion of the building, the lead contractor shall test the quality of the finished building fabric and its construction according to EN13817 and EN 13829 or equivalent in order to ensure that there are no defects and that the design performance has been achieved. **Verification:** The tenderer shall provide a commitment to carry out, upon

44 Tight Vent Europe, *Building airtightness: A critical review of building testing, reporting and quality schemes in 10 countries*, Report No 4, September 2012.

45 Energy and Thernal Improvements for Construction in Steel, *Report on National and European requirements regarding air-tightness*, 2008,

46 Heike.E-K, Erhorn.H, Lahmidi.H and R,Anderson, Airtightness requirements for high performance building Envelopes, Published by Asiepi, 2010 *and* ATTMA, *Measuring air permeability of building envelopes*, Technical standard L2, October 2010

47 Hannover Landeshauptstadt, *Modell Kronsberg: Sustainable building for the future*, September 2000

	completion, testing of the thermal integrity and airtightness of the building fabric and to address any defects that may arise.
CONTRACT PERFORMANCE CLAUSE	
F3. Quality of the completed building fabric The lead contractor shall test the quality of the finished building fabric and its construction to ensure that they meet the design specifications for air tightness. A blower door test shall be carried out for at least 20% of the buildings useable internal floor space demonstrating that the design air tightness is 4 $m^3/(h.m^2)$ at 50 Pascals for new-build and 8 $m^3/(h.m^2)$ at 50 Pascals for major renovations. The test shall be carried out in accordance with EN 13829 or equivalent standards accepted by the respective building control body where the building is located. Where defects are identified, remedies shall be proposed. **Verification:** The testing shall be carried out following practical completion of the building. The contractor shall provide a copy of the survey report or certificate confirming that the building meets the air tightness requirement following a test carried out according to EN 13829 or equivalent.	**F3. Quality of the completed building fabric** The lead contractor shall test the quality of the finished building fabric and its construction to ensure that they meet the design specifications for airtightness and continuity of insulation. This shall take the form of thermal imaging carried out in accordance with EN 13187 and a blower door test for at least 20% of the buildings useable internal floor space demonstrating that the design air tightness is 2 $m^3/(h.m^2)$ at 50 Pascals for new-build and 5 $m^3/(h.m^2)$ at 50 Pascals for major renovations. The latter shall be carried out in accordance with EN 13829 or equivalent standards accepted by the respective building control body where the building is located. Where defects are identified then remedies shall be proposed. **Verification:** The testing shall be carried out following practical completion of the building. The contractor shall provide a copy of the survey report or certificate confirming that: - The building meets the air tightness requirement following a test carried out according to EN 13829 or equivalent. - There are no significant defects in the construction details in accordance with EN 13187 or equivalent.

Summary rationale:

- As the market for low energy office buildings develops, architects and construction contractors will become more experienced in the detailing of construction details at the design stage and the control of quality on-site in order to ensure that the as-built performance closely matches design performance.
- However, evidence suggests that continuity of the fabric insulation and air tightness are two areas where on-site inspection and testing have the potential to drive improvements in quality, both on the project itself and subsequent projects managed by contractors.
- An air leakage target together with a requirement for testing upon completion is proposed as a Core criterion. This will ensure a focus on air leakage from the building fabric at the design stage and during construction.
- A commitment to carry out thermal imaging upon completion is proposed as a Comprehensive criterion. This will ensure a focus on continuity of the fabric insulation at the design stage and during construction.
- Air tightness testing and thermal imaging (as appropriate) would then be carried out as a contract performance clause. The blower door test is currently a legal requirement in a number of Member States and advised in others. Thermal imaging is not currently a legal requirement in a majority of Member States but is an effective inspection tool.

- In both cases an EN standard is specified which provides a reference point for carrying out the testing.

2.2.1.4 At what stage of the procurement process are the criteria relevant?

The evaluation of the minimum energy performance of an office building has been proposed as a technical specification and additionally as award criteria, to further performance improvements over and above the previous technical specifications, (both Core and Comprehensive criterion). These criteria have to be applied during the detailed design and performance requirements procurement phase. The *Design team*, the D*esign & Build tenderer or* the *DBO tenderer* shall submit information demonstrating that the building design to be submitted for permitting by the local authority complies with the GPP requirements. This shall consist of the predicted energy performance of the building according to the national calculation methodology applicable where the building is situated. Either a competent authority or building assessor certified to use the methodology shall verify the calculations.

The correct installation and commissioning of building energy systems has been proposed as a technical specification (both Core and Comprehensive criterion) and is supplemented by a contract performance clause to ensure the control of the correct execution in the framework of the construction of the building or major renovation works. The main *construction contractor* or the *DBO contractor* shall, upon completion and handover, provide a copy of the survey report or certificate confirming that testing of the building services has been carried out and providing data showing that the systems perform within design parameters.

The quality of the completed building fabric has been proposed as a technical specification (both Core and Comprehensive criterion) which is supplemented by a contract performance clause to ensure the control of the correct execution in the framework of the practical completion and handover. The *contractor* shall provide a copy of the survey report or certificate confirming that there are no defects in the construction details in accordance with EN 13187 or equivalent and, where required by a criterion, EN 13829.

The criteria classification, their reference numbers in the criteria document and the respective procurement phase can be cross referenced as follows.

Title of the criterion	**Procurement phase**	**Criterion classification**	**Criteria typology**	**Reference number in the criteria document**
Minimum Energy performance	B. Detailed design and performance requirements	Core and Comprehensive	Technical specification	B1.
Minimum Energy performance requirements	B. Detailed design and performance requirements	Core and Comprehensive	Award criteria	B8.
Installation and commissioning of building energy systems	D. Construction of the building or major renovation works	Core and Comprehensive	Technical specification	D2.
	F. Practical completion and handover	Core and Comprehensive	Contract performance clause	D6.
Quality of the building fabric	D. Construction of the building or major renovation works	Core and Comprehensive	Technical specification	F1.
	F. Practical completion and handover	Core and Comprehensive	Contract performance clause	F3.

2.2.2 Lighting

2.2.2.1 Performance requirements: lighting control systems

2.2.2.1.1 Background technical discussion and rationale

Electricity use associated with lighting is a significant contributor to the energy use of buildings. Moreover, because of the higher CO_2 emissions associated with electricity generation, lighting has a proportionally greater contribution to Global Warming Potential in LCA results compared to other energy uses such as heating.

Lighting is already addressed to some extent within the modelling of a buildings overall energy consumption in order to comply with national minimum requirements in each Member State. The 'common general framework for the calculation of energy performance of buildings' set out in Annex 1 of the recast Energy Performance of Buildings Directive 2010/31/EU [48] requires that the methodologies used in each Member State consider built-in lighting installations and the 'positive influence' in calculations of natural lighting.

Whilst the EPBD places the main emphasis on the efficiency of the lighting technology itself, there is strong evidence to suggest that control systems are an important additional consideration [49] and that, as highlighted by the whole building renovation studies in Section 2.1.1.1, it can be one of the most cost effective energy saving measures. These can include occupancy sensors that turn off lights when offices or spaces are not occupied and daylight sensors that reduce artificial lighting levels in function of increased natural lighting. Post-occupancy studies of low energy buildings have also highlighted the importance of good user controls in conjunction with automatic controls to minimise use.

Whilst literature suggests that the potential savings from lighting controls can have a wide variance [50], best practice indicates a potential of between 30% and 50% on lighting energy use [51]. Occupancy sensors appear to offer the greatest savings potential followed by daylight linked dimming, with the potential to reduce overall lighting power density to as low as 3-4 W/m^2 [52]. Indicative costs at 2011 prices are 2.7€/m^2 for natural lighting sensors and 7.2€/m^2 for occupancy sensors.[53].

There is a separate GPP criteria set for indoor lighting products. Whilst the main focus of the criteria is on the energy performance and lifespan of the product they also address the design of lighting systems. Technical specification 3.2.3 addresses lighting controls. The Core criterion includes requirements for time switches and/or occupancy sensors as well as automatic daylight linked dimming in common areas. The Comprehensive criterion adds a more extensive requirement for automatic daylight linked dimming in working areas.

In order to check how lighting controls are accounted for in national energy calculation methodologies, the methods used in the UK and Spain were selected. In both Member States the calculation methods include for the potential to enter detailed assumptions relating to lighting specifications. These include factors for efficiency gains from, for example, occupancy sensors and daylight linked systems.

Post occupancy surveys of low energy and passive buildings identify user control of lighting as an important factor. Controls should be both easy to use and readily available so that occupiers feel they are able to manage the comfort level in their working environment.

2.2.2.1.2 Revised criteria proposal

Core criteria	**Comprehensive criteria**
TECHNICAL SPECIFICATIONS	
B2. Lighting control systems Where lighting control systems are not a minimum requirement in a Member State or their contribution is not taken into account in the national calculation	**B2. Lighting control systems** Where lighting control systems are not a minimum requirement in a Member State or their contribution is not taken into account in the national calculation method, occupancy sensors and

48 Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (recast)

49 CIBSE (2014) *Lighting control technologies and strategies to cut energy consumption*, CIBSE Journal CPD programme, http://www.cibsejournal.com/cpd/2010-11/

50 Roisin et al, *Lighting energy savings in offices using different control systems and their real consumption*, Energy and Buildings 40 (2008) 514–523

51 The Carbon Trust, *Lighting technology overview*, December 2011

52 Galasiu.A.D, *Energy Saving Lighting Control Systems for Open-Plan Offices: A Field Study*, LEUKOS: The Journal of the Illuminating Engineering Society of North America, Volume 4, Issue 1, 2007

53 See IPF (2009)

method, occupancy sensors shall be installed in line with Technical Specification 3.2.3 of the indoor lighting EU GPP criteria (published in 2012). The indoor lighting EU GPP criteria are available here: http://ec.europa.eu/environment/gpp/pdf/Indoor%20Lighting%20-%20EU%20GPP%20Criteria%20Final%20draft.pdf In addition, occupiers shall be able to control or override lighting systems in local zones or rooms within the building. **Verification:** The Design team or the Design & Build tenderer or the DBO tenderer shall provide technical specifications for the lighting control systems to be installed. Verification relating to commissioning and handover is addressed in Section F3.	daylight-linked controls shall be installed in line with Technical Specification 3.2.3 of the indoor lighting EU GPP criteria (published in 2012). The indoor lighting EU GPP criteria are available here: http://ec.europa.eu/environment/gpp/pdf/Indoor%20Lighting%20-%20EU%20GPP%20Criteria%20Final%20draft.pdf In addition, occupiers shall be able to control or override lighting systems in local zones or rooms within the building. **Verification:** The Design team or the Design & Build tenderer or the DBO tenderer shall provide technical specifications for the lighting control systems to be installed. Verification relating to commissioning and handover is addressed in Section F3.

Summary rationale:

- Lighting control systems linked to daylighting and occupancy have a significant energy saving potential, with evidence suggesting in the range of 30% and 50%.
- The EPBD requires national calculation methodologies for energy to include built-in light fittings and to take into account the 'positive influence' of natural lighting. Some national calculation methodologies may include factors that can account for savings from daylight sensors linked to dimmers and occupancy sensors.
- The current GPP criteria for indoor lighting include a criterion under lighting design that addresses control systems, with a focus on occupancy and daylight sensors.
- Given that lighting controls are in part required to be accounted for within national energy calculation methodologies it is proposed that Technical specification 3.2.3 from the current GPP criteria is required only where occupancy sensors and daylight linked systems are not included.

2.2.2.2 Commissioning and handover of lighting control systems

2.2.2.2.1 Background technical discussion and rationale

Whilst lighting controls have been identified as an important improvement measure to save energy, such systems introduce additional complexity into the electrical installation for a building. The complex interaction between the lighting units, which may be individually controlled and networked with Digital Addressable Lighting Interfaces (DALI's), controls, sensors and the building's energy management system, require careful installation and commissioning to ensure that their use is optimised.

The IEA Task 31 project on daylighting in buildings identifies poor commissioning as the main reason for systems failing to meet design performance objectives [54]. For example, common issues can include the correct calibration and positioning of occupancy and daylight sensors. The current EU GPP indoor lighting design contract performance clause 3.3.1 addresses this specific issue. Moreover, Technical Specification 3.3.1 also contains a requirement for the provision of written instructions on how to manage the control systems, including the adjustment of occupancy sensors, daylighting linked controls and time switches.

54 IEA, *Task 31: Daylighting buildings in the 21st Century: Calibration and commissioning guide*, 27th May 2006

2.2.2.2.2 Revised criteria proposal

Core criteria	Comprehensive criteria
TECHNICAL SPECIFICATIONS	
D2. Installation and commissioning of building energy systems Depending on the procurement route, this may also apply to systems installed by a third party energy services contractor (see Section E). The following systems shall be designed, installed and commissioned in conformance with optimised designs and specifications: - Heating, cooling and ventilation (HVAC) - Low and Zero Carbon energy technologies - Building Energy Management System (BEMS) - Lighting controls Each system shall be subjected to a functional performance testing routine, including measurement of performance. HVAC systems shall be in conformance with EN12599 or equivalent and, as relevant to other systems installed, other applicable EN, ISO or national standards, or their equivalent. **Verification:** The main construction contractor or the DBO contractor shall describe and commit to carrying out a functional performance testing routine in order to ensure that the systems perform within design parameters.	**D2. Installation and commissioning of building energy systems** Depending on the procurement route this may also apply to systems installed by a third party energy services contractor (see Section E). The following systems shall be designed, installed and commissioned in conformance with optimised designs and specifications: - Heating, cooling and ventilation (HVAC) - Low and Zero Carbon energy technologies - Building Energy Management System (BEMS) - Lighting control Each system shall be subjected to functional performance testing routine, including measurement of performance. HVAC systems shall be in conformance with EN12599 or equivalent and, as relevant to other systems installed, other applicable EN, ISO or national standards, or their equivalent. **Verification:** The main construction contractor or the DBO contractor shall describe and commit to carrying out a functional performance testing routine in order to ensure that the systems perform within design parameters.
CONTRACT PERFORMANCE CLAUSES	
F4. Lighting control systems Systems shall be commissioned in accordance with contract performance clause 3.3.1 from the same criterion. The main contractor shall provide an operational manual for the systems in line with GPP indoor lighting design (technical specification) criterion 3.3.1. Training shall be provided to either the occupants and (*where relevant*) the appointed facilities management provider on how to use the systems. The interface with the BEMS (criterion F2) shall also be addressed. **Verification:** The Design team or the Design & Build contractor or the DBO contractor shall provide a copy of the survey report or certificate confirming that testing of the lighting systems has been carried out and providing data showing that the systems perform to within design parameters. They shall additionally confirm that the required materials and training have been provided.	**F4. Lighting control systems** Systems shall be commissioned in accordance with contract performance clause 3.3.1 from the same criterion. The main contractor shall provide an operational manual for the systems in line with GPP indoor lighting design (technical specification) criterion 3.3.1. Training shall be provided to either the occupants and (*where relevant*) the appointed facilities management provider on how to use the systems. The interface with the BEMS (criterion F2) shall also be addressed. **Verification:** The Design team or the Design & Build contractor or the DBO contractor shall provide a copy of the survey report or certificate confirming that testing of the lighting systems has been carried out and providing data showing that the systems perform to within design parameters. They shall additionally confirm that the required materials and training have been provided.

Summary rationale:

- The correct installation and commissioning of lighting control systems, including functional testing, is an important step to ensure that the potential energy savings from the investment in technology are realised.
- It is proposed that lighting controls are commissioned using a functional testing routine and that an aftercare service with follow-up testing is encouraged as an award criteria.
- The contractor shall additionally ensure that a user manual is provided upon handover and that basic training is provided to the occupant and/or the appointed facilities manager.

2.2.2.3 At what stage of the procurement process are the criteria relevant?

The lighting control systems have been proposed as a Comprehensive technical specification to be applied during the detailed design and performance requirements procurement phase. Moreover, an operational manual and training on how to use the lighting control systems have also been proposed to be provided according to a contract performance clause to be applied during the practical completion and handover procurement phase. In detail, the *Design team* or the *Design & Build tenderer* or the *DBO tenderer* shall provide technical specifications for the lighting control systems to be installed. Moreover, during the practical completion and handover, the *Design team* or the *Design & Build contractor* or the *DBO contractor* shall demonstrate compliance with the commissioning routine and additionally provide materials and training.

The correct installation and commissioning of lighting control systems has been proposed as a contract performance clause (both for Core and Comprehensive criteria) to be applied during the Construction of the building or major renovation works procurement phase. The main *construction contractor* or the *DBO contractor* shall provide a copy of the survey report or certificate confirming that testing of the systems has been carried out and providing data showing that the systems perform to within design parameters.

The criteria classification, their reference numbers in the criteria document and the respective procurement phase can be cross referenced as follows.

Title of the criterion	Procurement phase	Criterion classification	Criteria typology	Reference number in the criteria document
Lighting control systems	B. Detailed design and performance requirements	Comprehensive	Technical specification	B2
Installation and commissioning of building energy systems	D. Construction of the building or major renovation works	Core and comprehensive	Technical specification	D2.
Lighting control systems	F. Practical completion and handover	Comprehensive	Contract performance clause	F4.

2.2.3 Building Energy Management System (BEMS)

2.2.3.1 Performance requirements: BEMS

2.2.3.1.1 Background technical discussion and rationale

Building Energy Management Systems (BEMS) are increasingly installed in new and renovated office buildings, sometimes as a component of Building Management System (BMS). They allow for the digital control and co-ordination of the building services that provide heating, cooling, ventilation and lighting, as well as the resulting ambient conditions and comfort levels for occupants. IEA Task 16 on BEMS adopted the following definition[55]:

> *'An electric control and monitoring system that has the ability to communicate data between control nodes (monitoring points) and an operator terminal. The system can have attributes for all facets of*

55 IEA (1997) *Building Energy Management Systems: Technical synthesis reports for Annex 16 and 17*, Energy Conservation in Buildings and Community Systems programme.

building control and management functions such as HVAC, lighting, fire, security, maintenance management and energy management.'

Systems can integrate controls relating to timing, ambient conditions (internal and external) and occupancy. They can also provide building operators with accurate data on patterns of energy use in order to monitor and understand how energy is being consumed in the building. The use of such an active control system is specifically supported in Article 8 of the recast EPB Directive 2010/31/EU.

Experience suggests that whilst a BEMS has significant potential to facilitate energy saving, with the IEA suggesting conservative savings in the range of 15-30% based on surveys, this tends only to be realised if it is carefully designed and commissioned.

The critical first step for a public authority is the decision to specify that control systems are required to ensure good energy management and that a BEMS is the preferred approach. Important aspects that have been recommended to request related to the design of the BEMS include [56]:

- Design of a user interface that is easy to use, provides an overview of performance and allows for adjustment of important system variables;
- Engagement of building operators in the design of user interfaces;
- Specification of systems to manage energy and not just occupant comfort conditions;
- Integration of low or zero carbon technologies into the control systems so as to ensure efficient operation alongside conventional technologies.

The costs for BEMS have been estimated at 28€/m^2 for a major office renovation [57] or approximately 1.0% of a new building's total capital cost [58].

2.2.3.1.2 Revised criteria proposal

Core criteria	**Comprehensive criteria**
TECHNICAL SPECIFICATIONS	
B3. Building energy management system A building energy management system (BEMS) shall be installed and commissioned that provides occupants and facilities managers with real-time information on the energy use by using networked sensors and a minimum of half hourly utility metering. The user interface shall allow for information on the buildings energy use to be easily analysed and downloaded by occupants and facilities managers. The performance of key aspects of the building that can be controlled by the system shall be easy to adjust i.e. lighting, heating, cooling. **Verification:** The Design team or the Design & Build tenderer or the DBO tenderer shall provide specifications for the BEMS including information about the user interface. They shall additionally demonstrate how information will be displayed, reported and made available to at least the facilities and/or energy managers for the building.	**B3. Building energy management system** A building energy management system (BEMS) shall be installed and commissioned that provides occupants and facilities managers with real-time information on the energy use by using networked sensors and a minimum of half hourly utility metering. The user interface shall allow for information on the buildings energy use to be easily analysed and downloaded by occupants and facilities managers. Occupants shall also be able to adjust comfort conditions in zones of the building. The performance of key aspects of the building that can be controlled by the system shall be easy to adjust i.e. lighting, heating, cooling. Additionally the system shall allow for: • Analysis and control of energy uses for different zones within the building (as a minimum for heating, cooling, lighting); • Performance optimisation according to ambient conditions inside and outside the building, and; • Diagnosis of the reason for any deviations from design performance. **Verification:**

56 The Carbon Trust, *Taking control: Lessons learned from installing control systems in low carbon buildings*, UK, August 2011

57 Davis Langdon, *Cost model: Building refurbishments*, Edit of an article first appearing in Building magazine (UK), June 2012

58 See IEA (2007)

	The Design team or the Design & Build tenderer or the DBO tenderer shall provide specifications for the BEMS including information about the user interface. They shall additionally demonstrate how information will be displayed, reported and made available to at least the facilities and/or energy managers for the building.

Summary rationale:

- A BEMS allows for intelligent control of building energy use by operators, with systems giving access to real-time data on the status of the energy systems and their performance. Such a system also allows for the fine tuning of energy use on a temporal basis in response to ambient conditions, user comfort requirements, feedback from sensors and HVAC system efficiencies.
- It is important that systems incorporate any low or zero carbon energy technologies that are installed, as these usually need to work in tandem with conventional systems and it can also be difficult to commission and fine tune their performance.
- Studies and surveys of experience with the use of BEMS suggest that they can lead to energy savings in the range of 15-30% for an estimated 1.0% additional capital cost.
- It is proposed that a basic BEMS providing real-time data on energy use is a Core technical specification and that the addition of systems for the optimisation of performance based on internal and external feedback is a Comprehensive criterion.

2.2.3.2 Commissioning and handover

2.2.3.2.1 Background technical discussion and rationale

Experience and guidance on the installation and use of BEMS highlights the importance of careful commissioning and handover of the systems in order to realise the potential benefits. Moreover, guidance also suggests that a badly installed system can actually result in higher than predicted energy consumption.

As discussed in Section 2.1.3.1, functional performance testing has been identified as a critical step. Specific functional testing routines highlighted as being important include [59]:

- Checking that the BEMS is installed as specified;
- Checking that sensors are positioned, calibrated and function correctly;
- Checking that metering is fully functional so that the overall system outputs can be tested;
- Checking that the whole system functions once HVAC, LZC technologies and lighting installations have been completed;
- Carrying out seasonal commissioning if there is the additional budget to use the original commissioning team.

Training is also important because staff of the contracting authority or the facilities management company will need to be aware of the capabilities of the system and how they can use it to better management energy use. The system should also be documented in a user manual. This manual is important to support ongoing management of the building and to support future energy savings in case there may be changes in staff or the facilities management company.

59 The Carbon Trust, *Building controls: Realising savings through the use of controls*, CTV032 Technology overview, UK, August 2007

2.2.3.2.2 Revised criteria proposal

Core criteria	Comprehensive criteria
TECHNICAL SPECIFICATIONS	
D2. Installation and commissioning of building energy systems Depending on the procurement route this may also apply to systems installed by a third party energy services contractor (see Section E). The following systems shall be designed, installed and commissioned in conformance with optimised designs and specifications: - Heating, cooling and ventilation (HVAC) - Low and Zero Carbon energy technologies - Building Energy Management System (BEMS) - Lighting controls Each system shall be subjected to functional performance testing, including measurement of performance. HVAC systems shall be in conformance with EN12599 or equivalent and, as relevant to other systems installed, other applicable EN, ISO or national standards, or their equivalent. **Verification:** The main construction contractor or the DBO contractor shall describe and commit to carrying out a functional performance testing routine in order to ensure that the systems perform within design parameters.	**D2. Installation and commissioning of building energy systems** Depending on the procurement route this may also apply to systems installed by a third party energy services contractor (see Section E). The following systems shall be designed, installed and commissioned in conformance with optimised designs and specifications: - Heating, cooling and ventilation (HVAC) - Low and Zero Carbon energy technologies - Building Energy Management System (BEMS) - Lighting controls Each system shall be subjected to functional performance testing, including measurement of performance. HVAC systems shall be in conformance with EN12599 or equivalent and, as relevant to other systems installed, other applicable EN, ISO or national standards, or their equivalent. **Verification:** The main construction contractor or the DBO contractor shall describe and commit to carrying out a functional performance testing routine in order to ensure that the systems perform within design parameters.
CONTRACT PERFORMANCE CLAUSE	
F5. Building energy management system The BEMS shall be commissioned in accordance with the required technical specifications. The main contractor shall provide an operational manual for the Building Energy Management System (BEMS). Training shall be provided to either the occupants and (*where relevant*) the appointed facilities management provider on how to use the BEMS. This shall include use of the user interface to analyse and download energy data using accessible software tools. **Verification:** The main construction contractor or the DBO contractor shall provide: – A copy of the survey report or certificate confirming that testing of the BEMS has been carried out, – Data showing that the systems perform within design parameters, – Confirmation that the required materials and training have been provided.	**F5. Building energy management system** The BEMS shall be commissioned in accordance with the required technical specifications. The main contractor shall provide an operational manual for the Building Energy Management System (BEMS). Training shall be provided to the occupants and (*where relevant*) the appointed facilities management provider on how to use the BEMS. This shall include use of the user interface to analyse and download energy data using accessible software tools. **Verification:** The main construction contractor or the DBO contractor shall provide: – A copy of the survey report or certificate confirming that testing of the BEMS has been carried out, – Data showing that the systems perform within design parameters, – Confirmation that the required materials and training have been provided.

<u>*Summary rationale:*</u>

- The careful commissioning of a BEMS is an important step in ensuring that it is fully functional in accordance with the design specification and as a system integrating and co-ordinating HVAC, LZC technologies and lighting systems once these have been installed and commissioned.
- The training of users of the BEMS, supported by a detailed user manual, has been shown to be important in order to ensure that benefits of such a system are realised by those who will operate it.

- It is proposed that functional performance testing, training and documentation are required as technical specifications.

2.2.3.3 At what stage of the procurement process are the criteria relevant?

The building energy management system has been proposed as a technical specification (both in Core and Comprehensive criteria) to be applied during the detailed design and performance requirements procurement phase. Moreover, an operational manual for the BEMS has also been proposed as technical specifications (both in Core and Comprehensive criteria) to be applied during the practical completion and handover procurement phase. The *Design team* or the *Design & Build tenderer* or the *DBO tenderer* shall provide specifications for the BEMS including information about the user interface. They shall additionally demonstrate how information will be displayed, reported and made available to at least the facilities and/or energy managers for the building. Moreover, during the practical completion and handover, the *Design team* or the *Design & Build contractor* or the *DBO contractor* shall provide materials and training.

A requirement to carry out functional performance testing as part of the commissioning of building energy systems has been proposed as a technical specification (both in Core and Comprehensive criteria) to be carried out during the construction of the building or major renovation works procurement phase. This would be monitored by a contract performance clause requiring that the main *construction contractor* or the *DBO contractor* provides a copy of the survey report or certificate confirming that testing of the building services has been carried out and providing data showing that the systems perform to within design parameters.

The criteria classification, their reference numbers in the criteria document and the respective procurement phase can be cross referenced as follows.

Title of the criterion	**Procurement phase**	**Criterion classification**	**Criteria typology**	**Reference number in the criteria document**
Building energy management system	B. Detailed design and performance requirements	Core and Comprehensive	Technical specification	B3.
Installation and commissioning of building energy systems	D. Construction of the building or major renovation works	Core and Comprehensive	Technical specification	D2.
Building energy management system	F. Practical completion and handover	Core and Comprehensive	Contract performance clause	F5.

2.2.4 Low or zero carbon energy sources

2.2.4.1 Performance requirements for energy supply systems

2.2.4.1.1 Background technical discussion and rationale

The Renewable Energy Directive 2009/28/EC states that *'Member States shall introduce in their building regulations and codes appropriate measures in order to increase the share of all kinds of energy from renewable sources in the building sector'*. Moreover, Member States shall also ensure that new public buildings and existing buildings subject to major renovation 'fulfill an exemplary role'.

The recast EPB Directive 2010/31/EU broadens the focus, highlighting the importance of integrating low or zero carbon energy generation systems into new building designs. In Article 6 it refers to 'high efficiency' systems that use the electricity from the grid more efficiently to provide heating or cooling (e.g. heat pumps) or which use fuels more efficiently to generate electricity, heating and cooling (e.g. Combined Heat and Power supplying district heating and cooling). It states that for new buildings:

> *'...the technical, environmental and economic feasibility of high-efficiency alternative systems such as those listed below, if available, is considered and taken into account:*
>
> *(a) decentralised energy supply systems based on energy from renewable sources;*
>
> *(b) cogeneration;*

(c) district or block heating or cooling, particularly where it is based entirely or partially on energy from renewable sources;

(d) heat pumps.'

The recast EPB Directive 2010/31/EU also introduced the concept of Nearly Zero Energy Buildings (NZEB), highlighting how the remaining energy requirements should be '*covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby'*. The two extracts from the recast Directive therefore highlight the important to office buildings of encouraging both 'high efficiency' systems and renewable energy sources.

Whilst there is no consistent reference point in EU legislation for the minimum proportion of energy that should be supplied, or the level of CO_2 emissions reduction to be achieved by either forms of energy generation, initiatives by leading public authorities across Europe have established between a 10% and 20% contribution as a de facto energy planning requirement promoted by networks such as Energie Cites and the Covenant of Mayors [60]. This approach was originally based on a planning ordinance established by Barcelona City Council in which the use of solar thermal or photovoltaic technology was required in new buildings [61]. Alternatively, in countries where district heating and cooling are more common, developers may be required to connect new buildings to existing network infrastructure [62].

Evidence studies in support of Member States' building regulations on Nearly Zero Energy Buildings suggest, however, that the practical and cost effective potential for high efficiency or renewable energy systems in office buildings varies according to climate zone, building design and energy technology. The proportion of electricity that could be supplied by a roof mounted solar photovoltaic array will be constrained by the building's roof area. In contrast, a natural gas-fired Combined Heat and Power (CHP) plant could supply efficient electricity, heat and cooling to meet a whole building's needs but would still depend on fossil fuel. In the latter case such a CHP plant may already exist in the local area where the office is to be built, enabling the building to benefit from existing infrastructure. This could therefore be a cost effective solution as savings can be made on boilers and cooling plant that otherwise would have to be purchased.

The availability of third party financing to pay for energy generating technologies can help to support more ambitious targets. This is because separate financing can be sought for these technologies, secured against future sales of energy to building occupiers as well as to local electricity, heating and cooling networks. The investment is usually made by an energy service company, who are specialists in managing the costs and risks associated with energy generating equipment [63].

2.2.4.1.2 Revised criteria proposal

Core criteria	**Comprehensive criteria**
TECHNICAL SPECIFICATIONS	
B4. Low or zero carbon energy sources Where the building is located so as to benefit from the potential to connect to a high efficiency alternative energy systems (e.g. gas cogeneration, district heating/cooling, biomass district heating), the building's energy systems shall be designed to connect to this infrastructure. **Verification:** The Design team or the Design & Build tenderer or the DBO tenderer shall identify where existing infrastructure exists and determine whether it would be beneficial environmentally for the building to connect to this infrastructure. The primary energy savings shall be quantified.	**B4. Low or zero carbon energy sources** A minimum of 10% of the primary energy demand for the building shall be supplied/generated by localised renewable energy sources (e.g. solar panels, biomass boiler, wind turbines, etc) or high efficiency alternative systems (e.g. cogeneration, district heating/cooling, heat pumps) installed within the curtilage of the building or which are shared with other buildings. **Verification:** The Design team or the Design & Build tenderer or the DBO tenderer shall provide designs and drawings for the energy systems to be installed together with calculations of their modelled energy generation and the net contribution to the building's primary energy use.

60 POLIS co-operation project, *Solar urban planning guide*, Intelligent Energy Europe, September 2010

61 C40 Cities, *Barcelona's solar hot water ordinance*, http://www.c40.org/case_studies/barcelonas-solar-hot-water-ordinance

62 Danish Board of District Heating, *Danish district heating characteristics*, http://dbdh.dk/characteristics/

63 European Association of ESCo's (2011) *Energy Performance Contracting in the European Union*

AWARD CRITERIA	
	B9. Low or zero carbon energy sources *This criterion supplements and encourages improved performance over and above the requirements of criterion B4.* The procurer shall award points in proportion to the primary energy demand for the building to be supplied/generated by localised renewable energy sources (e.g. solar panels, biomass boiler, wind turbines, etc) or high efficiency alternative systems (e.g. cogeneration, district heating/cooling, heat pumps) installed within the curtilage of the building or which are shared with other buildings. **Verification:** The Design team (in the case of a Design Contest) or Design & Build contractor or DBO contractor shall provide designs and drawings for the energy systems to be installed together with calculations of their modelled energy generation and the net contribution to the building's primary energy use.

Summary rationale:

- The Renewable Energy Directive 2009/28/EC highlights the exemplary role for public buildings in supporting the installation of renewable energy sources. Moreover, the recast Energy Performance of Building Directive (EPBD) 2010/31/EU highlights the importance of both high efficiency and renewable energy sources in new buildings and major renovations.
- Best practice in urban energy planning is to require a proportion (10-20%) of a new building's energy to be obtained from renewable energy sources or to require a justification why a connection should not be made to a district heating and cooling network, where they exist.
- The cost effective proportion of energy that can be obtained from low, neutral or zero CO2 emitting energy generation varies according to climate zone, building design and energy technology.
- Third party financing provided by energy service companies can be attracted on the basis of future energy contracts and can enable higher levels of on-site energy generation to be achieved, from both high efficiency and renewable energy sources.
- It is proposed that a Core requirement is made that, where available, existing heating and cooling infrastructure shall be connected to as a low cost, low risk option.
- A more ambitious Comprehensive requirement of a minimum contribution of 10% towards the primary energy use of an office building is proposed. This would be flexible, with both high efficiency and renewable energy sources promoted. Experience from a number of EU countries suggests that this can be achieved at minimal additional cost.
- An award criterion is proposed that would incentivise proportionally greater contributions to the remaining energy requirements of an office building.

2.2.4.2 Commissioning and handover of energy supply systems

2.2.4.2.1 Background technical discussion and rationale

As previously highlighted in Section 2.1.1.2, it is important that building energy technologies are thoroughly commissioned using functional performance testing routines. This is important not just to ensure that the technologies are installed and work according to design specifications, but also to ensure that they are correctly integrated with building control systems. Low and zero carbon energy generating technologies are no exception. In some cases systems can be complex, for example geothermal heat pumps, and may require careful adjustment in order to achieve design performance.

2.2.4.2.2 Revised criteria proposal

Core criteria	Comprehensive criteria
TECHNICAL SPECIFICATIONS	
D2. Installation and commissioning of building energy systems Depending on the procurement route this may also apply to systems installed by a third party energy services contractor (see Section E). The following systems shall be designed, installed and commissioned in conformance with optimised designs and specifications: - Heating, cooling and ventilation (HVAC) - Low and Zero Carbon energy technologies - Building Energy Management System (BEMS) - Lighting controls Each system shall be subjected to functional performance testing, including measurement of performance. HVAC systems shall be in conformance with EN12599 or equivalent and, as relevant to other systems installed, other applicable EN, ISO or national standards, or their equivalent. **Verification:** The main construction contractor or the DBO contractor shall describe and commit to carrying out a functional performance testing routine in order to ensure that the systems perform within design parameters.	**D2. Installation and commissioning of building energy systems** Depending on the procurement route this may also apply to systems installed by a third party energy services contractor (see Section E). The following systems shall be designed, installed and commissioned in conformance with optimised designs and specifications: - Heating, cooling and ventilation (HVAC) - Low and Zero Carbon energy technologies - Building Energy Management System (BEMS) - Lighting controls Each system shall be subjected to functional performance testing, including measurement of performance. HVAC systems shall be in conformance with EN12599 or equivalent and, as relevant to other systems installed, other applicable EN, ISO or national standards, or their equivalent. **Verification:** The main construction contractor or the DBO contractor shall describe and commit to carrying out a functional performance testing routine in order to ensure that the systems perform within design parameters.
AWARD CRITERIA	
F2. Installation and commission of low or zero carbon energy sources Additional points shall be awarded to tenderers that provide aftercare service over and above minimum warranty requirements to ensure that systems function correctly. **Verification:** The main construction contractor or the DBO contractor shall outline the extent of the aftercare services expressed in terms of staff time and technical scope.	**F2. Installation and commission of low or zero carbon energy sources** Additional points shall be awarded to tenderers that provide an aftercare service over and above minimum warranty requirements to ensure that systems function correctly. **Verification:** The main construction contractor or the DBO contractor shall outline the extent of the aftercare services expressed in terms of staff time and technical scope.
CONTRACT PERFORMANCE CLAUSES	
F6. Installation and commissioning of low or zero carbon energy sources The low or zero carbon energy systems shall be commissioned in accordance with the required technical specifications. **Verification:** The main construction contractor or the DBO contractor shall provide a copy of the survey report or certificate confirming that testing of the energy systems has been carried out and providing data showing that the systems perform within design parameters.	**F6. Installation and commissioning of low or zero carbon energy sources** The low or zero carbon energy systems shall be commissioned in accordance with the required technical specifications. **Verification:** The main construction contractor or the DBO contractor shall provide a copy of the survey report or certificate confirming that testing of the energy systems has been carried out and providing data showing that the systems perform within design parameters.

Summary rationale:

- It is proposed that low and zero carbon energy technologies are subjected to functional performance testing alongside HVAC, BEMS and lighting controls. This will ensure that they are installed correctly and are integrated with other building systems.
- As for these other systems, it is proposed that an award criterion is used to encourage support services to adjust systems following completion and handover.

2.2.4.3 Heating systems including CHP

2.2.4.3.1 Background technical discussion and rationale

The most common form of energy generation installed by energy service contractors are combinations of boilers and CHP units. Both of these products are addressed by separate GPP criteria for heating systems according to defined capacity thresholds. The CHP criteria set addresses prime movers (the engine, turbine or fuel cell generating the heat and power) with an electricity generating capacity of greater than 50 kWe. The water-based heaters criteria have now been published and address boilers and heat pumps with a capacity of up to 400 kW of heat output and CHP units with an electricity generating capacity of less than or equal to 50 kWe.

Both criteria sets contain technical specifications which specify minimum percentage requirements for primary efficiency. The CHP criteria have an additional criterion requiring that CHP units shall be demonstrated to achieve a minimum primary energy saving of at least 10% compared to separate electricity and heat production, which is an important test for office buildings because, particularly for new buildings, CHP may not always be an efficient option [64].

To avoid double counting of potential energy savings by specifying a criterion that is already addressed in the overall energy calculations for a building, a brief review of selected national calculation methodologies in the UK and Spain was made. The aim was to check the extent to which savings in primary energy from heating systems are already addressed. In both the selected countries' methodologies, the contribution of heating systems to the energy use of the building and the emissions factor for the energy generated are calculated. The overall efficiency of the system used is not, therefore, accounted for.

2.2.4.3.2 Revised criteria proposal

Core criteria	**Comprehensive criteria**
TECHNICAL SPECIFICATIONS	
E1. Heating systems, including Combined Heat and Power (CHP) All heating systems, including those supplied by CHP units, that supply heat to either water or air based heating distribution systems for an office building shall meet the relevant Core GPP criteria that demonstrate the efficiency of each technology: • Water-based heaters, which covers boilers and heat pumps up to 400 kW heat output and CHP units with an electricity generating capacity of less than or equal to 50 kWe. http://ec.europa.eu/environment/gpp/pdf/criteria/water_based/heaters_en.pdf • Combined Heat and Power which covers prime movers with an electricity generating capacity of greater than 50 kWe. Technical specification 3.2.1 shall be met. http://ec.europa.eu/environment/gpp/pdf/chp_GPP_product_sheet.pdf **Verification:** Tenderers shall provide technical performance data for the products proposed to be installed demonstrating how they will comply with the appropriate GPP criteria.	**E1. Heating systems, including Combined Heat and Power (CHP)** All heating systems, including those supplied by CHP units, that supply heat to either water or air based heating distribution systems for an office building shall meet the relevant Comprehensive GPP criteria that demonstrate the efficiency of each technology: • Water-based heaters, which covers boilers and heat pumps up to 400 kW heat output and CHP units with an electricity generating capacity of less than or equal to 50 kWe. http://ec.europa.eu/environment/gpp/pdf/criteria/water_based/heaters_en.pdf • Combined Heat and Power which covers prime movers with an electricity generating capacity of greater than 50 kWe. Technical specification 3.2.1 shall be met. http://ec.europa.eu/environment/gpp/pdf/chp_GPP_product_sheet.pdf **Verification:** Tenderers shall provide technical performance data for the products proposed to be installed demonstrating how they will comply with the appropriate GPP criteria.

Summary rationale:

64 See DCLG (2009)

- It is proposed that a reference shall be made to the GPP criteria for water-based heating systems and CHP systems. Heating systems shall, as a minimum, comply with the technical specifications.
- Where a separate contract is to be let for energy services, these criteria shall be used to communicate the required minimum technical specifications to bidders.
- It is proposed to add a note in the accompanying EU GPP procurement guidance for Office Buildings that service engineers should carry out an evaluation of the primary energy savings achievable from CHP in order to decide whether it is the right option to procure. This is because as a standalone system it may not always be the best option for office buildings.

2.2.4.4 At what stage of the procurement process are the criteria relevant?

The low or zero carbon energy sources have been proposed as a technical specification (for both Core and Comprehensive criteria) and, additionally, as award Comprehensive criteria, to further performance improvements over and above the previous technical specifications. These criteria have to be applied during the detailed design and performance requirements procurement phase.

In the case of Core criterion, the *Design team* or the *Design & Build tenderer* or the *DBO tenderer* shall identify whether appropriate infrastructure exists and determine whether it would be beneficial environmentally for the building to connect to this infrastructure. The primary energy savings shall be quantified. In the case of Comprehensive criteria (both for technical specification and award criteria), the *Design team* or the *Design & Build tenderer* or the *DBO tenderer* shall provide designs and drawings for the energy systems to be installed together with calculations of their modelled energy generation and the net contribution to the building's primary energy use.

The installation and commissioning of building energy systems has been proposed as a technical specification (both for Core and Comprehensive criteria) to be applied during the Construction of the building or major renovation works procurement phase. Moreover, additional points shall be awarded to tenderers that provide aftercare service over and above minimum warranty requirements during the practical completion and handover procurement phase. The main *construction contractor* or the *DBO contractor* shall provide a copy of the survey report or certificate confirming that testing of the building services has been carried out and providing data showing that the systems perform within design parameters.

The choice of heating systems including Combined Heat and Power (CHP) has been proposed as a technical specification (for both Core and Comprehensive criteria) to be applied during the installation of energy systems and the supply of energy services procurement phase. *Tenderers* shall provide technical specifications for the products proposed to be installed demonstrating how they will comply with the appropriate GPP criteria

The criteria classification, their reference numbers in the criteria document and the respective procurement phase can be cross referenced as follows.

Title of the criterion	**Procurement phase**	**Criterion classification**	**Criteria typology**	**Reference number in the criteria document**
Low or zero carbon energy sources	B. Detailed design and performance requirements	Core and Comprehensive	Technical specification	B4.
Low or zero carbon energy sources	B. Detailed design and performance requirements	Comprehensive	Award criterion	B9.
Installation and commissioning of building energy systems	D. Construction of the building or major renovation works	Core and Comprehensive	Technical specification	D2.
Installation and commissioning of building energy systems	F. Practical completion and handover	Core and Comprehensive	Award criterion	F2.
Heating systems including Combined Heat and Power (CHP)	E. Installation of energy systems and the supply of energy services	Core and Comprehensive	Technical specification	E1.
Installation and commissioning of	F. Practical completion and handover	Core and Comprehensive	Contract performance	F6.

low or zero carbon energy sources			clause	

2.2.5 Facilities energy management

2.2.5.1 Reporting on energy use

2.2.5.1.1 Background technical discussion and rationale

A range of data can be downloaded from a Building Energy Management System (BEMS) for analysis by building managers and occupiers. This data can be used to identify overall trends as well as to pinpoint specific energy uses within a building that could be addressed. If the facilities manager is responsible for energy use, this could form part of their contract (see section 2.2.5.2), however, if the contracting authority has their own energy manager, it can be specified that reports and data are provided to them in order to be able to take action.

2.2.5.1.2 Revised criteria proposal

Core criteria	Comprehensive criteria
TECHNICAL SPECIFICATIONS	
G1. Building energy management system The facilities manager shall produce monthly reports for the occupier using data from the Building Energy Management System (BEMS). The arrangement shall be subject to a review on an annual basis. The reports shall disaggregate heating, cooling, ventilation and lighting energy use on a seasonal basis. **Verification:** Potential facilities management contractors or DBO contractors shall submit their proposed format for the reports as part of their ITT response.	**G1. Building energy management system** The facilities manager shall produce monthly reports for the occupier using data from the Building Energy Management System (BEMS). The arrangement shall be subject to a review on an annual basis. The reports shall identify trends in energy use within the building, disaggregated so that heating, cooling and lighting can be identified on a seasonal basis as well as by zone or department. The reports shall include recommendations on remedial action and/or further energy savings that could be made. **Verification:** Potential facilities management contractors or DBO contractors shall submit their proposed format for the reports as part of their ITT response.

Summary rationale:

- Feedback provided to occupiers of a building is an important step in identifying trends in energy use and potential opportunities to make savings. It can also help identifying areas where consumption is higher than expected and pinpoint where remedial action could be taken.
- It is proposed as a Core criterion that the data arising from a BEMS is taken advantage of by requiring the facilities manager, if contracted out, to provide monthly reports on a disaggregated basis to the occupier.
- This requirement could be extended in the Comprehensive criterion to include the identification of trends and the provision of recommendations on energy saving steps to the occupiers.

2.2.5.2 Performance-based energy contracting

2.2.5.2.1 Background technical discussion and rationale

The SCI Network in their guidance on how to procure innovative and sustainable construction highlights the potential in Design, Build and Operate arrangements to place contractors in charge of key operational costs [65]. In this way the contractor who will operate the office building, where they are responsible for ongoing energy management as part of their facilities management role, can benefit from efficiency gains because savings are internalised within their business plan instead of accruing only to the building occupier.

65 SCI Network (2012) *Procuring innovative and sustainable construction*, www.sci-network.eu

An example is cited by the SCI Network of a public authority in Finland that had procured school buildings on the basis of a 'shared cost' energy performance contract [66]. Under this arrangement any savings in energy in comparison with projections are shared between the contracting authority and the contractor [67]. In the cited example any increase in energy use is penalised as the contractor is made liable for these costs.

A similar arrangement may exist in so-called 'Chauffage' or 'Build-Own-Operate-Finance' (BOOT) contracts, like those provided by Berlin Energy Agency [68]. In this arrangement, energy savings are retained by the contractor in order to pay for energy efficient building renovations in combination with new low carbon energy supply systems.

A methodology such as the International Performance Measurement and Verification Protocol (IPMV) [69] may be used to calculate and agree the projected energy use that will form the basis for such a contractual arrangement.

2.2.5.2.2 Revised criteria proposal

Core criteria	**Comprehensive criteria**
TECHNICAL SPECIFICATION	
G2. Energy performance contract The building operator or facilities manager (as appropriate) shall agree, based on the preliminary modelling of the buildings energy consumption (see criterion A1), limits on energy consumption associated with lighting, heating, cooling, ventilation and auxiliary power. This shall exclude predicted loads relating to the users such as servers and small power loads. If energy usage were to exceed these limits, the building operator or facilities manager (as appropriate) would be liable for the additional costs. If energy usage were to be below these limits, the savings would be shared 50:50 (or an alternative agreed apportionment of the savings) with the contracting authority. The arrangement shall be subject to a review on an annual basis. **Verification:** The building operator or facilities manager shall make a contractual commitment to the agreed arrangement, including the scope and energy limits. A process for independent collation and presentation of the annual data shall be provided.	**G2. Energy performance contract** The building operator or facilities manager (as appropriate) shall agree, based on the preliminary modelling of the buildings energy consumption (see criterion A1) limits on energy consumption by lighting, heating, cooling, ventilation and auxiliary power. This shall exclude predicted loads relating to the users such as servers and small power loads. If energy usage were to exceed these limits, the building operator or facilities manager (as appropriate) would be liable for the additional costs. If energy usage were to be below these limits, the savings would be shared 50:50 (or an alternative agreed apportionment of the savings) with the contracting authority. The arrangement shall be subject to a review on an annual basis. **Verification:** The building operator or facilities manager shall make a contractual commitment to the agreed arrangement, including the scope and energy limits. A process for independent collation and presentation of the annual data shall be provided.
CONTRACT PERFORMANCE CLAUSE	
G4. Energy performance contract Energy data shall be independently collated so that the energy performance of the building can be monitored on an annual basis against the agreed energy consumption limits. **Verification:** The building operator or facilities manager shall arrange for the third party collation of data from utility bills/meters and the Building Energy Management System. This data shall be reviewed annually by both the operator and	**G4. Energy performance contract** Energy data shall be independently collated so that the energy performance of the building can be monitored on an annual basis against the agreed energy consumption limits. **Verification:** The building operator or facilities manager shall arrange for the third party collation of data from utility bills/meters and the Building Energy Management

66 The city of Jyväskylä, Finland under the Jyväskylä Optimi project to promote innovative and life cycle thinking in procurement.

67 European Commission Joint Research Centre, *Energy performance contracting*, Institute for Energy and Transport, http://iet.jrc.ec.europa.eu/energyefficiency/european-energy-service-companies/energy-performance-contracting

68 Berlin Energy Agency, *Energy Performance Contracting*, http://www.berliner-e-agentur.de/en/topics/energy-performance-contracting

69 Efficiency Valuation Organisation, *International Performance Measurement and Verification Protocol* http://www.evo-world.org

the contracting authority in order to determine the building energy consumption and the monthly profit/loss for the operator and public authority.	System. This data shall be reviewed annually by both the operator and the contracting authority in order to determine the building energy consumption and the monthly profit/loss for the operator and public authority.

Summary rationale:

- Energy efficient operation of buildings can be incentivised in DBO arrangements by structuring the arrangement so that the contractor benefits from any energy savings made. One example of how this can be done is through an incentive scheme whereby the contractor is penalised for greater energy use and rewarded for less energy use.
- Such an incentive framework is proposed as a combination of a technical specification and a contract performance clause, given that it can only be monitored and verified once the contract has been awarded.

2.2.5.3 At what stage of the procurement process are the criteria relevant?

The Building energy management system has been proposed as a technical specification (both for Core and Comprehensive criteria) to be applied during the facilities management procurement phase. Potential *facilities management contractors* or *DBO contractors* shall submit their proposed format for the reports as part of their ITT response.

The Energy performance contract has been proposed as a combination of an initial technical specification complemented by a contract performance clause (both for Core and Comprehensive criteria) to be applied during the facilities management procurement phase. The *building operator* or *facilities manager* shall commit to the third party collection and verification of data from utility bills or meters and the Building Energy Management System. This shall be reviewed annually by both the operator and the contracting authority in order to determine the building energy consumption and the monthly profit/loss for the operator and public authority.

The criteria classification, their reference numbers in the criteria document and the respective procurement phase can be cross referenced as follows.

Title of the criterion	Procurement phase	Criterion classification	Criteria typology	Reference number in the criteria document
Building energy management system	G. Facilities management	Core and Comprehensive	Technical specification	G1.
Energy performance contract	G. Facilities management	Core and Comprehensive	Technical specification	G2.
	G. Facilities management	Core and Comprehensive	Contract Performance Clause	G4.

2.3 Resource efficient construction

2.3.1 Life cycle performance

2.3.1.1 Performance requirements of the main building elements

2.3.1.1.1 Background technical discussion and rationale

As the recast EPB Directive 2010/31/EU proposes the construction of "nearly-zero-energy-buildings" by 2018 in the case of public buildings and by 2020 for other buildings, it has to be expected that in the coming years the operational impacts of buildings will decrease due to primarily heating, cooling, ventilation and lighting and the embodied impact[70] of the construction materials and products will become more important[71]. As part of the preliminary study for GPP Office Building criteria an environmental impact assessment conducted in the form of a Life Cycle Assessment (LCA, according to ISO 14040 and 14044) along the office building life cycle[72], showed that, after the use phase, the construction phase gives rise to the second most significant environmental impact. The environmental performance of a product depends generally on its use within the buildings, maintenance and repair demands on its end-of-life scenario. Interactions between construction products can cause complex impacts; therefore, the entire life cycle of the whole building has to be assessed to determine the environmental contribution of construction materials and products as well as building elements [73]. Materials have to be compared on the basis of a common functional unit, i.e. considering aspects such as technical performance, durability, recyclability, required maintenance, etc.

Characterising the different systems used by existing building certification schemes

Well-recognised labels that identify lower environmental impact construction materials are those classified according to ISO 14024 as Type I Ecolabels, taking into account the environmental impacts along the entire life cycle. However, the most important construction materials are not yet covered by these ecolabels and there is a significant variability between countries.

Environmental Product Declarations (EPD), developed according to ISO 14025 and ISO 21930, are Type III labels that can provide environmental information from LCA studies in a comparable format, based on common rules, known as Product Category Rules (PCRs). EPDs do not prove that a product or material is environmentally friendlier but, generally speaking, the manufacturers make declarations in order to communicate better performance which is externally verifiable. The use of EPDs could make possible a comparison of the environmental impact at the level of technically equivalent construction materials and products or at the level of building elements or even a whole building when assessing the environmental performance of a building. To be comparable, however, EPDs must have the same PCRs, to ensure that scope, methodology, data quality and environmental impact indicators are the same and that all the relevant life cycle stages have been included within the study.

With the advent of the European single market for construction products, there was a concern that national EPD schemes and building level assessment schemes would represent a barrier to trade across Europe. Therefore, two standards have been developed and published by CEN TC350:

- EN 15804 [74]: 2012. This standard provides the PCRs for all construction products and services, with the aim to ensure that all EPDs of construction products, construction services and construction processes are derived, verified and presented in a harmonised way.
- EN 15978 [75]: 2011. This standard deals with aggregation of the information at the building level, among other describing the rules for applying EPD in a building assessment. The identification of boundary conditions and the setting up of scenarios are major parts of the standard.

Many European countries, including France, Germany, the Netherlands, the Nordic countries and the UK, have developed national PCR schemes regulating the use of EPDs (see Figure 2.7). The main national EPDs schemes have been, or are in the process of being, aligned with EN 15804, such as for example the "BRE

70 Embodied impacts are related to the production of construction materials and products, including the resources used to manufacture products and process materials as well as emissions arising from material extraction and energy used in their processing, also termed embodied energy

71 CPA (2012) *A guide to understanding the embodied impacts of construction products* http://www.constructionproducts.org.uk/sustainability/products/embodied-impacts/

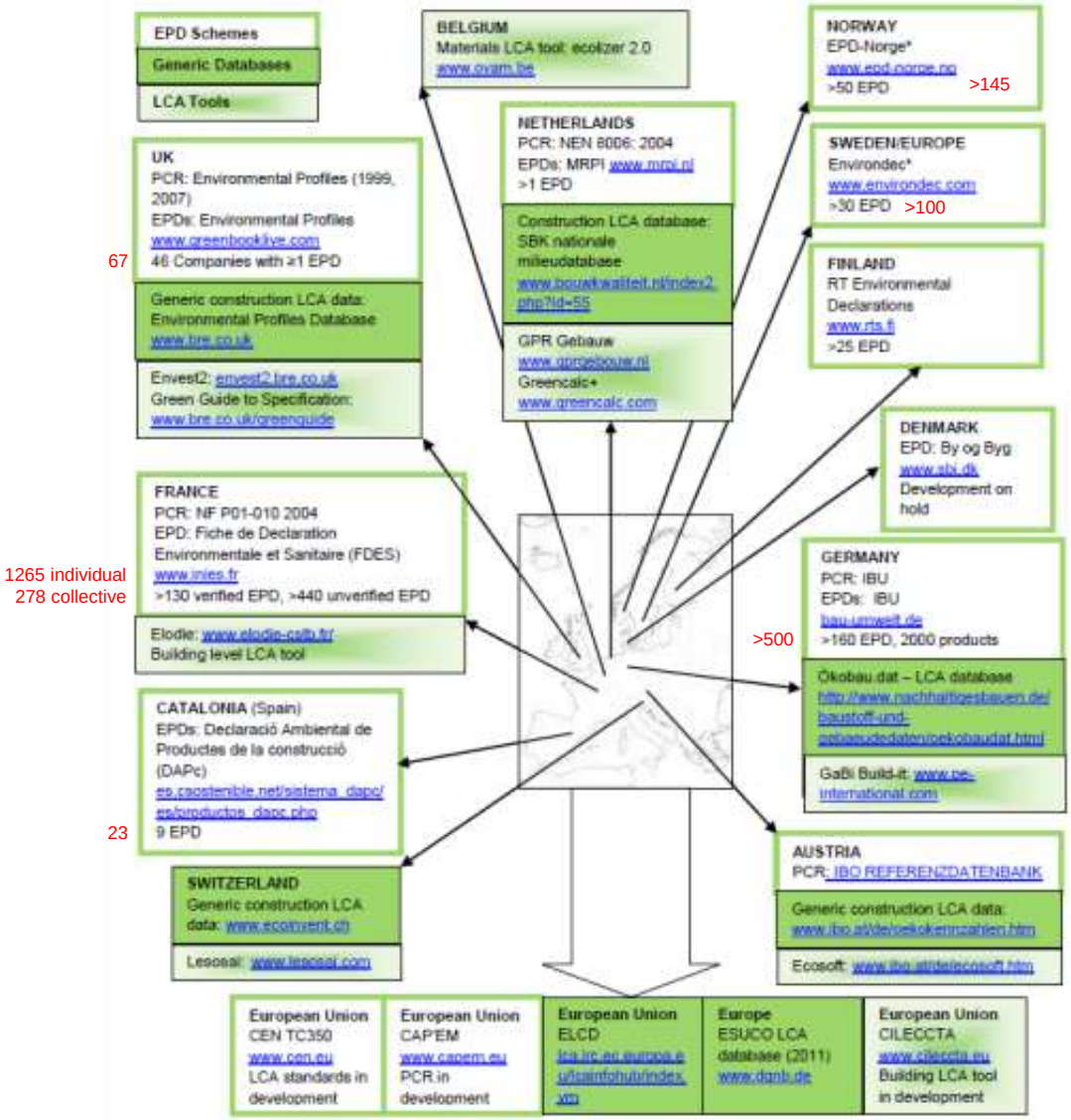
72 JRC IPTS Draft Preliminary Study (2011): http://susproc.jrc.ec.europa.eu/buildings/docs/Draft%20Report%20Task%203.pdf

73 LoRe-LCA (2011): Low Resource consumption buildings and constructions by use of LCA in design and decision making http://www.sintef.com/project/LoRe-LCA/Deliverables/LoRe-LCA-WP2-D2.3-IFZ-rep%20epd-2011-12-15.pdf

74 EN 15804: 2012 + A1:2013. Sustainability of construction works - Environmental product declarations – Core rules for the product category of construction products

75 EN 15978: 2011. Sustainability of construction works - Assessment of environmental performance of buildings - Calculation method

Environmental Profiles 2013: Product Category Rules (PCR) for Type III environmental product declaration of construction products to EN 15804:2012"[76]



EPDs numbers correct as of October 2010 – EPDs numbers updated as of July 2014 are highlighted in red

Figure 2.7. National LCA schemes using EPDs according to the CPA guide [77]

The main differences between the larger EPD schemes in terms of scope and methodology have been highlighted in the Construction Products Association's guide to LCA and are reported in Table 2.6.

76 http://www.bre.co.uk/filelibrary/Materials/BRE-EN-15804-PCR-PN514.rev-0.1.pdf

77 CPA (2012): A guide to understanding the embodied impacts of construction products http://www.constructionproducts.org.uk/sustainability/products/embodied-impacts/

Table 2.6. Differences between the main EPDs schemes used in Europe according to the CPA guide[78]

	UK	France	Germany	Sweden
Scheme	BRE Environmental Profiles	Fiche de Declaration Environmentale et Sanitaire (FDES)	IBU EPD	International EPD® system (Environdec)
Scope	Cradle to Grave, including 60 year study period	Cradle to Grave, including study period (normally 50 years)	Cradle to Site plus optionally transport use and/or End of Life (EOL) stage	Cradle to Gate plus optionally transport use and/or End of Life (EOL) stage
Declared Unit (DU) or Functional Unit (FU)	FU: product in 1 m^2 building element over 60 year study period	DU: Product (e.g. m^2/kg) over study period	DU: Product (e.g. kg/m^2)	DU: Product (e.g. kg/m^2)
End of Life recycling	Allocation from primary to recycled based on primary to scrap value	System boundary at stockpile. No allocation over system boundary	EOL modelled based on impact of disposal and any recycling, plus benefits of recycling	Waste processing / recycling included until waste has a value.
Verification	BRE Global verify LCA. Manufacturer data is audited and certified by BRE/BBA	From 2012, independent third party verification by verifiers certified by AFNOR required	Independent third party verification by verifiers appointed by IBU	Independent third party verification. Manufacturer can select from a list of approved verifiers

Several LCA software programs can be used to assess the environmental impact of buildings as a whole and for the selection of construction materials and products. Most of these software programs use specific databases (as Ökobau the German National construction LCIA database) or LCA databases (such as GaBi or Ecoinvent). It has to be highlighted that, nowadays, the lack of widespread and high quality available databases at European level is one of the main obstacles to be solved in order to have a harmonised and representative system.

In order to better understand the differences between different methodologies, some examples of the most used certification schemes across Europe are reported below with reference to the results presented in the EURIMA FORCE report[79].. It can be seen that they use a range of different approaches to the use of EPD or LCA-based construction material, product and/or element assessments,

- **BREEAM** refers to the *Green Guide to Specification* as the basis for scoring the embodied impacts of construction materials. BREEAM deals with typical building elements at a whole building level (aggregations of building products and materials e.g. wall systems), rather than separate products or materials; moreover, building foundations, parts of the core superstructure, building services and some of the fit-out are not covered. The EPD system works at a building element level and evaluates how construction materials and products contribute to the overall sustainability of the building from a cradle-to-grave perspective.

  LCA data for generic and certified products for which data is submitted by industry are translated into an A+ to E rating system for building elements. In this way, solutions with low embodied impacts for any construction project can be selected. Depending on the building type, 12-15 basic credits are available in the materials category, corresponding to 11-14% of the total amount of credits available for the building (Table 2.7). Half of these credits (6-8) are based on quantified environmental information assessed according to the *BRE Methodology for Environmental Profiles of Construction Products* PCR rules. The other half of these credits are reserved for qualitative assessments regarding re-use of existing building elements, responsible sourcing and designing for robustness (e.g. adequate protection of exposed parts of the building). LCA results are thus used in BREEAM to assign a maximum of one credit (depending on if it is a new built or a renovation) to each of the following elements:

78 CPA (2012): A guide to understanding the embodied impacts of construction products http://www.constructionproducts.org.uk/sustainability/products/embodied-impacts/

79 EURIMA, FORCE (2012): Analysis of five approaches to environmental assessment of building components in a whole building context http://www.eurima.org/uploads/ModuleXtender/Publications/97/Force_Study_Building_certification_systems_May_2012.pdf

- External walls
- Windows
- Roof
- Upper floor slabs
- Internal walls
- Floor finishes/coverings
- Hard landscaping and boundary protection
- Insulation

The *Environmental Profiles of Construction Products* are developed according to ISO 14040. In detail, Life Cycle Inventory (LCI) is calculated using a cradle to grave approach and in/outputs of the inventory are classified and characterised with respect to 13 impact categories, summarised in Table 2.7. *Normalisation* by dividing the impacts by the annual environmental impacts caused by one UK citizen followed by a *weighting system* are applied. The normalised results in the single impact categories are multiplied with the weight assigned to that specific category and create the *Ecopoint* score.

In the final step, the rating in the *Green Guide to Specification* is calculated: the range of impacts is divided into six categories, "A+" to "E", from lowest to highest. Ratings are given to performance in each environmental impact category and in an overall category. The rating system is only described very briefly in publicly available documents.

- **GPR Building** (NL) is an LCA tool now widely used by Dutch municipalities and professionals. It applies the Dutch harmonised LCA approach for material impacts; it is in compliance with the Dutch Energy Performance standards and it uses a multi-criteria analysis with a rating method based on realistic case studies. GPR Building is a design tool, focused not only on environmental aspects but also on the building quality. This tool can be used for both the design of new and the retrofit of existing buildings, and it is suitable for residential, office and school buildings. A building is rated on five indicators on a scale of 1 (worst) to 10 (best).

  The key performance indicators are: energy, environment, health, user quality, and long term value, divided into several sub-indicators as reported in Table 2.7. When assessed, the building performance is rated per indicator, but the main indicators are not aggregated into one overall score. Thus, policy makers can focus on the topics which are most relevant to a specific situation: in school buildings, for instance, the focus is often on energy, environment and health.

  The GPR-score for the modules and sub-modules is calculated on the basis of a multi-criteria analysis, except for the modules Energy and Materials. The sub-modulus materials are based on an LCA in terms of an Eco-profile; it is composed of nine separate environmental impact indicators, as reported in Table 2.7. The nine indicators are subsequently aggregated into one index, called the "environmental shadow costs" of a building, which is expressed in euros per square meter of usable floor area (heated and unheated) per year. Harmonization of the three major calculation tools used in the Netherlands for environmental impacts assessment of buildings (GPR Buildings, GreenCalc+ and BREEAM-NL) is currently ongoing.

- **DGNB** (or German Sustainable Building Certificate) provides Gold, Silver or Bronze awards for buildings reflecting environmental, economic and social characteristics (summarised in Table 2.7). The environmental impact of the building is weighted at 22.5% of the overall score, the same as the social and economic impact and technical quality. The certification system uses a building level LCA, including the operation of the building over 50 years, to evaluate both building materials (structure, fabric, building services and fit-out) and operational energy use. The scheme therefore considers the trade-offs between embodied and operational impacts, in line with the EN 15804 and EN 15978 standards.

  Each of the 11 impact assessment categories can receive a maximum of 10 points based on its documented or calculated quality. At the same time, it is possible to increase the weighting of each criterion. In the example of the scoring reported in Table 2.8, weighting factors between 1 and 3 were assigned to the different criteria. The weighting procedure is transparent, but it can still be

criticised from a strict LCA point of view as expressed in ISO 14040. A performance index is calculated for each criteria group, relative to a reference building. The five performance indices are subsequently weighted by 22.5% or 10% and the total performance index, measured in %, is calculated. Finally, the calculated total performance index is compared to pre-set values for the award of a Bronze, Silver or Gold certificate.

- **HQE** (or Haute Qualité Environmentale) is a French certification scheme. Specific targets for environmental quality within the 14 assessment categories reported in Table 2.7 have to be met in order to obtain an HQE certificate. For each category, there are three target levels, "basic", "performing" and high performing". In order to obtain the certificate, the building must be rated "high performing" in at least 3 categories and "basic" in maximum seven categories. Quantitative life cycle impacts of construction materials and products are assessed in category n.2 *Integrated choices in construction products, systems, and processes*, sub-categories 2.3.1 "*knowledge of environmental impacts of construction products*" and 2.3.2 "*choice of construction products to minimize environmental impacts of buildings*". In several other categories, impacts of construction materials and products are also qualitatively assessed.
    - In subcategory n. 2.3.1, an EPD (in accordance to the French standard NF P01010 or to the equivalent European standards EN 15804 and EN 15978) must be made available
        - for at least 50% of the components in at least 2 categories of finishing products and 1 category of structural products (basic rating)
        - for at least 50% of the components in at least 4 categories of finishing products and 2 categories of structural products (performing rating)
        - for at least 80% of the components in at least 4 categories of finishing products and 2 categories of structural products (high performing rating)

      A large EPD database is available, conforming to the requirements in NF P01010 and to EN 15804 (www.inies.fr).

      Fulfilling this requirement also results in so called "High performing points (HP points)":
        - 2 HP points: where an EPD is made available for at least 80% of the components in all categories of products (structural and finishing)
        - 3 HP points: where an EPD is made available for at least 100% of the components in all categories of products (structural and finishing).
    - In subcategory n. 2.3.2, to be rated "performing", different scenarios for the contribution of products to the overall environmental impacts must be established for either the underlying structure or for the finishing.

  The HP points obtained in subcategories 2.3.1 and 2.3.2 are added to the HP points obtained in the other subcategories in category 2, and at least 35% of all points available (13 HP points out of 37) must be scored in order for category 2 to be rated "high performing".

Table 2.7. Comparison of main assessment methods

Scheme	BREEAM	DGNB	GPR	HQE
Assessment method	BRE Environmental Profiles Method	DGNB Certificate	GPR Building	Démarche HQE
Assessment categories (score)	1. Management (12) 2. Health & Wellbeing (21) 3. Energy (39.9) 4. Transport (4) 5. Water (3.6) 6. Materials (15) 7. Waste (5.25) 8. Land use & Ecology (10) 9. Pollution (12) 10. Innovation (10)	1. ecological quality (22.5%) 2. economic quality (22.5%) 3. socio-cultural and functional quality (22.5%) 4. technical quality (22.5%) 5. process quality (10%)	1. Energy a. Energy performance b. Demand reduction 2. Environment a. Water b. Environmental care c. Materials 3. Health a. Noise b. Air quality c. Thermal comfort d. Lighting and visual comfort 4. User quality a. Accessibility b. Functionality c. Technical quality d. Safety 5. Long term value a. Adaptability and future amenities b. Flexibility c. Perceived value	1. The building's relationship with its immediate environment 2. Integrated choice for construction 3. Low nuisance worksite 4. Energy Management 5. Water Management 6. Management of activity generated waste 7. Servicing & Maintenance 8. Hygrometric comfort 9. Acoustic comfort 10. Visual comfort 11. Olfactory comfort 12. Health quality of space 13. Health quality of air 14. Health quality of water
Impact assessment categories	1. Climate change (GWP) 2. Water extraction (FW) 3. Mineral resource depletion (ADP-Elements)) 4. Stratospheric ozone depletion (ODP) 5. Human toxicity (HTP) 6. Ecotoxicity to water (FAETP) 7. Nuclear waste 8. Ecotoxicity to land (TETP) 9. Waste disposal 10. Fossil fuel depletion (ADP-Fossil) 11. Eutrophication (EP) 12. Photochemical ozone creation (PCOP) 13. Acidification (AP)	1. Global Warming Potential (GWP) 2. Ozone Depletion Potential (ODP) 3. Photochemical Ozone Creation Potential (POCP) 4. Acidification Potential (AP) 5. Eutrophication Potential (EP) 6. Risks For The Local Environment (Qualitative) 7. Sustainable Use of Resources/Wood (Qualitative) 8. Non Renewable Primary Energy Demand (PEnren) 9. Total Primary Energy Demand and Proportion of Renewable Primary Energy (PEges) 10. Drinking Water Demand and Volume of Waste Water (Wkw) (Only use stage) 11. Space Demand (Qualitatively using indicators)	1. Abiotic depletion potential, ADP 2. Global warming potential, GWP 3. Ozone Depletion potential, ODP 4. Photochemical oxidant creation potential, POCP 5. Human Toxicity Potential, HTP 6. Freshwater Aquatic Ecotoxicity, FAETP 7. Ecotoxicity sediments 8. Terrestric Ecotoxicity Potential, TETP 9. Acidification Potential, AP 10. Eutrophication Potential, EP	Determination of the environmental impact indicators of the construction products, in accordance with EN 15804 or standard ISO 21930: 1. Abiotic depletion potential (ADP-elements) for non-fossil resources 2. Abiotic depletion potential (ADP-fossil fuels) for fossil resources 3. Acidification potential of soil and water, AP; 4. Depletion potential of the stratospheric ozone layer, ODP; 5. Global warming potential, GWP; 6. Eutrophication potential, EP;
Normalisation	by dividing the impacts by the annual environmental impacts caused by one UK citizen, giving all impacts categories the units of "per year"	Normalisation stage to be detailed	Shadow price per year of impact assuming 50-year lifespan	-
Weighting	for individual categories is developed by a panel representing the interest of groups	Weighting of the individual categories is applied, moreover, with the use of significance factors for criteria	Shadow price per year of impact assuming 50-year lifespan	No weighting of categories. Each is equally weighted to give a profile score.

Source: EURIMA FORCE (2012) and Saskia van Hulten[80]

Table 2.8. Example of scoring and weighting of the ecological quality criteria group in DGNB (the criteria group accounts for 22.5% of the total amount of available points)

Criteria	Criteria points		Weighting factor	Weighted points		Group points		Group performance index
	Max	Achieved		Max	Achieved	Max	Achieved	
Global Warming Potential (GWP)	10	10	3	30	30	200	178.5	89%
Ozone Depletion Potential (ODP)	10	10	1	10	10			
Photochemical Ozone Creation Potential (POCP)	10	10	1	10	10			
Acidification Potential (AP)	10	10	1	10	10			
Eutrophication Potential (EP)	10	7.1	1	10	7.1			
Risks For The Local Environment	10	8.2	3	30	24.6			
Sustainable Use of Resources / Wood	10	10	1	10	10			
NonRenewable Primary Energy Demand	10	10	3	30	30			
Total Primary Energy Demand and Proportion of Renewable Primary Energy	10	8.4	2	20	16.8			
Drinking Water Demand and Volume of Waste Water	10	5	2	20	10			
Space Demand	10	10	2	20	20			

Source: EURIMA FORCE (2012)

Identifying the different methodologies available for assessing the performance of a building

In order to evaluate the resource efficiency of different building designs there needs to be comparability both in terms of the Bill of Quantities (also sometimes referred to as Bill of Materials), functional requirements and the methodology used. In some cases a Bill of Quantities (BoQ) for a reference building or a preliminary design is provided to bidders within the ITT. This could form a reference building that could be used as the basis for a comparative evaluation by design teams of designs. In other cases, where designs are submitted by different bidders in response to a design specification (e.g. in the case of DB contracts), the performance of these designs could be compared during a competitive process in order to encourage innovative resource efficient designs.

The BoQ for a reference building contains the preliminary evaluation of the amount and cost of main construction materials and products. The BoQ is put together on the basis of the preliminary information included in the concept and detailed design and aims to provide a common basis for bidders to put together their proposals and costings. This information could be used by tenderers to prepare their technical and environmental proposal, including an LCA analysis. Indeed, when the BoQ is provided, it should be possible to make a comparative evaluation of improvements in the life cycle performance of the main building elements.

In order to analyse a building design, tenderers and contractors could, based on our characterisation of the different schemes used across the EU and their associated methodologies, use a number of different approaches. Some are based on the use of EPDs aggregated at a building level; others are more complex (and potentially more comprehensive) as they rely on carrying out an LCA at a building level, thereby allowing for sensitivies to be tested and potential trade-offs to be more easily identified e.g. energy in use phase and energy intensive construction products.

In order to allow for flexibility in what is still an emerging area of expertise, with only early progress towards standardisation, we have identified five options which could form the basis for ITT's:

- Option 1: Aggregation of Environmental Product Declarations (EPDs) according to the following methods:

  1.1 Aggregation of EPD characterisation results (the raw LCA results for indicators) for each building element, *or*

  1.2 Aggregation of weighted EPD scores or ratings (usually a numeric score or letter rating) for each building element. This aggregation could, for example, be carried out with the above-mentioned *Environmental Profiles of Construction Products* within the BREAM scheme

80 Saskia van Hulten. *New sustainable building policy in Maastricht*:
http://www.w-e.nl/Bestanden/bestanden/publicaties/SB10_GPR%20Building_New%20policy%20Maastricht_Final.pdf

- Option 2: Carry out a Life Cycle Assessment (LCA) according to the following methods:

  2.1 Impact Category results: The aggregated characterisation results for each indicator obtained using the specified LCA method, representing a standalone LCA study;

  2.2 LCA tool score: A single score obtained using a national or regional building LCA tool used by public authorities. This method is employed for example by Greencalc+.

  2.3 Building assessment scheme LCA score: A normalised and weighted scoring derived from an LCA-based criterion within a national or regional building assessment and certification scheme used by public authorities. This method is employed for example by the DGNB certification scheme.

Given that comparability is considered to be the most important consideration at the procurement stage, a set of simplified guidelines have been developed with reference to ISO 14040, EN 15978 and EN 15804. These are intended to be used to establish the rules for design teams so that evaluations carried out according to Options 1 or 2 are comparable. A further step is added to ensure that evaluations by design teams are robust by proposing that the procurer is supported by a technical evaluator.

These guidelines are provided in Annexes I, II and III of the criteria document [81], and are proposed to be provided together with the GPP criteria document and provide specific information on comparability, technical guidelines and expert evaluation. A brief description and rationale is provided as following.

Comparability

In order to ensure comparability, the following rules can be set:

- Option 1: Aggregation of Environmental Product Declarations (EPDs)

  All EPDs have to be in conformance with ISO 14025 and have been selected within the same PCR scheme. EPDs can be supplemented by new primary data for building elements subjected to LCA analysis according to the same PCRs. As analysed in the first part of the chapter, some existing building assessment and certification schemes apply normalisation and/or weighting rules to EPDs results in order to generate a comparative score or rating. These rules are optional according to the ISO 14040/14044 and there is no consensus among the scientific community on them. However, as long as the national PCR rules are in compliance with ISO 14025 and/or EN 15804, it would appear feasible to use them on a comparative basis as long as the same system is used by all bidders.

- Option 2: Carry out a Life Cycle Assessment (LCA)

  The same LCIA method and Category indicators should be used in the LCA and would have to be specified in the ITT. The selection of Life Cycle Inventory (LCI) data shall follow the quality requirements set out in EN 15978 AND 15804. Verified primary data and supplementary secondary data may be used to fill gaps in the LCI following the guidance in ISO 14040/14044, ISO 14025 (if EPD data is used) and/or EN 15978 and 15804 but the selection and handling of this data, and the assumptions made, would need to be checked by the technical evaluator.

Identification of the most significant building elements

The balance between the significance of the production phase and the use phase is dynamic and has been changing as energy requirements have become stricter. Source: RICS (2012)

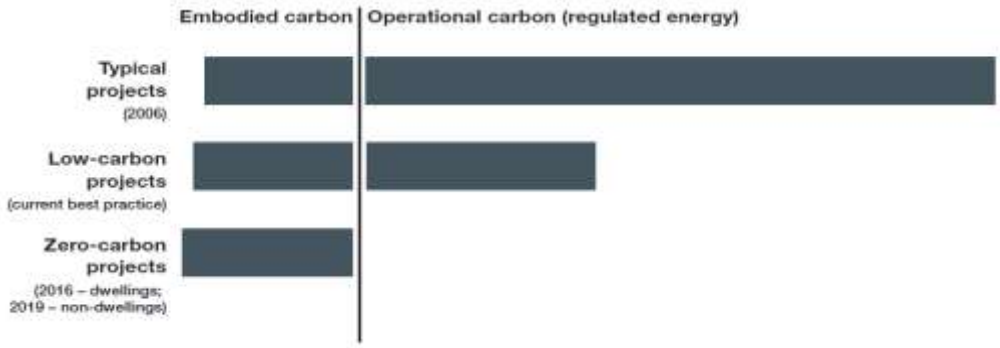
Figure 2.8 illustrates for embodied carbon emissions the overall change that has occurred in the UK between 2006 and as projected for 2016/19. The production phase increases marginally as more energy intensive materials are specified whilst the energy use of a building decreases to a position of net zero carbon. The evaluations of the life cycle environmental impacts of construction materials and products show that generally some construction products bring more environmental impacts than others.

The most significant building elements have been identified according to the outcomes of the technical and environmental analysis developed within the project[82]. For example, the contribution of the different life cycle phases in the overall contribution of the different building elements to the overall normalised and weighted environmental impact of the construction of 1m^2 of office area evaluated for the case study of an office building located in London are reported in Source: JRC-IPTS (2011)

81 Annexes I, II and III have been fully reported in section 2.3.1.1.2 Revised criteria proposal

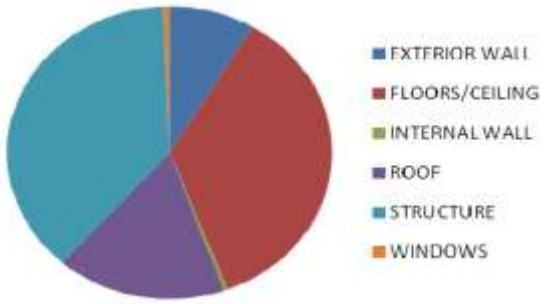
82 JRC IPTS Draft Preliminary Study (2011): http://susproc.jrc.ec.europa.eu/buildings/docs/Draft%20Report%20Task%203.pdf

Figure 2.9. Furthermore, literature reviewing LCAs carried out for office buildings, the requirements of the EN 15978[83] and the EN 15804[84] standards and the CPA guide[85] have also been considered in the identification of the main building elements.



Source: RICS (2012)

Figure 2.8 Comparison of the balance of production and use phase embodied carbon emissions over time (2006-2019)



Source: JRC-IPTS (2011)

Figure 2.9. Contribution of the different building elements to the overall environmental impact of the construction of 1m² of office area for an office building located in London

In conclusion, the main building elements proposed as a minimum to be analysed for a building design are listed in Table 2.9. According to the ICE Demolition Protocol [86], a limited number of building elements could be considered for renovations and this principle is also reflected in the two different lists proposed in Table 2.9.

Table 2.9. Identification of the main building elements

New-build	Renovation
– The structural frame, including beams, columns and slabs – External walls, cladding and insulation – Floors and ceilings – Internal walls – Windows – Roofs	– External walls, cladding and insulation – Re-roofing and insulation – Windows Where additional floors or building extensions are proposed that account for >25% of the existing useable floor area, the list of new-build elements shall also apply.

83 EN 15978: 2011. Sustainability of construction works - Assessment of environmental performance of buildings - Calculation method

84 EN 15804: 2012 + A1:2013. Sustainability of construction works - Environmental product declarations – Core rules for the product category of construction products

85 CPA (2012): A guide to understanding the embodied impacts of construction products http://www.constructionproducts.org.uk/sustainability/products/embodied-impacts/

86 ICE Demolition Protocol (2008): http://www.ice.org.uk/getattachment/eb09d18a-cb12-4a27-a54a-651ec31705f1/Demolition-Protocol-2008.aspx

Defining the building's life cycle, boundaries and functional unit

- Option 1: Aggregation of Environmental Product Declarations (EPDs)

  In order ensure that the total environmental impact for each building design can be compared, EPDs have to address cradle to grave life cycles and the declared unit of each EPD has to be multiplied by the appropriate quantity in the bill of materials.

- Option 2: Carry out a Life Cycle Assessment (LCA)

  The boundary for the analysis shall be cradle-to-grave (according to ISO 14040). Recycled or re-used materials either as inputs (product stage) or outputs (end of life stage) have to be allocated according to the rules in ISO 14044, Section 4.3.4.3.

  As a reference point for each design, the relevant technical and function requirements, the envisaged pattern of use and the requested service life should be the same for each LCA analysis and a common functional unit or reference unit shall be used to present the results (according to ISO 14040/14044).

Defining the Life Cycle Impact Assessment (LCIA) Category indicators to be used

In the preliminary study for the development of the GPP criteria, an LCA analysis of three different reference office buildings with three locations Madrid, London and Tallinn, as representative of the three climatic zones and user behaviours across Europe, was carried out[87]. The reference buildings modelled were specified to be in line with the current Building Regulations in the three locations, as of 2010/11. The environmental impacts calculated per each of the locations and base case office building models are provided in Table 2.10.

The results show that, for the majority of the environmental impact categories, the use phase dominates the environmental impacts, with the exception of abiotic resource depletion. Based on the trend identified in Figure 2.8, and reflecting the timescales in the recast EPBD, the significance of the use phase to new-build projects is likely to continue in the short term until around 2015/16, by which time nearly zero energy buildings will start to be required, thereby shifting the focus towards the production phase. It is to be noted, however, that in some Member States current requirements for the energy performance of buildings may already have the effect of reducing energy use sufficiently to shift the focus onto the production phase.

Table 2.10. Percentage of the environmental impacts depending on the location and phase of the buildings

Impact Category	Units (%) kg equiv	MADRID, 30% glazing				LONDON, 30% glazing				TALLINN, 30% glazing			
		Product	Construction	Use	End of life	Product	Construction	Use	End of life	Product	Construction	Use	End of life
GWP	kg CO_2	8	0	91	0	15	0	85	0	14	0	86	0
ODP	kg CFC 11	12	0	88	0	25	0	75	0	26	0	74	0
AP	kg SO_2	1	0	99	0	1	0	99	0	1	0	99	0
EP	kg $(PO_4)^{3-}$	4	0	95	1	4	0	95	1	4	0	95	1
POF	kg Ethene	1	0	98	0	1	0	98	0	1	0	98	0
ADP	kg Sb	94	0	6	0	95	0	5	0	95	0	5	0
PEC	MJ	6	0	94	0	6	0	94	0	5	0	94	0
WC	m^3	1	0	99	0	1	0	99	0	1	0	99	0

Note: GWP: green warming potential, ODP: Depletion potential of the stratospheric ozone layer, AP: Acidification potential of land and water, EP: eutrophication potential, POF: Photochemical ozone formation, ADP: Abiotic depletion potential, PEC: primary energy consumption and WC: water consumption

87 JRC IPTS Draft Preliminary Study (2011): http://susproc.jrc.ec.europa.eu/buildings/docs/Draft%20Report%20Task%203.pdf

According to several LCA reviews on construction materials and products and on the whole building life cycle[88,89], the most commonly considered environmental impact categories are global warming potential, acidification, eutrophication and stratospheric ozone depletion. Khasreen et al. (2009) specified that global warming potential is evaluated in almost every study, perhaps because GHG emissions can be more readily quantified than other impacts. Other environmental impact categories such as toxicity, resource depletion potential, land use, water consumption and waste management are also usually identified.

EN 15978 suggests considering the impact category indicators listed in Table 2.11 within a building LCA. These impact categories indicators have been chosen on the basis of agreed calculation methods for their evaluation. According to the EN standard, other indicators, such as human toxicity, eco-toxicity, biodiversity and land use have not been included due to the lack of scientifically agreed and robust calculation methods within the context of LCA.

Of relevance are also the impact category indicators selected in the Assessment of scenarios and options toward a Resource Efficient Europe[90] of the EC under the flagship 2020 initiative, as reported in Table 2.12. Similar impact category indicators can also be seen to have been selected by the most used certification schemes for buildings (see Table 2.7) and as now suggested by the new PCR for buildings published in February 2014 by Environdec [91].

Table 2.11. Impact category indicators to be included in the LCA according to EN 15978

Impact assessment categories		**Unit**
Indicators describing resource use	Use of renewable primary energy excluding energy resources used as raw material	MJ, net calorific value
	Use of renewable primary energy resources used as raw material	MJ, net calorific value
	Use of non-renewable primary energy excluding primary energy resources used as raw material	MJ, net calorific value
	Use of non-renewable primary energy resources used as raw material	MJ, net calorific value
	Use of secondary material	kg
	Use of renewable secondary fuels	MJ
	Use of non-renewable secondary fuels	MJ
	Net use of fresh water	m^3
Indicators describing environmental impacts	Global Warming Potential, GWP	kg CO2 equiv
	Depletion potential of the stratospheric ozone layer, ODP;	kg CFC 11 equiv
	Acidification potential of land and water; AP;	kg SO2- equiv
	Eutrophication potential, EP;	kg (PO4)3- equiv
	Formation potential of tropospheric ozone photochemical oxidants, POCP;	kg Ethene equiv
	Abiotic Resource Depletion Potential for elements; ADP_elements	kg Sb equiv
	Abiotic Resource Depletion Potential of fossil fuels ADP_fossil fuels	MJ, net calorific value

Table 2.12. Impact category indicators considered in the Assessment of scenarios and options toward a Resource Efficient Europe

Impact assessment categories		**Unit**
Indicators describing materials	Abiotic Resource Depletion Potential for elements; ADP_elements	kg Sb equiv
Indicators describing energy	Abiotic Resource Depletion Potential of fossil fuels ADP_fossil fuels	MJ, net calorific value
	Primary Energy Demand Non Renewable PED-NR	MJ, net calorific value
	Primary Energy Demand Renewable PED-R	MJ, net calorific value
Indicators describing water	Blue Water Consumption BWC	
Indicators describing emissions	Acidification potential AP	kg SO2- equiv
	Eutrophication potential EP	kg (PO4)3- equiv
	Global warming potential GWP	kg CO2 equiv
	Global warming potential excluding biogenic carbon GWP-EB	kg CO2 equiv
	Ozone Depletion Potential ODP	kg CFC 11 equiv

88 Ortiz et al. (2009). *Sustainability in the construction industry: A review of recent developments based on LCA*. Construction and Building Materials 23, pp. 28–39

89 Khasreen et al. (2009). *Life-Cycle Assessment and the Environmental Impact of Buildings: A Review*. Sustainability, *1*, 674-701

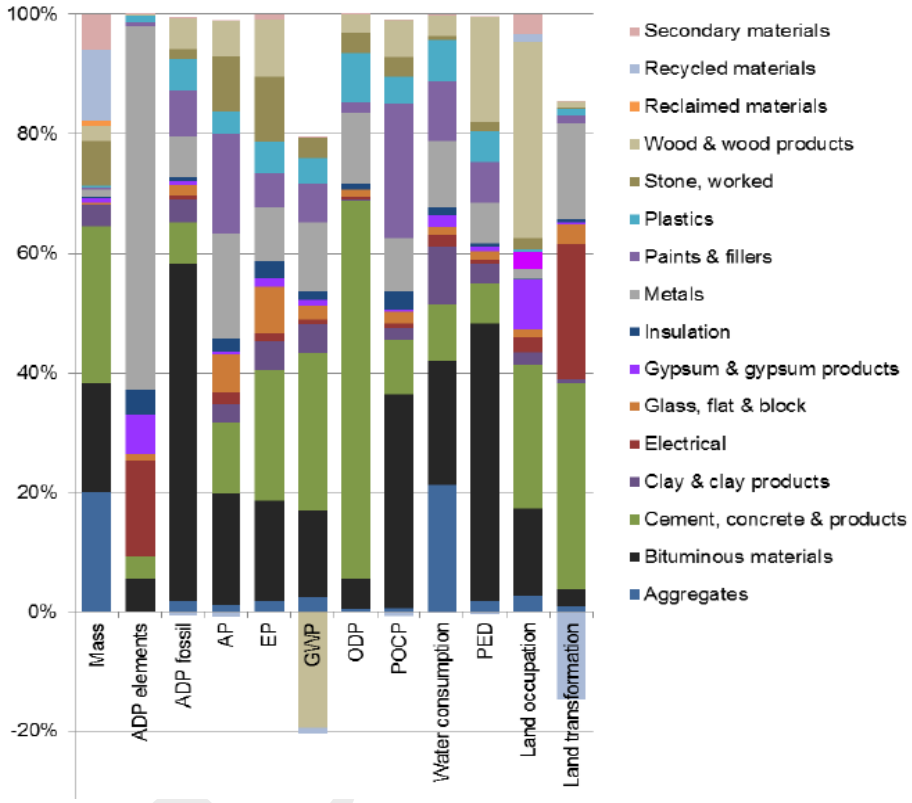
90 EC (2014). *Assessment of Scenarios and Options towards a Resource Efficient Europe. An Analysis for the European Built Environment*
http://ec.europa.eu/environment/enveco/resource_efficiency/pdf/TP_report.pdf

91 Environdec Product category rules according to ISO 14025:2006 (2014-02-26) product group: UN CPC 531 buildings. 2014:02 version 1.0
http://environdec.com/en/PCR/Detail/?Pcr=5950&id=158&epslanguage=en

	Photochemical Ozone Creation Potential POCP	kg Ethene equiv
Source: European Commission (2014)		

According to Scheuer et al. (2003)[92], impact indicators such as global warming potential, ozone depletion potential, acidification potential, eutrophication potential and solid waste generation are closely correlated with primary energy demand. Therefore, in order to simplify the choice of impact indictors within the GPP procurement process, it could be proposed to evaluate the most commonly used of these indicators. According to the technical evidence proposed, global warming potential appears the best candidate.

An LCA model for the UK's built environment in a single year has been evaluated in the Assessment of scenarios and options toward a Resource Efficient Europe[93] (unfortunately, a similar level of detail could not be found for Europe). This analysis indicated that abiotic resource depletion is dominated by the production stage of materials, whilst the use stage of buildings dominates emission related indicators. In the production phase, significant environmental impacts are related to non-metallic minerals and fossil energy materials, as illustrated by Figure 2.10. The study concludes that measures focussing on producing lower-impact products and more resource efficient products have the most potential of environmental impacts reduction within the building sector at the European level.



Source: EC, 2014

Figure 2.10: Environmental impacts associated with the consumption of construction products within the UK built environment [94]

To sum up, in order to simplify the impact assessment within the GPP criteria framework, it is proposed to require the calculation of the impact categories indicators that better express the impact in the production stage of construction materials and products, as well as any trade-offs between, for example, energy related emissions in the production and use phases. According to the evidence of the above described LCA results, the three most relevant impact category indicators that form the basis for a simplified performance comparison of PCRs (option 1) or when carrying out a LCA (option 2) are:

92 Scheuer et al. (2003). *Life cycle energy and environmental performance of a new university building: modeling challenges and design implications*. Energy and Buildings 35, pp. 1049–1064

93 EC (2014). Assessment of Scenarios and Options towards a Resource Efficient Europe. An Analysis for the European Built Environment http://ec.europa.eu/environment/enveco/resource_efficiency/pdf/TP_report.pdf

94 EC (2014). Assessment of Scenarios and Options towards a Resource Efficient Europe. An Analysis for the European Built Environment http://ec.europa.eu/environment/enveco/resource_efficiency/pdf/TP_report.pdf

- Global Warming Potential (GWP),
- Depletion of abiotic resources-elements (ADP elements)
- Depletion of abiotic resources-fossil fuels (ADP fossil fuels)

Moreover, where an LCA tool is used, only the result for these impact categories are proposed to be taken into account, rather than an aggregated overall score or rating that may be the output.

With reference to the impact assessment models, it is suggested to refer to the characterisation factors identified in the EN 15804 and applied in the European Reference Life Cycle Database (ELCD)[95], as suggested in the EN 15978, and in the PEF methodology[96], as reported in **Table 2.13**.

Table 2.13. Impact assessment models for the selected impact category indicators

Impact Category	Model	Unit	Source
Climate Change	Bern model – Global Warming Potentials (GWP) over a 100 year time horizon.	kg CO_2 equivalent	Intergovernmental Panel on Climate Change, 2007
Resource Depletion – mineral, fossil	CML2002 model	kg antimony (Sb) equivalent	van Oers et al., 2002

The allocation of CO_2 emissions that may be associated with the production of engineered structural timber products (which can be energy intensive but using biomass) would need to be considered under the GWP category indicator. This could be handled as suggested in ISO 14047 (Example 3) in which carbon sequestration is given a separate category indicator with negative emissions (GWP and GWP Excluding Biogenic).

The need for expert evaluation of the design assessments

The lack of experience in the interpretation of the results of the studies and the scope for manipulation of the results suggests that an expert evaluation of design assessments is required. LCA studies are not easy to interpret as the results are provided in the form of indicators, and conclusions can only be drawn considering the local conditions where the building is to be constructed. It is therefore proposed that a technical evaluator specialised in LCA shall assist in preparing the ITT and, once tenders have been received, they will either:

- Carry out a check for how EPDs have been aggregated, or
- Carry out a critical review of the LCA's for methodological choices, data quality and comparability.

The critical review is proposed to be carried out with reference to ISO 14044, section 6, and the following sections of the European Commission's Product Environmental Footprint (PEF) Guide:

- Critical review (section 9, p-68)
- Data collection checklist (Annex III)
- Data quality requirements (section 5.6, p-36)
- Interpretation of results (section 7, p-61)

95 *LCIA METHOD DATA SETS* in *ELCD* http://eplca.jrc.ec.europa.eu/ELCD3/LCIAMethodList.xhtml

96 EC (2012): Product Environmental Footprint (PEF) Guide http://ec.europa.eu/environment/eussd/pdf/footprint/PEF%20methodology%20final%20draft.pdf

2.3.1.1.2 Revised criteria proposal

<table>
<tr><th>Core criteria</th><th>Comprehensive criteria</th></tr>
<tr><td colspan="2">AWARD CRITERIA</td></tr>
<tr><td>

B10.1 Performance of the main building elements

This criterion <u>may only be applied</u> where a Bill of Quantities for a reference building is to be provided to bidders as the basis for comparison <u>or</u> where designs submitted by different bidders are to be compared during a competitive process.

Additional technical guidance shall be followed during the procurement process, as provided in Annex 1 (EPD option) and Annex 2 (LCA option).

A technical evaluator specialised in LCA shall assist in preparing the ITT and shall carry out a critical review of the submissions.

The procurer shall award points based on the improvement in life cycle performance of the main building elements listed in Table a in comparison with a reference building *or* other competing designs. This shall be according to either option 1 (based on EPDs) or option 2 (based on an LCA) as presented below. *The basis for the comparison and the option to be used shall be specified in the ITT.*

Table a Scope of the building elements to be evaluated

<table>
<tr><th>New-build</th><th>Renovation</th></tr>
<tr><td>– The structural frame, including beams, columns and slabs
– External walls, cladding and insulation
– Floors and ceilings
– Internal walls
– Windows
– Roofs</td><td>– External walls, cladding and insulation
– Re-roofing and insulation
– Windows
Where additional floors or building extensions are proposed that account for >25% of the existing useable floor area, the list of new-build elements shall also apply.</td></tr>
</table>

Option 1: Aggregation of Environmental Product Declarations (EPDs)

The performance shall be evaluated using Environmental Product Declarations (EPDs) that are in compliance with ISO 14025, EN 15804 or equivalent. The ITT shall specify which of the following two methods shall be used for the evaluation:

(i) Aggregation of EPD characterisation results (the raw LCA results for indicators) for each building element, *or*
(ii) Aggregation of weighted EPD scores or ratings (usually a numeric score or letter rating) for each building element.

</td><td>

B10.1 Performance of the main building elements

This criterion <u>may only be applied</u> where a Bill of Quantities for a reference building is to be provided to bidders as the basis for comparison or where designs submitted by different bidders are to be compared during a competitive process.

Additional technical guidance shall be followed during the procurement process, as provided in Annex 1 (EPD options) and Annex 2 (LCA options).

A technical evaluator specialised in LCA shall assist in preparing the ITT and shall carry out a critical review of the submissions.

The procurer shall award points based on the improvement in life cycle performance of the main building elements listed in Table b in comparison with a reference building or other competing designs. This shall be according to either option 1 (based on EPDs) or option 2 (based on an LCA) as presented below. The basis for the comparison and the option to be used shall be specified in the ITT.

Table 1b. Scope of the building elements to be evaluated

<table>
<tr><th>New-build</th><th>Renovation</th></tr>
<tr><td>– The structural frame, including beams, columns and slabs
– External walls, cladding and insulation
– Floors and ceilings
– Internal walls
– Windows
– Roofs</td><td>– External walls, cladding and insulation
– Re-roofing and insulation
– Windows
Where additional floors or building extensions are proposed that account for >25% of the existing useable floor area, the list of new-build elements shall also apply.</td></tr>
</table>

Option 1: Aggregation of Environmental Product Declarations (EPDs)

The performance shall be evaluated using Environmental Product Declarations (EPDs) that are in compliance with ISO 14025, EN 15804 or equivalent. The ITT shall specify which of the following two methods shall be used for the evaluation:

(i) Aggregation of EPD characterisation results (the raw LCA results for indicators) for each building element, or
(ii) Aggregation of weighted EPD scores or ratings (usually a numeric score or letter rating) for each building element.

</td></tr>
</table>

The Product Category Rules (PCRs) [97] for the EPDs shall be specified in the ITT and all bidders shall aggregate EPDs from the PCRs, which shall be in accordance with ISO 14025, EN 15804 or equivalent. Normalisation and weighting to give a score or rating for building elements shall be permitted where national PCRs have been established in support of a building assessment and certification scheme.	The Product Category Rules (PCRs) for the EPDs shall be specified in the ITT and all bidders shall aggregate EPDs from the PCR's, which shall be in accordance with ISO 14025, EN 15804 or equivalent. Normalisation and weighting to give a score or rating for building elements shall be permitted where national PCRs have been established in support of a building assessment and certification scheme.
Option 2: Carry out a Life Cycle Assessment (LCA) The performance shall be evaluated by carrying out a Life Cycle Assessment (LCA) of the building in accordance with ISO 14040/14044, EN 15978 or equivalent. The ITT shall specify which of the following methods shall be used for the evaluation: (i) Impact Category results: The aggregated characterisation results for each indicator obtained using the specified LCA method; (ii) LCA tool score: A single score obtained using a national or regional building LCA tool used by public authorities; (iii) Building assessment scheme LCA score: A normalised and weighted scoring derived from an LCA-based criterion within a national or regional building assessment and certification scheme used by public authorities. In each case the methodology shall include, as a minimum, the Lifecycle Impact Category Indicators specified in Annex 2 **Verification:** The Design team *or* the Design & Build tenderer *or* the DBO tenderer shall provide a bill of materials for the proposed design. The comparison with the reference building shall be written up in a concise technical report that compares the proposed design option(s) and calculates the improvement potential. Where the results from a building assessment and certification system are used, the tenderer's accredited building assessor shall provide verification according to the methodology used by the system. *The technical report shall be subject to a critical review by the contracting authorities appointed LCA technical evaluator. The critical review shall follow the guidelines in Annex 3.*	***Option 2: Carry out a Life Cycle Assessment (LCA)*** The performance shall be evaluated by carrying out a Life Cycle Assessment (LCA) of the building in accordance with ISO 14040/14044, EN 15978 or equivalent. The ITT shall specify which of the following methods shall be used for the evaluation: (i) Impact Category results: The aggregated characterisation results for each indicator obtained using the specified LCA method; (ii) LCA tool score: A single score obtained using a national or regional building LCA tool used by public authorities; (iii) Building assessment scheme LCA score: A normalised and weighted scoring derived from an LCA-based criterion within a national or regional building assessment and certification scheme used by public authorities. In each case the methodology shall include, as a minimum, the Lifecycle Impact Category Indicators specified in Annex 2 **Verification**: The Design team or the Design & Build tenderer or the DBO tenderer shall provide a bill of materials for the proposed design. The comparison with the reference building shall be written up in a concise technical report that compares the proposed design option(s) and calculates the improvement potential. Where the results from a building assessment and certification system are used, the tenderer's accredited building assessor shall provide verification according to the methodology used by the system. *The technical report shall be subject to a critical review by the contracting authorities appointed LCA technical evaluator. The critical review shall follow the guidelines in Annex 3.*

97 Product Category Rules are required to be followed for the production of each EPD within a scheme. They define how life cycle assessment shall be carried out and verified for each product so as to ensure consistency.

Award criteria B10.1: Proposed technical annexes

Annex 1

Supporting guidance for criterion B10.1: Option 1 – Aggregation of EPDs

In detailed design and performance award Criteria B10.1 it was described how Environmental Product Declarations (EPDs) could be used by bidders in order to demonstrate how they would reduce the environmental impact of the construction of an office building.. This brief guidance note describes:

- When this criterion can be used;
- The rules required to ensure that bids are comparable; and
- The technical support required for bid selection.

The need for conformity of EPDs with ISO 14025, EN 15804 or equivalent is also highlighted. However, additional normalisation and weighting rules within existing building assessment and certification schemes may be used to evaluate designs.

1.1 When can EPD option 1 be used?

The use of criteria B10.1 is only recommended where a comparison can be made against a reference building design and/or between different building designs. It is therefore relevant to the following procurement scenarios:

- Where the client already has a reference building design and bill of quantities that has been appraised in order to provide a guide price for comparison with bids;
- Where a design competition is to be used to encourage innovative building designs to be brought forward by design teams and/or contractors;
- Where building designs are required to demonstrate a defined level of environmental performance for specific building elements following rules with an existing building assessment and certification scheme.

In these scenarios, the aggregation of EPDs as the basis for evaluation of performance can be made an award requirement.

1.2 Conformity of the EPDs used

EPDs shall be compiled for the listed building elements. These EPDs shall all have been selected from within the same Product Category Rules (PCRs). All EPDs shall be in conformance with ISO 14025, EN 15804 or equivalent.

New primary data for building elements may be used to supplement these EPDs but shall be subject to LCA analysis according to the same PCRs.

Some existing building assessment and certification schemes apply normalisation and/or weighting rules to EPD results in order to generate a comparative score or rating. As long as the main PCR rules are in compliance with ISO 14025, EN 15804 or equivalent, these comparative scores or ratings may be used and each design shall be evaluated according to the system used with the same scheme.

1.3 Will additional expertise be required to evaluate bids?

In any bidding process for office buildings, the procurer is likely to require supporting design and technical expertise in order to set requirements and evaluate designs. The procurer may therefore wish to call upon expert input at two main stages:

1. Putting together the design brief and performance requirements: Bidders shall be instructed on what technical requirements they should follow in order to ensure that the designs submitted are comparable.
2. Evaluating designs and improvement options: A technical evaluation of bidders responses to this criteria should be carried out in order to support the procurer.

1.4 What instructions should be given to bidders?

The following technical instructions shall be incorporated into the ITT in order to ensure that bids are comparable. Where designs are to be evaluated against a reference building, this shall be clearly stated and quantities of the specified building elements provided.

Technical instructions for bidders using EPDs for building evaluations

Technical point to address	What this means in practice
a. Comparability of EPDs	The EPDs shall be selected from within the same Product Category Rules (PCRs). The PCR scheme shall therefore be specified. Where the normalisation and/or weighting rules of an EPD system linked to an existing building certification scheme are to be used,, each design shall be evaluated according to the same scheme and rules.
b. Building elements within the scope of the criteria	The scope of the criteria shall, as a minimum, comprise the following building elements: - The structural frame, including beams, columns and slabs - External walls and insulation - Floors and ceilings - Internal walls - Windows - Roofs
c. Definition of the building's life cycle and boundaries	EPDs that address cradle to grave shall be compiled.
d. Relevance of the results to the whole building	The declared unit for each EPD shall be multiplied by the appropriate quantity in the bill of materials. This is to ensure that the total environmental impact for each building design can be compared.
e. Lifecycle impact category indicators to be used for evaluation purposes	As a minimum the PCRs used shall include the following three impact category indicators: - Global Warming Potential (GWP), - Depletion of abiotic resources-elements (ADP elements) - Depletion of abiotic resources-fossil fuels (ADP fossil fuels)

Annex 2

Supporting guidance for criterion B10.1: Option 2 – LCA analysis

In detailed design and performance requirement award Criterion B10.1 it was described how Life Cycle Assessment (LCA) could be used by bidders in order to demonstrate how they have reduced the environmental impact of an office building's construction. This brief guidance note describes:

- When this criteria can be used;
- The rules required to ensure that bids are comparable; and
- The technical support required for bid selection.

All use of LCA shall be carried out with reference to ISO 14040/ISO 14044, EN 15978 or equivalent.

2.1 When can LCA option 2 be used?

The use of criteria 10b is only recommended where a comparison can be made of improvement options against a reference building design and/or between different building designs. It is therefore relevant to the following procurement scenarios:

- Where the client already has a reference building design and bill of quantities that has been appraised in order to provide a guide price for comparison with bids:
- Where a design competition is to be used to encourage innovative building designs to be brought forward by design teams and/or contractors:
- Where building designs are required to demonstrate a defined level of performance for specific building components using an LCA-based calculation tool:

In these scenarios an LCA analysis can be made an award requirement.

2.2 Will additional expertise be required to evaluate bids?

In any tender process for office buildings the procurer is likely to require supporting design and technical expertise in order to set requirements and evaluate designs. The procurer may therefore wish to call upon this expertise at two stages in the procurement process:

1. When putting together the design brief and performance requirements: Bidders shall be instructed on what technical requirements they should follow in order to ensure that the designs submitted are comparable. .
2. When evaluating designs and improvement options: A technical evaluation of tenderers' responses to this criterion should be carried out in order to support the procurer.

A technical evaluator shall be required to carry out a critical review of each tenderers LCA analysis according to the guidance in Annex 3.

2.3 What instructions should be given to bidders?

The following technical instructions should be incorporated into the ITT in order to ensure that bids are comparable. Where designs are to be evaluated against a reference building, this shall be clearly stated and the bill of materials provided.

Technical instructions for bidders using LCA for building evaluations

Technical point to address	**What this means in practice**
a. Method and inventory data	The impact assessment method and life cycle inventory (LCI) data to be used by each design team shall, be specified to ensure comparability. Verified primary data may be used to supplement gaps following the guidance in ISO 14040/14044, EN 15978 or equivalent, and for data from EPDs ISO 14025, EN 15804 or equivalent.
b. Comparison on the basis of functional equivalence	The following characteristics of the building shall be specified as a reference point for each design (see ISO 14040/14044, EN 15987 or equivalent): - Relevant technical and function requirements, as described in the performance requirements; - The envisaged pattern of use; - The requested service life. A common functional unit or reference unit shall then be used to present the results (see ISO 14040, EN 15987 or equivalent).
c. Definition of the buildings life cycle and boundaries	The boundary for the analysis shall be cradle-to-grave (see ISO 14040). In the case of a building refurbishment, design teams shall indicatively refer to Module B5 of EN 15978 'boundary for refurbishment' . Allocation for recycled or re-used materials either as inputs (product stage) or outputs (end of life stage) shall be made according to the rules in ISO 14044, Section 4.3.4.3.
d. Building elements within the scope of the criteria	The scope of the criteria shall, as a minimum, comprise the following building elements: - The structural frame, including beams, columns and slabs - External walls and insulation - Floors and ceilings - Internal walls - Windows - Roofs

e. Lifecycle category indicators to be used for evaluation purposes	As a minimum the following three of the impact category indicators shall be used: - Global warming potential (GWP) - Abiotic resource depletion potential for elements (ADP_elements) - Abiotic resource depletion potential of fossil fuels (ADP_fossil fuels) Where an LCA tool generates an aggregated scoring or rating for the building then only the result for these impact categories shall be taken into account.

Annex 3

Brief for LCA technical evaluator

The role of the technical evaluator will be to assist the procurer in setting the ground rules for the tenderers, with reference to either Annex 1 or 2, depending on the option chosen.

Once tenders have been received they will either:

(i) Carry out a check for how EPDs have been aggregated, or

(ii) Carry out a critical review of the LCAs for methodological choices, data quality and comparability.

The critical review will be carried out with reference to ISO 14044, section 6, and the following sections of the European Commission's Product Environmental Footprint (PEF) Guide:

- Critical review (section 9, p-68)
- Data collection checklist (Annex III)
- Data quality requirements (section 5.6, p-36)
- Interpretation of results (section 7, p-61)

The technical evaluator shall agree with the procurer the weighting of the LCIA indicator results, unless this is already predetermined by options ii or iii in Criterion 10B.1.

Summary rationale:

- As consequence of initiatives by some Member States and the implementation of the Energy Performance of Buildings Directive the energy performance of new buildings has improved. With the objective of nearly zero energy public buildings by 2018, energy use will decrease further and the relative significance of the embodied impacts of construction materials and products will become more important. This may include the use of more energy and resource intensive products and materials to achieve higher energy performance building fabrics. .
- According to the technical and environmental analysis developed within the project, the construction phase is associated with the second most significant environmental impacts after the use phase.
- Several LCA-based tools (developed according to ISO 14040-14044) are widely used in Europe to assess the environmental impact of buildings as a whole and for the selection of construction materials and products. Some of them are EPDs (developed according ISO 14025 and ISO 21930), following the same PCRs. Some examples of the most used schemes across Europe are linked to building assessment schemes (e.g. BREEAM, GPR Buildings, DGNB and HQE) have been described, highlighting assumptions, normalisation and weighting systems, in order to understand the differences between the different methodologies and the potential benefits achievable by means of the use of these tools.
- In conclusion, the evaluation of the improvement in life cycle performance of the main building elements is proposed as an award criterion (both for Core and Comprehensive criteria). Two broad options appear possible for the evaluation of this improvement, within which there are five different variations which would give procurers flexibility depending on the prevailing systems used in a Member State:
    - Option 1: Aggregation of EPDs

        1.1 Aggregation of EPD characterisation results for each building element, *or*

        1.2 Aggregation of weighted EPD scores or ratings for each building element (as in BREEAM)
    - Option 2: Carry out a Life Cycle Assessment (LCA) according to one of the following methods:

        2.1 Impact Category results: The aggregated characterisation results for each indicator obtained using the specified LCA method;

        2.2 LCA tool score: A single score obtained using a national or regional building LCA tool mandated for use by public authorities (such as GPR Buildings)

        2.3 Building assessment scheme LCA score: A normalised and weighted scoring derived from an LCA-based criterion within a national or regional building assessment and certification scheme used by public authorities (such as DGNB)
- It is necessary to ensure comparability between the analyses by means of using EPDs developed in conformance with ISO 14025 and/or EN 15804 and by referring to EPDs following the same PCR scheme (option 1) or by using the same LCIA method and life cycle inventory (LCI) data (option 2).
- The LCA analysis in option 1 and 2 has at least to consider the main building elements, which have been identified according to the outcomes of the technical and environmental analysis, the requirements of the EN 15978 and the EN 15804 standards and the CPA guide. Elements are proposed because these are most recognisable to design teams, forming the basis for the Bill of Quantities for a building and the increasing used of whole systems for parts of a building e.g. façade, glazing, structures, Moreover, if required they can be disaggregated into constituent products and materials.
- Based on a review of category indicators selected in LCA studies, a European-scale study of resource efficiency and EN 15978/15804 the following three categories have been selected in order to reflect impacts during the production phase and to facilitate easier comparison of bid designs - Global Warming Potential the depletion of abiotic resources-elements and of abiotic resources-fossil fuels. These shall be included, as a minimum, in PCRs (option 1) or when carrying out an LCA (option 2).

2.3.1.2 At what stage of the procurement process are the criteria relevant?

The evaluation of the performance of the main building elements has been proposed as an award criterion (both Core and Comprehensive criterion) to be applied during the detailed design and performance requirements procurement phase. The *Design team* or the *Design & Build tenderer* or the *DBO tenderer* shall provide a bill of materials for the proposed design. The comparison of the proposed design option(s) and the calculation of the improvement potential with the reference building shall be written up in a concise technical report. This comparison may only be applied where a bill of materials for a reference building is provided to bidders in the ITT as the basis for comparison or where designs submitted by different bidders are to be compared during a one or two stage competitive process.

An LCA technical evaluator appointed by the contracting authorities shall provide a critical review of the technical report, according to the rules provided in the section 2.2.1.1. Moreover, guidelines for the critical review are also provided in Annex III enclosed to the GPP criteria document.

The criteria classification, their reference numbers in the criteria document and the respective procurement phase can be cross referenced as follows.

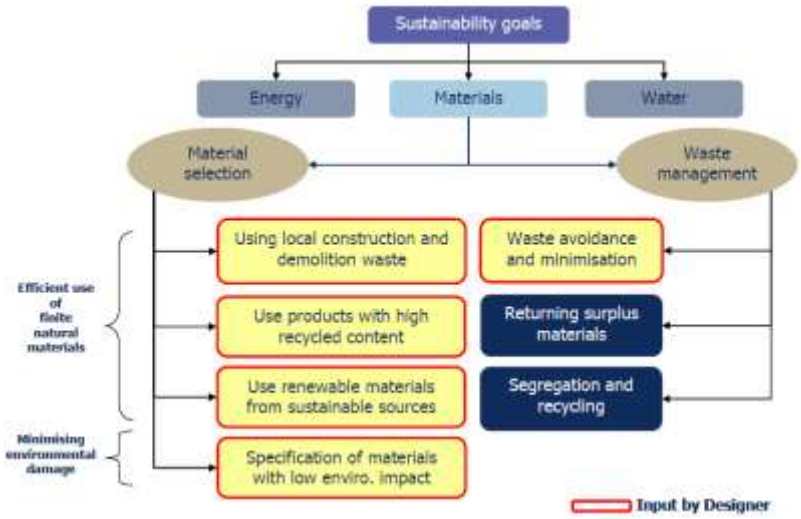
Title of the criterion	Procurement phase	Criterion classification	Criteria typology	Reference number in the criteria document
Performance requirements of the main building elements	B. Detailed design and performance requirements	Core and Comprehensive	Award criterion	B10.1

2.3.2 Recycled content

2.3.2.1 Incorporation of recycling content

2.3.2.1.1 Background technical discussion and rationale

Energy, water and material use are the three key areas where the construction industry needs to increase its resource efficiency. In Figure 2.11 the various ways in which efficient use of materials directly contributes to greater sustainability in construction are highlighted[98].



Source: WRAP (2009)

Figure 2.11: Materials selection and use is a key element of sustainable construction

According to the European Commission's Reference Document on Best Environmental Management Practice in the building and construction sector[99], the use of materials with high recycled content is one of the best

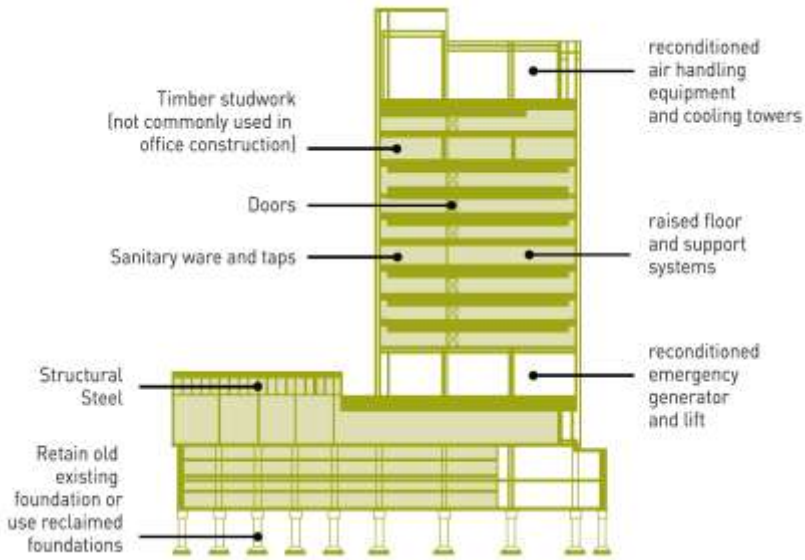
98 WRAP Delivering higher recycled content in construction projects (2009): http://www2.wrap.org.uk/downloads/Delivering_higher_recycled_content_in_construction_projects.a5cbdb03.5021.pdf

practices with the potential for greatest influence on resource efficiency in construction and should be taken into consideration by contracting authorities, project teams and relevant stakeholders during the procurement process. Moreover, it is claimed that recycled content can be checked along the supply chain, although in the absence of harmonised systems and protocols for declaration and traceability for most products and materials, this may be more difficult in some Member States.

Recycled content is defined by ISO 14021, which is a standard for Type II self-declarations by manufacturers, as the proportion, by mass, of recycled material in a product or packaging. In general, a reference to recycled content includes re-used products and materials. Industrial by-products as defined by art. 5 of the Waste Framework Directive[100] can also be classed as recycled content.

Employing more re-used and recycled material in construction is a significant way of making a contribution to resource efficiency by diverting materials from landfill and saving natural resources. Contractors and designers can make major improvements in materials efficiency, by minimising waste generation in construction, maximising the recycling rate, reusing materials and selecting construction products with a higher recycled content and lower embodied impacts.

In Figure 2.12 an example of the most common opportunities to incorporate re-used and recycled materials into a typical office building is shown[101].



Source: WRAP (2007)

Figure 2.12: Opportunities to incorporate reclaimed materials into a typical office building

According to a literature review, product types that commonly offer higher levels of recycled content tend to include:

- Bulk aggregates (sub-base, pipe bedding, fill, etc.)
- Pre-cast concrete (paving, slabs)
- Ready mix concrete
- Concrete tiles
- Dense blocks
- Lightweight blocks

99 EC Reference Document on Best Environmental Management Practice in the building and construction sector (2012): http://susproc.jrc.ec.europa.eu/activities/emas/documents/ConstructionSector.pdf

100 Waste Framework Directive (WFD) 2008/98/EC: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:312:0003:0030:en:PDF

101 WRAP, *Reclaimed building products guide*, http://www2.wrap.org.uk/downloads/Reclaimed_building_products_guide.c5526607.5259.pdf

- Bricks
- Insulation materials (floor, wall and roof)
- Plasterboard
- Floor coverings (carpet, underlays, etc.)
- Wooden floor coverings
- Paint and varnishes

Requiring a minimum of 10 to 15% recycled content by value for the project overall is broadly achievable according to literature [102, 103, 104]. In order to make best use of the data on material quantities and costs commonly available to the contracting authority and the design team, the most practical indicator is the recycled content by value. Calculation by mass would require access to data that is not usually included in cost plans and Bills of Quantities (BoQ).

In UK organisation WRAP's report *Delivering higher recycled content in construction projects* (2009), the findings of case studies undertaken for a broad range of building types are presented, as is shown in Table 2.14:. In detail, this underlines that most buildings contain greater than 10% recycled content by value using standard products. Moreover, by using cost-neutral good practice and readily available construction products with higher recycled content, an overall percentage of 15-30% recycled content by value could be easily obtained.

Table 2.14: Recycled content as a percentage of the total material cost for a selection of building types [105]

Type of project	Using standard practice products	Using cost-neutral good practice
Commercial retail	11–32%	21–44%
Commercial offices	10–22%	12–30%
Education, healthcare	12–20%	15–30%
Residential	6–26%	16–31%
Infrastructure	8–36%	25–49%

As reported in Table 2.15, data compiled from a number of different projects and studies illustrates that the level of recycled content (by mass) can vary widely from very low levels, according to standard materials used in the market, to very high levels which can be considered to represent good or best practices in the market.. Standard practice represents the baseline level at which the lowest recycled content is normally achieved. Good practices with higher level of recycled content are available in the market and are achievable at no or limited additional costs. Moreover, information is given also on the best practice level, in which the highest recycled content is generally achievable, based on the evidence reviewed, at additional cost. Even though it is not possible to generalise the results provided by these examples, they provide an indication of the feasible level of recycled content in currently used construction materials and products.

102 EC Reference Document on Best Environmental Management Practice in the building and construction sector (2012): http://susproc.jrc.ec.europa.eu/activities/emas/documents/ConstructionSector.pdf

103 WRAP Delivering higher recycled content in construction projects (2009): http://www2.wrap.org.uk/downloads/Delivering_higher_recycled_content_in_construction_projects.a5cbdb03.5021.pdf

104 BIOIS, EC (2011). Service Contract on Management of Construction and Demolition Waste – SR1. Final Report Task 2. Available online at http://ec.europa.eu/environment/waste/pdf/2011_CDW_Report.pdf

105 WRAP Delivering higher recycled content in construction projects (2009): http://www2.wrap.org.uk/downloads/Delivering_higher_recycled_content_in_construction_projects.a5cbdb03.5021.pdf

Table 2.15: Example of recycled content used in construction materials in different practices

	Standard practice (% by mass)	Good practice (% by mass)	Best practice (% by mass)
Brick and dense blocks	0-50 [c] 30 [b] 0-70 [d]	50-80 [c]	60-90 [c]
Ceiling materials	10-36 [c] 10-52 [d]	50-84 [c]	78-98 [c]
Concrete tiles	0-43 [c] 0-17 [d]	5-80 [c]	10-95 [c]
Aggregates	0-50 [c]	25-80 [c]	100 [c]
Mortar	3 [c]	4 [c]	70 [c]
Concrete	0-25 [c] 10-20 [b]	5-30 [c]	23-90 [c]
Insulation (mineral/glass wool)	25-30 [c]	50-80 [c]	80 [c]
Plasterboard	0 [b]	25-30 [b]	
[a] EC JRC[106] [b] EC Biois 2011[107]		[c] WRAP 2008[108] [d] WRAP 2009[109]	

With the high recycled content by mass collected in Table 2.15, most projects can exceed 10% recycled content by value with minimal effort. Moreover, by setting this minimum requirement, construction clients can motivate their design team and contractors to become aware of their current performance and then identify the most significant opportunities to improve that performance[110]. By adopting the available opportunities to increase recycled content through the use of cost competitive, readily available products (i.e. 'good practice' at no extra costs), levels exceeding 15–20% are common.

Choosing to use products with a higher recycled content and to achieve a high level of performance for the total Bill of Quantities is more challenging. For example, specifications for concrete may imply higher levels of quality control on performance from suppliers and monitoring on site. In some cases it may also imply changes in on-site practices e.g. longer curing times to achieve the same performance.

On the basis of the information reviewed, award criteria could be proposed to encourage the further incorporation of recycled content into the main building elements (either individually or in total) as defined in Table 2.15 and into the finishing elements used in the fit-out, which shall obviously be weighted lower than the main building elements in the evaluation.

As a Core award criterion, points could be proposed in proportion to incorporation of the recycled content and/or industrial by-products greater than a minimum of 15% by value into the main building elements and the most relevant finishing elements, which on the basis of the literature review, have been identified in:

- Ceiling tiles
- Paints and varnishes
- Textile floor and wall coverings
- Laminate and flexible floor coverings
- Wooden floor coverings

As Comprehensive award criterion, points are proposed in proportion to incorporation of the recycled content, re-used content and industrial by-products greater than a minimum of 30% by value into the main building elements and the finishing elements.

106 EC Reference Document on Best Environmental Management Practice in the building and construction sector (2012): http://susproc.jrc.ec.europa.eu/activities/emas/documents/ConstructionSector.pdf

107 BIOIS, EC (2011). Service Contract on Management of Construction and Demolition Waste – SR1. Final Report Task 2. Available online at http://ec.europa.eu/environment/waste/pdf/2011_CDW_Report.pdf

108 WRAP Choosing construction products. Guide to the recycled content of mainstream construction products (2008): http://www.wrap.org.uk/sites/files/wrap/Const%20Product%20Guide%20Version%204.1.pdf

109 WRAP Delivering higher recycled content in construction projects (2009): http://www2.wrap.org.uk/downloads/Delivering_higher_recycled_content_in_construction_projects.a5cbdb03.5021.pdf

110 http://www.wrapni.org.uk/sites/files/wrap/Recyclability%20Efficiency%20Metric.pdf

Monitoring recycled content

The estimation of the recycled content should be kept up to date and be accurate to support verification. Information on the level of recycled content should be periodically updated to reflect the emerging design and specification. The frequency with which the recycled content of the building needs to be reviewed will depend on the scale of any design changes that occur. Increasing the proportion of the materials used in a project that come from a recycled source is a relatively simple, practical and cost-neutral way of showing a measurable contribution to more sustainable construction.

Options for Verification

Under the Construction Products Regulation (CPR - 305/2011/EU) [111]. several products with recycling potential are covered by harmonised European standards (hEN). Currently these standards are covering the performance of a product per se (e.g. structural stability, fire safety, emission of dangerous substances) no matter if the materials used are primary or secondary materials. However, the ongoing discussion at EU and national level on covering environmental performance in hENs and the development of horizontal product category rules (PCR) in a European standard (15804) has motivated several technical committees in CEN to assess if and how reliable information on recycled content could be addressed in specific hENs for construction products.

Products covered by harmonised European standards that might have significant potential of using recycled materials are:

- Rc = Concrete, concrete products, mortar & concrete masonry units
- Ru = Unbound aggregate, natural stone & hydraulically bound aggregate
- Rb = Clay masonry units (i.e. bricks and tiles), calcium silicate masonry units & aerated non-floating concrete
- Rg = Glass

Having this information reported makes the identification of the recycled content easier. In the UK, for example, the application of an End-of-Waste Quality Protocol for recycled and secondary aggregates [112] has provided a benchmark for standards, giving aggregate users the confidence that recycled and secondary materials are of the required quality and are equivalent to primary, or natural, materials supporting an increased use of recycled content in the building sector.

Whilst an annual production average for a dedicated production line is understood to be readily verifiable further feedback is needed from stakeholders on whether batch production to a specified content can be accurately verified. An approach based on a mass balance for batches of product delivered to site (for example, ready mix concrete for which each batch is tested before dispatch) or the factory production of specific product lines with claimed content levels (for example, a block work or insulation product) is proposed. During the construction phase, all the certificates providing information would have to be collated, including product data sheets, data from test reports and supporting certificates for recyclates.

2.3.2.1.2 Revised criteria proposal

Core criteria	**Comprehensive criteria**
AWARD CRITERIA	
B10.2 Incorporation of recycled content in concrete, masonry and insulation *This criterion is applicable to office buildings with concrete structural frames and masonry internal and external walls.* The procurer shall award points to tenderers that achieve	**B10.2 Incorporation of recycled or re-used content in concrete, masonry and insulation** *This criterion is applicable to office buildings with concrete structural frames and masonry internal and external walls.* The procurer shall award points to tenderers that achieve greater than or equal to 30% by value of recycled content,

111 Construction Products Regulation (CPR) 305/2011/EU: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:088:0005:0043:EN:PDF

112 DEFRA, WRAP Quality Protocol. Aggregates from inert waste (2013): http://www.mineralproducts.org/documents/aggregates_quality_protocol.pdf

greater than or equal to 15% by value of recycled content and/or by-products[113] for the sum of the main building elements in Table c.

Table c. Scope of the building elements to be included

New-build	Renovation
– The structural frame, including beams, columns and slabs – External walls, cladding and insulation – Floors and ceilings – Internal walls – Roofs	– External walls, cladding and insulation – Internal walls – Re-roofing and insulation Where additional floors or building extensions are proposed that account for >25% of the existing useable floor area, the list of new-build elements shall also apply.

The recycled content shall be calculated on the basis of an average mass balance of recycled materials and/or by-products according to how they are produced and delivered to site (*as applicable*):

- The total number of ready mixed batches delivered to site in accordance with EN 12620 and EN 206 or equivalent;
- On an annual basis for factory made panels, columns, blocks and elements with claimed content levels in accordance with EN 12620 and EN 206 or equivalent;
- On an annual basis for dedicated insulation production lines for specific product brands with claimed content levels.

Verification: The Design team *or* the Design & Build tenderer *or* the DBO tenderer shall quantify the proportional contribution of the recycled content to the overall value of the specified building elements, based on the information provided by the supplier(s) of the construction product.

This information must include the average mass balance calculations as described above, supported by batch testing results, delivery documentation and/or factory production control documentation. In each this shall be verified by a third party audit.

The ordering and delivery to site of these building elements shall later be verified by the main construction contractor (see Section D7).

re-used content and/or by-products[114] for the sum of the main building elements in Table d.

Table d. Scope of the building elements to be included

New-build	Renovation
– The structural frame, including beams, columns and slabs – External walls, cladding and insulation – Floors and ceilings – Internal walls – Roofs	– External walls, cladding and insulation – Internal walls – Re-roofing and insulation Where additional floors or building extensions are proposed that account for >25% of the existing useable floor area, the list of new-build elements shall also apply.

The recycled or re-used content shall be calculated on the basis of an average mass balance of recycled materials and/or by-products according to how they are produced and delivered to site (*as applicable*):

- The total number of ready mixed batches delivered to site in accordance with EN 12620 and EN 206 or equivalent;
- On an annual basis for factory made panels, columns, blocks and elements with claimed content levels in accordance with EN 12620 and EN 206 or equivalent;
- On an annual basis for dedicated insulation production lines for specific product brands with claimed content levels;
- Whole re-used products, including confirmation of their origin.

Re-used content shall be weighted higher in the evaluation than recycled content. Additional points shall be awarded to designs that re-use the primary load bearing structure of an existing building either in-situ or from another site.

Verification: The Design team *or* the Design & Build tenderer *or* the DBO tenderer shall quantify the proportional contribution of the recycled or re-used content to the overall value of the specified building elements, based on the information provided by the supplier(s) of the construction product.

This information must include the average mass balance calculations as described above, supported by batch testing results, delivery documentation and/or factory production control documentation. In each this shall be verified by a third party audit.

The ordering and delivery to site of these building elements shall later be verified by the main construction contractor (see Section D7).

113 A by-product is defined in art. 5 of the Waste Framework Directive as *'A substance or object, resulting from a production process, the primary aim of which is not the production of that item…..'*

114 A by-product is defined in art. 5 of the Waste Framework Directive as *'A substance or object, resulting from a production process, the primary aim of which is not the production of that item…..'*

CONTRACT PERFORMANCE CLAUSES	
D6. Incorporation of recycled content As materials are ordered and brought onto site, recycled content claims shall be verified for each batch of product. **Verification:** The main construction contractor *or* the DBO contractor shall verify claims by obtaining information from supplier(s) of the construction products used. This shall include mass balance calculations supported by batch testing results, delivery documentation and/or factory production control documentation. In each the data shall be verified by a third party audit.	**D6. Incorporation of recycled or reused content** As materials are ordered and brought onto site, recycled or re-used content claims shall be verified for each batch of product. **Verification:** The main construction contractor *or* the DBO contractor shall verify claims by obtaining information from supplier(s) of the construction products used. This shall include mass balance calculations supported by batch testing results, delivery documentation and/or factory production control documentation. In each the data shall be verified by a third party audit.

Summary rationale:

- The use of materials with high recycled content is one of the practices which has the greatest potential to improve resource efficiency in the construction sector. This practice contributes to sustainable development by diverting materials from landfill and saving natural resources.
- According to the literature, requiring a minimum of 10-15% recycled content by value for the project overall is broadly achievable. The findings of case studies undertaken for a broad range of building types have shown that most buildings have greater than 10% recycled content by value using standard products. Moreover, by using cost-neutral good practice and readily available construction products with higher recycled content, an overall percentage of 15-30% recycled content by value could be obtained.
- On the basis of the collected information, award criteria are proposed on the incorporation of a higher amount of recycled content greater than a minimum of 15% into the main building elements. Evidence suggests that this criteria would only work for concrete, masonry and insulation products, being those where recycled content is traceable and for which there would be environmental benefits from stimulating the market. In detail the proposals are as follows:
    - As Core criterion, award points can be proposed in proportion to the incorporation of the recycled content and/or by-products greater than a minimum of 15% by value into the main building elements.
    - As Comprehensive criterion, award points are proposed in proportion to incorporation of the recycled content, re-used content and by-products greater than a minimum of 30% by value into the main building elements.
- The estimation of the recycled content should be accurately reportable for verification purposes – either on the basis of being averaged for batches delivered to site or for a production line with batches dedicated to specific product brands. This could be obtained from production management records or batch testing e.g. as part of ISO 9001.
- Information on the level of recycled content should be periodically updated to reflect the emerging design and specification, the source and verification method.

2.3.2.2 At what stage of the procurement process are the criteria relevant?

First it has to be underlined that, to fully benefit from the use of recycled materials, good practice must be adopted at the earliest possible stage (preliminary scoping and feasibility), and targeted requirements on recycled content should be communicated between the contracting authority and contractor and passed down through the supply chain across all project phases.

The incorporation of the recycled content has been proposed as a Core award criterion and the incorporation of the recycled or reused content as a Comprehensive award criterion. These criteria have to be applied during the detailed design and performance requirements procurement phase. Moreover, recycled content

has to be verified during construction of the building or major renovation works procurement phase by means of a contract performance clause.

In detail, during detailed design and performance requirements procurement phase, the *Design team* or the *Design & Build tenderer* or the *DBO tenderer* shall quantify the proportional contribution of the recycled content to the overall value of the building elements and finishing elements. Moreover, the specific building elements and proposed products to be used shall also be specified within the detailed design. The ordering and delivery to site of these building elements shall later be verified during the construction of the building or major renovation works procurement phase by the main *construction contractor* or the *DBO contractor* by providing an independent third party certification of the chain of custody and mass balance for the product and/or recyclate *or* equivalent documentation provided by suppliers and processors.

The criteria classification, their reference numbers in the criteria document and the respective procurement phase can be cross-referenced as follows.

Title of the criterion	**Procurement phase**	**Criterion classification**	**Criteria typology**	**Reference number in the criteria document**
Incorporation of recycled content	B. Detailed design and performance requirements	Core and Comprehensive	Award criterion	B10.2
Monitoring the recycled content	D. Construction of the building or major renovation works	Core and Comprehensive	Contract performance clauses	D7.

2.3.3 Timber

2.3.3.1 Responsible sourcing of timber construction materials

2.3.3.1.1 Background technical discussion and rationale

Timber construction materials are renewable raw materials of which the continued availability should be preserved to ensure a sustainable future supply and to protect the important role of forests as biological systems and habitats. The importance of ensuring that the wood and wood-based materials used in the construction and renovation of buildings are sourced from legal and sustainable sources is a policy objective at international and EU level. Moreover, there is significant experience in Member States and within the timber and construction industries in sourcing according to the sustainable forestry criteria of established private certification schemes.

Legally sourced timber

The Timber Regulation (EC) 995/2010 [115] introduced new requirements for the sourcing of timber products from 2013. It prohibits illegally harvested timber from being placed on the EU market and introduces requirements for 'due diligence', which it defines as comprising:

> *(a) measures and procedures providing access to the [origin of] the operator's supply of timber or timber products placed on the market;*
>
> *(b) risk assessment procedures enabling the operator to analyse and evaluate the risk of illegally harvested timber or timber products derived from such timber being placed on the market.*
>
> *(c) except where the risk identified in course of the risk assessment procedures referred to in point (b) is negligible, risk mitigation procedures which consist of a set of measures and procedures that are adequate and proportionate to minimise effectively that risk and which may include requiring additional information or documents and/or requiring third party verification.*

The Regulation defines legally harvested as wood and wood-based materials (excluding packaging and recycled wood) that has been '*harvested in accordance with the applicable legislation in the country of*

115 Regulation (EU) No 995/2010 of the European Parliament and of the Council of 20 October 2010 laying down the obligations of operators who place timber and timber products on the market

harvest'. "Applicable legislation" means the legislation in force in the country of harvest covering the following matters:

- Rights to harvest timber within legally gazetted boundaries;
- Payments for harvest rights and timber including duties related to timber harvesting;
- Timber harvesting, including environmental and forest legislation including forest management and biodiversity conservation, where directly related to timber harvesting;
- Third parties' legal rights concerning use and tenure that are affected by timber harvesting; and
- Trade and customs, in so far as the forest sector is concerned.

Valid EU FLEGT and UN CITES licenses are deemed to provide assurance of legality. Europe is in the process of introducing the FLEGT (Forest Law Enforcement Governance and Trade) licensing scheme. FLEGT is based on bilateral agreements between the EU and timber producing countries. Third party forest and forest products certification systems that meet the due diligence criteria set out in Article 6 of the Regulation can be used as a valuable tool in the due diligence system.

Despite the obligations from the Timber Regulation, there is still a risk that timber provided under a public contract may come from non-legal sources. This can pose a major reputational risk for the contracting authority. Public authorities, which wish to have a higher degree of reassurance that the timber is actually legally sourced, can include a selection criterion regarding the technical ability of the tenderer to ensure compliance with the obligations from the EU Timber Regulation, combined with a contract performance clause requiring that the timber supplied under the contract has been legally placed on the market.

Sustainably Sourced timber

Further investigation of the basis for both European sustainable forestry policy [116] and certification schemes for sustainable forestry [117] confirms their basis in the UNEP and FAO principles of Sustainable Forestry Management (SFM) established at the Rio Earth Summit in 1992 [118]. These principles, although not defined in specific detail in UNEP or FAO literature, provide an internationally agreed reference point which is used by certification schemes. The conformance of schemes with ISO/IEC 17065 is also a consideration in relation to the quality and assurance provided by the verification systems used [119].

In terms of market share the two most significant certification schemes are those operated by the Forestry Stewardship Council (FSC) [120] and the Programme for the Endorsement of Forestry Certification (PEFC)[121]. FSC is an NGO-initiated scheme which was formally established following the Rio Earth Summit 1992. The PEFC scheme is industry-led scheme and now incorporates the Sustainable Forestry Initiative (SFI), the Malaysian Timber Certification Council (MTCC) and American Tree Farm System (ATFS) [122].

In 2009 these schemes accounted for 9% of global forestry and 26% of industrial timber supplies[123]. PEFC is the most significant scheme, accounting for over two thirds of certified timber on the world market. The majority (over 90%) of certified timber originates from Europe and North America.

Belgium[124], Denmark, Germany[125], the UK[126] and the Netherlands[127] are notable for their detailed monitoring and evaluation of forestry certification schemes in support of Green Public Procurement (GPP) [128]. These

116 European Commission, *EU forests and forest related products*, http://ec.europa.eu/environment/forests/home_en.htm

117 Rametsteiner, E and M, Simula, *Forest certification—an instrument to promote sustainable forest management?* Journal of Environmental Management 67 (2003) 87–98

118 Castaneda, F. *Criteria and indicators for sustainable forestry management*. UN FAO, http://www.fao.org/docrep/x8080e/x8080e06.htm#TopOfPage

119 ISO/IEC 17065: 2012, Conformity assessment – requirements for bodies certifying products, processes or services.

120 Programme for the Endorsement of Forestry Certification, http://www.pefc.org/

121 Forestry Stewardship Council, http://www.fsc.org/

123 UNECE and FAO (2010) *Forest products annual market review 2009-2010*

123 UNECE and FAO (2010) *Forest products annual market review 2009-2010*

124 UK Central Point of Expertise on Timber, *Government procurement of timber in Belgium*, http://www.cpet.org.uk/uk-government-timber-procurement-policy/international-context/international-policies-1/belgium

125 Germany Government Procurement Policy, *Wood and paper based products*, http://www.sustainableforestprods.org/tools/german_government_procurement_policy

126 UK Central Point of Expertise on Timber (2008) *Review of forestry certification schemes results*,

127 Timber Procurement Assessment Committee, Netherlands, http://www.tpac.smk.nl/

Member States use their own adapted criteria and processes to determine whether certification schemes provide sufficient assurance. The current consensus of these Member States is that, in general, FSC and PEFC provide sufficient levels of assurance based on their national criteria. Denmark, Germany, the Netherlands and the UK are currently working together to identify the common ground of their respective timber procurement policies.

Whilst the proportion of forestry covered by these certification schemes market is still relatively low they are considered by the FAO and independent research to have played an important role in influencing forestry practices and in raising awareness of the threat to global forests[129]. However, it has also been highlighted by the UNEP, the FAO and by European Commission policy that in countries where there is poor governance and limited enforcement of forestry protection compliance with these schemes can be challenging [130].

Although certified sustainable wood is widely available, supply chain development may be required to build relationships with alternative suppliers in some countries. Anecdotal evidence from the construction industry in Member States such as the UK and Germany does, however, suggest that there are no general difficulties in obtaining supplies on major projects.

Sustainable certified wood may carry a modest price premium due to both the added cost of wood producers needing to pay for independent audits and the general willingness for customers to pay a premium for final products made with certified sustainable wood. A report by CBI Ministry of Foreign Affairs stated that a general price premium of 10-30% existed for FSC-certified wood imported to the Netherlands[131]. However, in general there is no clear evidence as to whether or not certified sustainable wood is more expensive than non-certified wood across the EU.

Although 100% certified sustainable wood is desirable, it could be difficult to achieve due to possible fluctuations in market demand, particularly for SMEs that are accustomed to working with a limited number of suppliers. Instead, it is considered more appropriate to require a minimum of 25% sustainable wood should be easily achievable while more ambitious public authorities could set a minimum requirement of 70%, with a recommendation to seek feedback from the market prior to publishing the ITT.

As mentioned above, several Member States use their own criteria to define sustainable management of forests and have different processes in place to determine whether certification schemes provide sufficient assurance. Work between leading Member States is under way to identify common ground. In this situation, it was not possible, within the framework of this criteria development process, to provide a harmonised definition of sustainable managed forestry. Once the work of the above-mentioned Member States is finalised, the Commission will evaluate the results and decide on possible steps to be taken.

2.3.3.1.2 Revised criteria proposal

Core criteria	**Comprehensive criteria**
SELECTION CRITERIA	
D1. Legal sourcing of timber by the lead construction contractor Tenderers must demonstrate their technical capacity to comply with the requirements of Regulation (EU) 995/2010 (EU Timber Regulation) in the supply of timber or timber products required under this contract, namely to demonstrate that such products are placed legally on the EU market. **Verification:** Technical capacity in this regard may be demonstrated	**D1. Legal sourcing by the lead construction contractor** Tenderers must demonstrate their technical capacity to comply with the requirements of Regulation (EU) 995/2010 (EU Timber Regulation) in the supply of timber or timber products required under this contract, namely to demonstrate that such products are placed legally on the EU market. **Verification:** Technical capacity in this regard may be demonstrated by showing that the tenderer, or the operator supplying the timber if this is not the tenderer, has in place a due diligence system in accordance with Article 6 of the EU Timber

128 UK Central Point of Expertise on Timber (2008)*A comparative study of the national criteria for 'legal and 'sustainable' timber and assessment of certification schemes in Denmark, UK, Netherlands and Belgium* http://www.cpet.org.uk/uk-government-timber-procurement-policy/international-context/international-policies-1/comparative-study-of-danish-uk-dutch-and-belgium-national-criteria

129 UNECE and FAO (2010) *Forest products annual market review 2009-2010* see also Rametsteiner, E and M, Simula, *Forest certification—an instrument to promote sustainable forest management?* Journal of Environmental Management 67 (2003) 87–98

130 UNECE, FAO and UNFF (2009) *Vital forest graphics*

131 CBI report, accessed online at: http://www.cbi.eu/system/files/marketintel/FSC-certified_tropical_timber_garden_furniture_in_The_Netherlands.pdf

by showing that the tenderer, or the operator supplying the timber if this is not the tenderer, has in place a due diligence system in accordance with Article 6 of the EU Timber Regulation. Where tenderers are Traders within the meaning of the Regulation they must also provide information regarding their technical capacity to demonstrate traceability of timber in accordance with Article 5.	Regulation. Where tenderers are Traders within the meaning of the Regulation they must also provide information regarding their technical capacity to demonstrate traceability of timber in accordance with Article 5.
CONTRACT PERFORMANCE CLAUSE	
D7. Legal sourcing of timber All timber or timber products supplied under the contract must have been placed legally on the EU market in accordance with Regulation (EU) 995/2010 (EU Timber Regulation.) In order to demonstrate compliance with the EU Timber Regulation, the lead contractor shall be required to provide the following information in respect of timber or timber products provided under the contract: • A description of each type of timber used, including the trade name, type of product, the common name of tree species and, where applicable, its full scientific name; • Name and address of the trader who supplied the timber and timber products; • The country of harvest, and where applicable: (i) Sub-national region where the timber was harvested; (ii) Concession of harvest; (iii) Quantity (expressed in volume, weight or number of units); • Name and address of the supplier to the operator (trader); • Documents or other information indicating compliance of those timber products with the applicable legislation; • Evidence of the risk assessment and mitigation procedures put in place in accordance with Article 6(1) (b) and (c) of Regulation (EU) 995 of 2010 Valid EU FLEGT or UN CITES licenses and/or third party certification of due diligence according to Regulation (EU) No 995/2010 shall be accepted as evidence of legal harvesting and sourcing.	**D7. Legal sourcing of timber** All timber or timber products supplied under the contract must have been placed legally on the EU market in accordance with Regulation (EU) 995/2010 (EU Timber Regulation.) In order to demonstrate compliance with the EU Timber Regulation, the lead contractor shall be required to provide the following information in respect of timber or timber products provided under the contract: • A description of each type of timber used, including the trade name, type of product, the common name of tree species and, where applicable, its full scientific name; • Name and address of the trader who supplied the timber and timber products; • The country of harvest, and where applicable: (i) Sub-national region where the timber was harvested; (ii) Concession of harvest; (iii) Quantity (expressed in volume, weight or number of units); • Name and address of the supplier to the operator (trader); • Documents or other information indicating compliance of those timber products with the applicable legislation; • Evidence of the risk assessment and mitigation procedures put in place in accordance with Article 6(1) (b) and (c) of Regulation (EU) 995 of 2010 Valid EU FLEGT or UN CITES licenses and/or third party certification of due diligence according to Regulation (EU) No 995/2010 shall be accepted as evidence of legal harvesting and sourcing.

Sustainable Sourcing of Timber

These GPP criteria do not include a proposal on the sourcing of timber from sustainable forestry, for the following reasons:

Several Member States are using their own criteria to define sustainable management of forests and have different processes in place to determine whether certification schemes provide sufficient assurance. Work between leading Member States (Belgium, Denmark, Germany , the UK and the Netherlands) is under way to identify common ground. In this situation, it was not possible, within the framework of this criteria development process, to provide a harmonised definition of sustainable managed forestry. Once the work of the above-mentioned Member States is finalised, the Commission will evaluate the results and decide on possible steps to be taken.

The current consensus of the above-mentioned Member States is that, in general, FSC and PEFC provide sufficient levels of assurance for compliance with their national criteria. Although 100% certified sustainable wood is desirable, it could

be difficult to achieve due to possible fluctuations in market demand, particularly for SMEs that are accustomed to working with a limited number of suppliers. Instead, a minimum of 25% sustainable wood should be easily achievable while more ambitious public authorities could set a minimum requirement of 70%, with a recommendation to seek feedback from the market prior to publishing the ITT.

Note to contracting authorities on the legal sourcing of timber:

Suitable remedies should be provided under the contract for cases of non-compliance with the above clause. Advice on the application of these requirements, and the monitoring organisations able to verify compliance, may be obtained from the competent national authorities listed at:
http://ec.europa.eu/environment/forests/pdf/list_competent_authorities_eutr.pdf

Summary of the rationale:

- The high profile of public construction projects suggests that it is important that the origin of timber used for construction is legal and sustainable. Moreover, this shall be traceable and verifiable to provide a high level of assurance.
- Timber placed on the EU market must now be from legal sources. It is proposed that for all Office Building projects contractors shall provide documentary evidence of due diligence to verify legal sourcing.
- Both a specific Selection criterion and a Contract Performance Clause are proposed in order to provide contracting authorities with additional assurance and risk management that timber is sourced legally.
- For the moment, in view of the differences in national approaches to sustainable timber procurement and the on-going work aiming at identifying the communalities between different schemes, no definitions or proposed criterion addressing the sustainability of timber is proposed within this criteria set,.

2.3.3.2 At what stage of the procurement process are the criteria relevant?

It is important that tenderers for the construction contract for construction of the building and major renovation works identify where wood is to be used in the building, the type and quantity of wood and how the legality of the wood will be ensured. This will ensure that tenderers that have developed their supply chain for responsibly sourced wood are encouraged to bid.

As construction proceeds, it is then important that the main construction contractor collates evidence that the wood brought onto site is responsibly sourced, as this has been a point of weakness in some high profile public building contracts. The contractor shall submit independently certified chain of custody certificates for wood purchases demonstrating that it is sustainably sourced. The criteria classification, their reference numbers in the criteria document and the respective procurement phase can be cross-referenced as follows.

Title of the criterion	Procurement phase	Criterion classification	Criteria typology	Reference number in the criteria document
Legal sourcing of timber by the lead construction contractor	D. Construction of the building or major renovation works	Core and Comprehensive	Selection	D2.
Legal sourcing of timber	D. Construction of the building or major renovation works	Core and Comprehensive	Contract Performance Clause	D3.

2.3.4 Waste management plan

Raw materials for the building sector are extracted, processed, transported, used in the construction phase and finally disposed. All these stages imply a range of environmental impacts, which are significant due to the substantial amount of materials involved. Moreover, the environmental impacts of the end-of-life phase due to the landfilling of construction and demolition waste (C&DW) derive from the large use of land and the lifetime of the landfill.

Although LCA studies on office buildings across Europe show that the influence of the end-of-life phase cannot be considered as significant from a life cycle perspective, the relative importance of different scenarios was investigated in the JRC IPTS draft preliminary report[132]. In one scenario 100% of the waste was landfilled, while in another high recycling rates were considered, with a recycling potential up to 90% for materials as concrete, bricks and steel (representing the 83% of the total weight of the building) and a 95% rate of efficiency for recycling processes.

The difference in the overall environmental impacts between the two above mentioned scenarios was around 2%., taking into consideration the whole life cycle of the building. However, keeping in mind the continued reduction of energy consumption by new buildings, other life cycle phases such as construction resource efficiency will gain more importance and therefore, the relative importance of recycling and re-use is expected to be greater in future. A recent assessment of scenarios and options for resource efficiency for the European Resource Efficiency Platform of the Commission [133] highlighted the importance of:

- Recycling concrete instead of landfilling,
- The use of recycled construction and demolition waste, and
- A reduction in the amount of waste from construction.

It has to be considered that the characteristics of waste produced during the construction phase is significantly different compared to the waste produced during the demolition (end of life) phase. At the demolition phase, which can comprise both the demolition of existing buildings that may be on site and the End-of-Life demolition of the new building, significant amounts of mixed waste, including C&DW and dismantled equipment, are produced through standard demolition practices. Segregated streams of waste can be produced by means of more sophisticated and costly selective demolition practices, which should be planned from the initial design phase. During the construction phase, the waste streams are easily segregated and consist mainly of separated streams of concrete, metals, gypsum, timber, packaging, paints.

These waste management and reuse, recycling and recovery activities differ notably depending on the type of waste to be dealt with and may be carried out by different contractors. It therefore appears advisable to differentiate the GPP criteria between site waste management during the construction phase, and demolition waste management prior to commencement on site and at the end of the building life. Different scenarios have to be taken into consideration for the development of the GPP criteria in this area:

- the total or partial demolition of an existing building, aimed in the first case at creating a site for a new building and in the second case the renovation of an existing building. In these cases, the management of demolition waste has to be planned at an early stage including project-specific targets for total waste arisings to be checked during a pre-demolition/strip-out audit;
- the construction phase during which waste produced should be managed by means of planning, monitoring and implementing measures
- the total or partial demolition of the constructed building at the end of its lifetime. This scenario could be similar to the first one, but in a different time frame.

With reference to a possible chronological sequence of practices, firstly a criterion would address demolition waste management (to be applied both to the demolition of an existing building and the future demolition of the constructed building) followed by a criterion addressing site waste management.

132 JRC IPTS Draft Preliminary Study (2011): http://susproc.jrc.ec.europa.eu/buildings/docs/Draft%20Report%20Task%203.pdf

133 European Commission (2014) *Assessment of scenarios and options towards a resource efficient Europe: An analysis for the European built environment*.

2.3.4.1 Demolition waste audit and management plan

2.3.4.1.1 Background technical discussion and rationale

The importance of waste management is reflected in the development of the Waste Framework Directive[134]. Article 11.2 is of particular relevance to the building sector, stating that:

> *(b) by 2020, the preparing for re-use, recycling and other material recovery, including backfilling operations using waste to substitute other materials, of non-hazardous construction and demolition waste* (C&DW) *excluding naturally occurring material defined in category 17 05 04 in the list of waste shall be increased to a minimum of 70 % by weight.*

C&DW has been identified as a priority waste stream by the European Union because there is a high potential for recycling and re-use of this waste type. The potential is assessed to be large due to the existing level of recycling and re-use of C&DW, which varies greatly (between less than 10% and over 90%) in the Member States (PE EC DG-ENV, 2013)[135]. BIOIS, EC (2011) has reported an average recycling percentage of 46% across the EU[136].

According to WRAP's Guidance on procurement requirements for reducing waste and using resources efficiently[137], it is recommended that a Demolition Waste Management Plan is developed from an early stage including project-specific targets for total waste arisings and the amount of waste sent to landfill. The purpose of the waste management plan is to ensure, firstly, a reduction of the C&DW generation and, secondly, a suitable treatment of the unavoidable C&DW generated to ensure that it causes the lowest environmental impact. Deconstruction at the end of the building's life may often be a limited opportunity if the building/infrastructure was not designed for deconstruction[138].

According to both the scientific literature and experience from Member States, a pre-demolition/strip-out audit allows for identification of the key building and infrastructure materials, which will arise from demolition and excavation works. The typical information provided by the audit comprises:

- Identification and risk assessment of hazardous waste that may require specialist handling and treatment, or emissions that may arise during demolition;
- A Demolition Bill of Quantities with a breakdown of different building materials and products,
- An estimate of the % re-use and recycling potential based on proposals for systems of separate collection during the demolition process,
- An estimation of the % potential for other forms of recovery from the demolition process,

In addition, reclamation of fit-out items, systems and servicing equipment from the building could imply an income or at least cost-neutral opportunity.

A review of fifteen published studies by Mália et al (2013) determined that the average composition of C&DW waste consists mainly of concrete, ceramic and timber materials [139]. For a new-build re-inforced concrete framed building an estimate is made of waste arisings from demolition of between 742 and 1637 kg m^{-2}. For a new-build non-residential building there is an estimated range of waste arisings from the demolition of a concrete framed building of between 742 and 1637 kg m^{-2} and for a masonry building of between 664 and 825 kg m^{-2}. Based on a review of eleven published studies of non-residential refurbishment a range was determined of between 20 and 326 kg m^{-2}.

Excavation and backfilling operations are not to be taken into consideration in the best practices described within the EC EMAS Reference Document on Best Environmental Management Practice in the building and

134 Waste Framework Directive (WFD) 2008/98/EC: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:312:0003:0030:en:PDF

135 PE EC DG-ENV (2013). Assessment of Scenarios and Options towards a Resource Efficient Europe. Topical Paper 4: Validation of technical improvement options for resource efficiency of buildings and infrastructure: http://ec.europa.eu/environment/enveco/resource_efficiency/pdf/TP4.pdf

136 BIOIS, EC (2011). Service Contract on Management of Construction and Demolition Waste – SR1. Final Report Task 2: http://ec.europa.eu/environment/waste/pdf/2011_CDW_Report.pdf

137 WRAP Guidance Procurement requirements for reducing waste and using resources efficiently: http://www.wrap.org.uk/sites/files/wrap/WRAP%20Construction%20Guide%20_FINAL.pdf

138 ICE Demolition Protocol (2008): http://www.ice.org.uk/getattachment/eb09d18a-cb12-4a27-a54a-651ec31705f1/Demolition-Protocol-2008.aspx

139 Mália.M, de Brito.J, Pinheiro.M.D and M,Bravo, *Construction and demolition waste indicators*, Wsste Management & Research, 31(3) p-241-255

construction sector[140]. This is supported by ENCORD's construction waste measurement protocol which recommends recording separately construction, demolition and excavation waste arisings [141]. Excluding excavation and backfilling from the data provided in several references including BIOIS, EC 2011[142], WRAP Guidance Procurement requirements for reducing waste and using resources efficient[143] and the ICE Demolition Protocol[144], the following non-hazardous waste generated during demolition and strip-out works are suggested to be prepared for re-use, recycling and other forms of material recovery:

- Timber, glass, metal, brick, stone, ceramic and concrete materials recovered from the main building structures;
- Fit-out and non-structural elements, to include doors and their frames, flooring, ceiling tiles, gypsum panels, plastic profiles, insulation materials window frames, window glass, bricks, concrete in the form of blocks and precast elements, steel rebars.

According to WRAP's Guidance and the ICE Demolition Protocol[145], a specific target of at least 80% of demolition, strip-out and excavation materials to be reused, recycled and recovered can be determined. This reflects a higher band of best practice in some Member States as identified by BIOIS, EC (2011). ENCODE, whose members include a range of EU construction companies, propose 'diversion rates' of 80% for segregated waste sent off site, 100% for segregated waste which is classified as end-of-waste under the Waste Framework Directive and 50% for inert soil and stones that will be put to beneficial use (e.g. backfilling and restoration) [141].

Because of the proposed exclusion of excavation waste and backfilling in order to avoid downcycling and to stimulate further improvements in the resource efficiency of the construction sector, a reduction of the specific target to a minimum of 55% by weight can be proposed as Core GPP criterion, reflecting the lower end band of best practice identified by BIOIS, EC (2011). The specific target of at least 80% by weight could still be proposed as a Comprehensive GPP criterion, but potentially only for use in those Member States where this represents best practice and for materials to be prepared for re-use and recycling rather than recovery, in order to stimulate innovations in line with the WFD hierarchy[146].

2.3.4.1.2 Revised criteria proposal

Core criteria	**Comprehensive criteria**
TECHNICAL SPECIFICATIONS	
C1. Demolition waste audit and management plan A minimum of 55% by weight of the non-hazardous waste generated during demolition and strip-out works, and excluding excavations and backfilling, shall be prepared for re-use, recycling and other forms of material recovery. This shall include: (i) Timber, glass, metal, brick, stone, ceramic and concrete materials recovered from the main building structures; (ii) Fit-out and non-structural elements, to include doors and their frames, flooring, ceiling tiles, gypsum panels, plastic profiles, insulation materials window frames, window glass, bricks, concrete in the form of blocks and precast	**C1. Demolition waste audit and management plan** A minimum of 80% by weight of the non-hazardous waste generated during demolition and strip-out works, and excluding excavations and backfilling, shall be prepared for re-use, recycling. This shall include: (i) Timber, glass, metal, brick, ceramics and concrete materials recovered from the main building structures, (ii) Fit-out and non-structural elements, to include doors and their frames, flooring, ceiling tiles, gypsum panels, plastic profiles, insulation materials window frames, window glass, bricks, concrete in the form of blocks and precast elements, steel rebars.

140 EC Reference Document on Best Environmental Management Practice in the building and construction sector (2012): http://susproc.jrc.ec.europa.eu/activities/emas/documents/ConstructionSector.pdf

141 ENCORD, *Construction waste measurement protocol*, Version 1.0, May 2013

142 BIOIS, EC (2011). Service Contract on Management of Construction and Demolition Waste – SR1. Final Report Task 2. Available online at http://ec.europa.eu/environment/waste/pdf/2011_CDW_Report.pdf

143 WRAP Guidance Procurement requirements for reducing waste and using resources efficiently: http://www.wrap.org.uk/sites/files/wrap/WRAP%20Construction%20Guide%20_FINAL.pdf

144 ICE Demolition Protocol (2008): http://www.ice.org.uk/getattachment/eb09d18a-cb12-4a27-a54a-651ec31705f1/Demolition-Protocol-2008.aspx

145 ICE Demolition Protocol (2008): http://www.ice.org.uk/getattachment/eb09d18a-cb12-4a27-a54a-651ec31705f1/Demolition-Protocol-2008.aspx

146 Waste Framework Directive (WFD) 2008/98/EC: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:312:0003:0030:en:PDF

elements, steel rebars. The contractor shall carry out a pre-demolition/strip-out audit in order to determine what can be re-used, recycled or recovered. This shall comprise: (i) Identification and risk assessment of hazardous waste that may require specialist handling and treatment, or emissions that may arise during demolition; (ii) A bill of quantities with a breakdown of different building materials and products, (iii) An estimate of the % re-use and recycling potential based on proposals for systems of separate collection during the demolition process, The materials, products and elements identified shall be itemised in a Demolition Bill of Quantities. **Verification:** The lead construction contractor, Design & Build contractor *or* DBO contractor shall submit a pre-demolition/strip-out audit that contains the specified information. A system shall be used to monitor and account for waste arisings. The destination of consignments of waste and end-of-waste materials shall be tracked using consignment notes and invoices. Monitoring data shall be provided to the contracting authority.	The contractor shall carry out a pre-demolition/strip-out audit in order to determine what can be re-used, recycled. This shall comprise: (i) Identification and risk assessment of hazardous waste that may require specialist handling or treatment, or emissions that may arise during demolition; (ii) A bill of quantities with a breakdown of the different constituent building materials and products, (iii) An estimate of the % re-use and recycling potential based on proposals for systems of separate collection during the demolition process, The materials, products and elements identified shall be itemised in a Demolition Bill of Quantities. **Verification:** The lead construction contractor, Design & Build contractor *or* DBO contractor shall submit a pre-demolition/strip-out audit that contains the specified information. A system shall be used to monitor and account for waste arisings. The destination of consignments of waste and end-of-waste materials shall be tracked using consignment notes and invoices. Monitoring data shall be provided to the contracting authority.

<u>*Summary rationale:*</u>

- The importance of waste management is reflected in the development of the Waste Framework Directive, in which C&DW has been identified as a priority waste stream because there is a high potential for recycling and re-use of this waste type. An average recycling percentage of 46% of recycling and re-use of C&DW across the EU could be reported (with a great variation among the Member States, between less than 10% and over 90%). Two distinct bands of best practice can be identified, dependent on the development of infrastructure to support better waste management.
- A Demolition Waste Management Plan can be developed from an early stage including project-specific targets for total waste arisings and the amount of waste sent to landfill. Moreover, a pre-demolition/strip-out audit allows identifying the key building and infrastructure materials, which will arise from demolition and excavation works. The typical information provided are the identification and risk assessment of hazardous waste, a demolition bill of quantities with a breakdown of different building materials and products, an estimation of the % re-use and recycling potential from the demolition process.
- In literature, a target of at least 80% of demolition, strip-out and excavation materials to be reused, recycled and recovered have been identified.
- Backfilling operations cannot be taken into consideration as best practices in the building and construction sector.
- Other non-hazardous demolition waste such as timber, glass, metal, brick, stone, ceramic and concrete materials and fit-out and non-structural elements has to be considered for setting specific benchmarks on re-use, recycling or other form of recovery. In detail, considering the above mentioned materials, the following benchmarks are proposed:
    - a minimum of 55% by weight as technical specification for the Core criteria;
    - a minimum of 80% by weight as technical specification for the Comprehensive criteria. In this case, it is recommended to not consider recovery activities, in order to stimulate innovations in line with the WFD hierarchy.

2.3.4.2 Site waste management plan

2.3.4.2.1 Background technical discussion and rationale

According to Osmani et al., 2008 [147], on average 33 % of waste generation from a construction site is the responsibility of a failure to implement waste prevention measures during both the design and preliminary construction phases. Reporting on findings from a survey of projects in the Netherlands, Bossink and Brouwers (1996) reported that on average 9% by weight of purchased construction materials leaves a site as waste [148]. Significant contributors by weight included stone cladding (29%), piles (17%), concrete (13%), mortar (8%), packaging (7%) and bricks (3%). Additional causal factors highlighted included ordering errors during procurement, damage during materials handling and on-site operational practices.

A review of twenty-three published studies by Mália et al (2013) determined that for a new-build re-inforced concrete framed non-residential building the site waste arisings could be within a range of 48 and 135 kg m^{-2}. Concrete and brick generally accounted for approximately 70% of the overall waste volume generated. For all the types of non-residential building structure sampled there was a range of 12 to 135 kg m^{-2} with a median of approximately 50 kg m^{-2} [139].

A site waste management plan (SWMP) is a commonly cited and widely practiced approach used in the construction industry to plan, monitor and implement actions to manage waste during construction. Such a plan is prepared prior to the commencement of work on-site. A site waste management plan usually consists of:

- A bill of materials ordered with estimates for waste arisings based on good practices, and the potential for waste prevention based on good practice,
- Estimates of the % re-use potential based on the use of segregated collection systems during the construction process,
- An estimation of the % recycling and recovery potential based on the use of segregated collection systems.

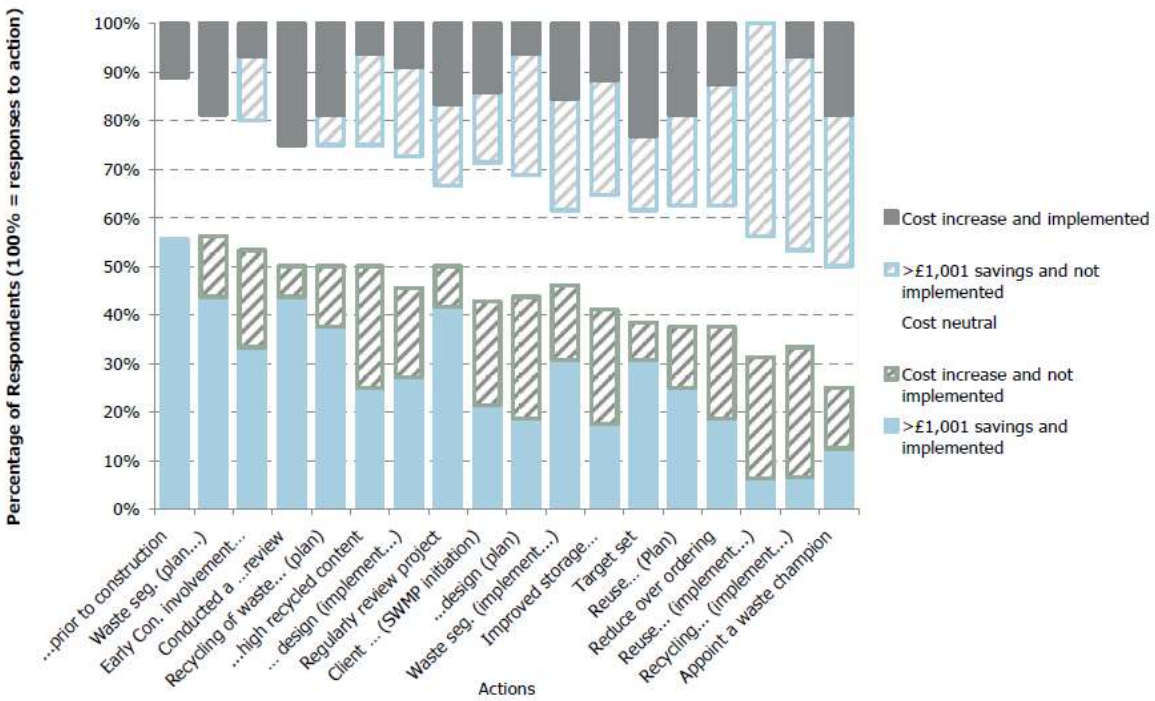
The UK provides access to extensive data and feedback from the implementation of SWMP's, having supported a number of best practice initiatives and enacted a legislative requirement between 2008 and 2013. In UK organisation WRAP's Site Waste Management Plans impacts survey 2009[149], the results are presented of a stakeholders consultation on site waste management plans sent to over 800 contractors and clients in UK. The survey aim was to identify the environmental and economic costs and benefits generated by using a SWMP to implement good practice. It has been highlighted that, if a SWMP is used properly, there can be significant benefits in terms of economic savings and project planning. The top actions identified in the SWMP were the prevention of waste through better design, waste segregation, recycling of waste produced and re-use of materials on site..Figure 2.13 provides an indication of how actions were implemented by 19 completed projects considered within the survey.

In detail, Figure 2.13 shows if these actions have achieved significant cost reductions, were cost-neutral or have resulted in cost increases. This Figure shows the percentage of projects that implemented (full colour) or did not implement actions (diagonal line) and how the SWMP affected the costs (blue: reduce, grey: increase). Starting the SWMP prior to construction, waste segregation at the planning stage and early contractor involvement were the top three actions that were implemented by cost saving projects and not implemented by increased cost projects. This would suggest that these actions, if implemented, are likely to help to reduce costs.

147 Osmani, M., Glass, J., Price, A.D.F., 2008. Architects' perspectives on construction waste reduction by design. Waste Management 28, 1147-1158

148 Bossink,B.A.G and H.J.H.Brouwers, *Construction waste: Quantification and source evaluation*, Journal of Construction Engineering and Management, March 1996

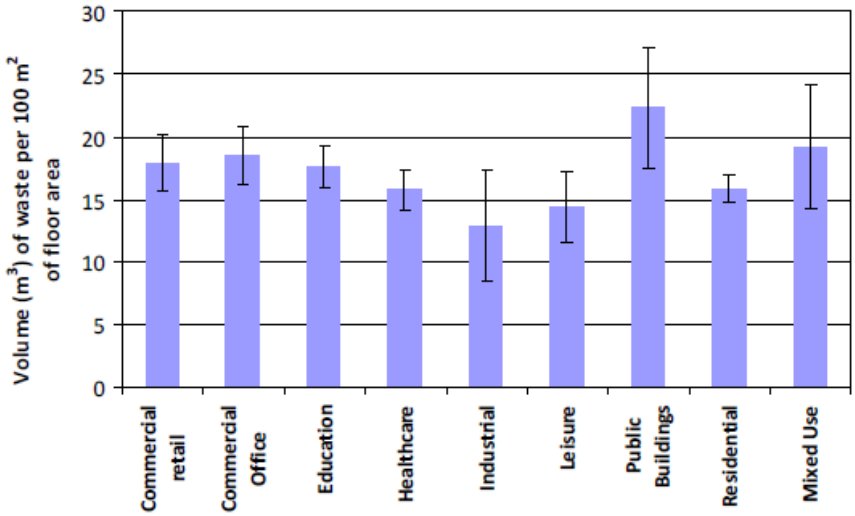
149 WRAP 2009: Site Waste Management Plans impacts survey 2009: http://www.wrapni.org.uk/sites/files/wrap/SWMP%20Impacts%20Survey%20Final%20Report.pdf



Source: WRAP (2009)

Figure 2.13. Elements of good practice (based on 19 completed projects)

In the EC EMAS Reference Document on Best Environmental Management Practice in the building and construction sector[150], waste generation at 603 construction sites between 2004 and 2010 for different building types is reference from the UK Construction Resources and Waste Platform, 2009[151]. As reported in Figure 2.14, average values are around 15 – 20 m^3 of waste per 100 m^2 (around 10 – 15 t/100 m^2). Figure 2.15 shows different waste typologies for different types of buildings. As observed, there are four main fractions of waste: bricks, concrete, mixed waste and inert fraction. The rest is composed of timber, packaging waste, metals and other minor quantities of other materials.

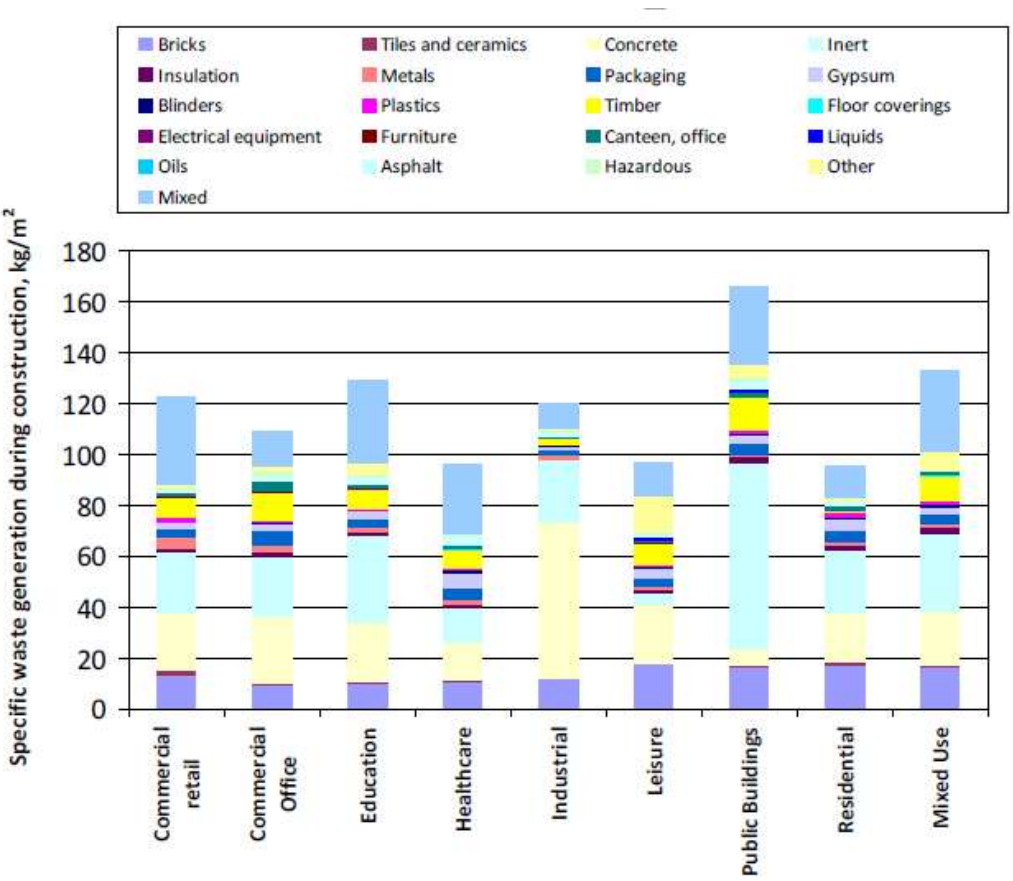


Source: CRWP (2010)

Figure 2.14. Waste generation during construction for different types of buildings

150 EC Reference Document on Best Environmental Management Practice in the building and construction sector (2012): http://susproc.jrc.ec.europa.eu/activities/emas/documents/ConstructionSector.pdf

151 Construction Resources and Waste Platform, 2010. Benchmarks and Baselines 2009. Report, available at www.wrap.org.uk



Source: CRWP (2010) and European Commission (2012)

Figure 2.15. Waste generation per type during construction of different types of buildings (in volume and mass units)

The survey data referred to previously had been used as a reference for the BREEAM 2011 building assessment system for offices. The data captured using the SMARTWaste system[152] has been used to set benchmarks for resource efficiency in site waste management. As shown in Table 2.16, up to three credits could be assigned within the overall BREEAM assessment to non-hazardous construction waste generated by the building's design and construction if the resource efficiency benchmarks are met or exceeded. Demolition and excavation waste are excluded from this evaluation. It can be seen that 11 tonnes of generated waste represents a resource efficiency benchmark in the top 50% amongst projects and 6-7 tonnes in the top 25% of projects.

Table 2.16. Resource efficiency benchmarks set in BREEAM for waste generation [153]

BREEAM credits	Amount of waste generated per 100m² (gross internal floor area)		Suggested performance benchmarks
	m^3	tonnes	
One credit	≤ 13.3	≤ 11.1	in the top 50% of projects (better than standard practice)
Two credits	≤ 7.5	≤ 6.5	in the top 25% of projects (good practice)
Three credits	≤ 3.4	≤ 3.2	in the top 10% of projects (best practice)
Exemplary Level	≤ 1.6	≤ 1.9	in the top 5% of projects (exemplary practice)

Note - Volume (m^3) is actual volume of waste (not bulk volume)

152 www.smartwaste.co.uk

153 http://www.breeam.org/BREEAM2011SchemeDocument/content/10_waste/wst01.htm#Construction_waste_groups

In line with the above mentioned results, it is proposed that the site waste management plan (SWMP) shall establish systems for the separate collection of materials on-site for re-use, recycling and other forms of recovery and it shall encompass the following materials:

- Construction products that form main building elements, including timber, glass, metal, brick, ceramics, concrete and inert waste, as well as associated packaging materials.
- Construction products that form part of the building fit-out, including flooring, ceiling tiles, plaster and gypsum panels, plastic profiles and insulation materials, as well as associated packaging materials.

Moreover, with reference to literature results, the following performance requirements are proposed:

- Waste arisings during construction and renovation, and excluding demolition waste, shall be less than or equal to 11 tonnes per 100m^2 gross internal office floor area as Core criterion
- Waste arisings during construction and renovation, and excluding demolition waste, shall be less than or equal to 7 tonnes per 100m^2 gross internal office floor area as Comprehensive criterion.

The 25% and 50% performance benchmarks lie within the range reported by Mália et al (2013) for re-inforced concrete non-residential buildings. However, the 50% of performance benchmark is significantly higher than the reported median (5 tonnes per 100 m^2) for a wider range of construction systems, suggesting that further feedback and data is required from stakeholders to cross-check that these benchmarks are representative for other Member States.

2.3.4.2.2 Revised criteria proposal

Core criteria	**Comprehensive criteria**
TECHNICAL SPECIFICATIONS	
D3. Site waste management Waste arisings during construction and renovation, and excluding demolition waste, shall be less than or equal to 11 tonnes per 100m^2 gross internal office floor area. A site waste management plan shall be prepared prior to the commencement of work on-site. The plan shall establish systems for the separate collection of materials on-site for re-use, recycling and other forms of recovery. The site waste management plan shall encompass: (i) Construction products that form main building elements, including timber, glass, metal, brick, ceramics, concrete and inert waste, as well as associated packaging materials. (ii) Construction products that form part of the building fit-out, including flooring, ceiling tiles, plaster and gypsum panels, plastic profiles and insulation materials, as well as associated packaging materials. Separate material collection for re-use, recycling and recovery shall respect the waste hierarchy in Directive 2008/98/EC. **Verification:** The lead construction contractor, Design & Build contractor *or* DBO contractor shall submit a site waste management plan consisting of: (i) A bill of materials with estimates for waste arisings based on good practices, (ii) Estimates of the % re-use potential based on separate collection during the construction process, (iii) An estimation of the % recycling and recovery potential based on separate collection, A system shall be used to monitor and account for waste arisings and to track the destination of consignments of	**D3. Site waste management** Waste arisings during construction and renovation, and excluding demolition waste, shall be less than or equal to 7 tonnes per 100m^2 gross internal office floor area. A site waste management plan shall be prepared prior to the commencement of work on-site. The plan shall identify opportunities for waste prevention and shall establish systems for the separate collection of materials on-site for re-use, recycling and other forms of recovery. The site waste management plan shall encompass: (i) Construction products that form main building elements, including timber, glass, metal, brick, ceramics, concrete and inert waste, as well as associated packaging materials. (ii) Construction products that form part of the building fit-out, including flooring, ceiling tiles, plaster and gypsum panels, plastic profiles and insulation materials, as well as associated packaging materials. Separate material collection for re-use, recycling and recovery shall respect the waste hierarchy in Directive 2008/98/EC. **Verification:** The lead construction contractor, Design & Build contractor *or* DBO contractor shall submit a site waste management plan consisting of: (i) A bill of materials with estimates for waste arisings and the potential for waste prevention based on good practices, (ii) Estimates of the % re-use potential based on separate collection during the construction process, (iii) An estimation of the % recycling and recovery potential based on separate collection,

waste. Monitoring data shall be provided to the contracting authority.	A system shall be used to monitor and account for waste arisings and to track the destination of consignments of waste. Monitoring data shall be provided to the contracting authority.
CONTRACT PERFORMANCE CLAUSE	
D8. Site waste management Operation of the agreed site waste management plan shall be monitored and reported on during progress of construction work on-site. This shall include data accounting for the weight of materials collected by the separate collection of materials on-site for re-use and recycling according to the scope described in the technical specifications. **Verification:** A system shall be used to monitor and quantify waste arisings and materials segregated for recycling and re-use. It shall also track and verify the destination of consignments of waste. The monitoring and tracking data shall be provided to the contracting authority. on an agreed periodic basis.	**D8. Site waste management** Operation of the agreed site waste management plan shall be monitored and reported on during progress of construction work on-site. This shall include data accounting for the weight of materials collected by the separate collection of materials on-site for re-use and recycling according to the scope described in the technical specifications. **Verification:** A system shall be used to monitor and quantify waste arisings and materials segregated for recycling and re-use. It shall also track and verify the destination of consignments of waste. The monitoring and tracking data shall be provided to the contracting authority. on an agreed periodic basis.

Summary rationale:

- According to Osmani et al., 2008 [154], on average 33 % of waste generation in a construction site is the responsibility of a failure to implement waste prevention measures during both the design and preliminary construction phases. A site waste management plan (SWMP) has been identified as an important tool to enable the planning, monitoring and management of waste during construction. The SWMP includes a bill of materials with estimates for waste arisings and the potential for waste prevention based on good practices. Moreover, the SWMP includes the estimation of the % re-use potential based on separate collection during the construction process and of the % recycling and recovery potential based on separate collection. If properly used, the SWMP can bring significant benefits in terms of economic savings and project planning. Prevention of waste through better design, waste segregation, recycling of waste produced and re-use of materials on site are the top identified actions.
- Average values around 15-20 m^3 of waste per 100 m^2 (around 10-15 t/100 m^2) have been identified from literature. Moreover, in the BREEAM system, in which data from hundreds of real life projects are reflected, 11 tonnes represents a resource efficiency benchmark in the top 50% amongst projects and 6-7 tonnes in the top 25% of projects. Demolition and excavation waste are excluded from this evaluation.
- In conclusion, it is proposed that the SWMP shall establish systems for the separate collection of construction products that form part of the main building elements (including timber, glass, metal, brick, ceramics, concrete and inert waste, as well as associated packaging materials) and of the building fit-out (including flooring, ceiling tiles, plaster and gypsum panels, plastic profiles and insulation materials, as well as associated packaging materials).
- Moreover, the following performance requirements are proposed on waste arisings during construction and renovation, and excluding demolition waste,
  - less than or equal to 11 tonnes per 100m^2 gross internal office floor area as technical specification for Core criterion
  - less than or equal to 7 tonnes per 100m^2 gross internal office floor area as technical specification for Comprehensive criterion.

154 Osmani, M., Glass, J., Price, A.D.F., 2008. Architects' perspectives on construction waste reduction by design. Waste Management 28, 1147-1158

2.3.4.3 At what stage of the procurement process are the criteria relevant?

It has to be underlined that to fully benefit from waste reduction and recovery on a project, good practice must be adopted at the earliest possible stage (preliminary scoping and feasibility), and planned actions, metrics and targeted outcomes shall be communicated between the contracting authority and tenderers and passed down through the supply chain (including the design teams, subcontractors, waste management contractors and material suppliers) and across all project phases.

Waste management planning has been split into demolition waste management plan and site waste management plan, proposed both as technical specifications (both in Core and Comprehensive criteria). The criteria on the demolition waste management plan should be applied during the strip-out, demolition and site preparation works procurement phase, whilst the criteria on the site waste management plan should be applied during the construction of the building or major renovation works procurement phase.

With reference to the demolition waste management plan, the lead *construction contractor*, *Design & Build contractor or DBO contractor* shall carry out and submit a pre-demolition/strip-out audit that contains the specified information on what can be re-used, recycled (for Core and Comprehensive criteria) or recovered (only for Core criteria). With reference to the demolition waste management plan, the lead *construction contractor*, *Design & Build contractor or DBO contractor* shall submit the site waste management plan.

For both criteria, waste arisings shall be accounted for and monitored, including information on the transportation distances of waste and end-of-waste materials (only in the case of the demolition waste management plan) using consignment notes and invoices. Monitoring data shall be provided to the contracting authority.

The criteria classification, their reference numbers in the criteria document and the respective procurement phase can be cross-referenced as follows.

Title of the criterion	**Procurement phase**	**Criterion classification**	**Criteria typology**	**Reference number in the criteria document**
Demolition waste audit and management plan	C. Strip-out, demolition and site preparation works	Core and Comprehensive	Technical specifications	C1.
Commissioning of site waste management	D. Construction of the building or major renovation works	Core and Comprehensive	Technical specifications	D3.
Site waste management	D. Construction of the building or major renovation works	Core and Comprehensive	Contract performance clauses	D8.

2.4 Other environmental criteria

2.4.1 Space/design of facilities

2.4.1.1 Recyclable waste storage

2.4.1.1.1 Background technical discussion and rationale

In order to support the reuse, recycling and recovery of secondary materials during occupation of the building, dedicated storage space should be designed into the building, or within the curtilage of the building, to facilitate the segregation of recyclable materials and end-of-life products by occupiers. In this way, recyclable waste streams can be diverted from landfill or incineration. Most of the waste will consist of paper and carton, plastic, metal and glass.

According to BREEAM 2011[155], the dedicated storage space to cater for recyclable materials generated by the building during occupation should be:

- clearly labelled for recycling. Moreover, individual recycling bins located at convenient locations throughout the building are necessary to maximise recycling rates;
- placed within accessible reach of the building and
- in a location with good vehicular access to facilitate collections. Indeed, where the facilities are situated internally, vehicular gate heights/widths and manoeuvring and loading space must be sized correctly to ensure ease of access for vehicles collecting recyclable materials.

The size of the space allocated must be adequate to store the likely volume of recyclable materials generated by the building's occupants/operation For example, in BREEAM 2011 for New Construction, the following sizes are provided for office buildings:

- At least 2m^2 per 1000m^2 of net floor area for buildings <5000m^2
- A minimum of 10m^2 for buildings ≥5000 m^2
- An additional 2m^2 per 1000m^2 of net floor area where catering is provided (with an additional minimum of 10m^2 for buildings ≥5000m^2).

Moreover, the separation and storage of waste should be in compliance with the local waste collection scheme provided by the local municipality or privately contracted service.

The French building assessment scheme HQE makes specific reference in its criteria to 'activity waste management' services to be provided upon occupation of the building and to the sizing of rooms or areas for storage. Credits can be awarded for:

- Making links to existing recycling channels that will achieve 50% or 100% waste recycling;
- Providing organic waste recycling, including the potential for on-site recycling units;
- Adequete sizing of waste storage areas and 'optimised operational flows'.

2.4.1.1.2 Revised criteria proposal

Core criteria	**Comprehensive criteria**
TECHNICAL SPECIFICATION	
B5. Recyclable waste storage Dedicated storage space shall be provided within the building, or within the curtilage of the building, to facilitate the segregation of recyclable materials and end-of-life products by occupiers (with reference to the requirements in Section F5). The waste collection area(s) shall be sized based on the	**B5. Recyclable waste storage** Dedicated storage space shall be provided within the building, or within the curtilage of the building, to facilitate the segregation of recyclable materials and end-of-life products by occupiers (with reference to the requirements in Section F5). The waste collection area(s) shall be sized based on the

155 BREEAM 2011 for New Construction: http://www.breeam.org/breeamGeneralPrint/breeam_non_dom_manual_3_0.pdf

likely level of occupation in order to accommodate sufficient containers to maximise recycling whilst also handling residual waste. **Verification:** Design teams or contractors shall provide plans of the building showing the space(s) that have been designated for waste segregation and collection as well as the assumptions made in order to estimate the space provision.	likely level of occupation in order to accommodate sufficient containers to maximise recycling whilst also handling residual waste. **Verification:** Design teams or contractors shall provide plans of the building showing the space(s) that have been designated for waste segregation and collection as well as the assumptions made in order to estimate the space provision.
CONTRACT PERFORMANCE CLAUSES	
F7. Recyclable waste storage Upon completion it shall be confirmed that dedicated storage space has been provided within the building, or within the curtilage of the building, to facilitate the segregation of recyclable materials and end-of-life products by occupiers (with reference to the requirements in criterion B6). **Verification:** The construction contractor, the Design & Build contractor or the DBO contractor shall provide final detailed plans of the recycling facilities as-built.	**F7. Recyclable waste storage** Upon completion it shall be confirmed that dedicated storage space shall be provided within the building, or within the curtilage of the building, to facilitate the segregation of recyclable materials and end-of-life products by occupiers (with reference to the requirements in criterion B6). **Verification:** The construction contractor, the Design & Build contractor or the DBO contractor shall provide final detailed plans of the recycling facilities as-built.

Summary rationale:

- In order to ensure the reuse, recycling and recovery, dedicated storage space for waste as paper and carton, plastic, metal and glasses has to be designed within the building, or within the curtilage of the building.
- The dedicated storage space should be clearly labelled for recycling, placed within accessible reach of the building and in a location with good vehicular access to facilitate collections. The size of the storage space must be adequate to store the likely volume of recyclable materials generated.
- Therefore, a technical specification on the storage of recyclable waste is proposed for both Core and Comprehensive criteria. Moreover, a contract performance clause is proposed upon completion of the building.

2.4.1.2 Waste management system

2.4.1.2.1 Background technical discussion and rationale

During the use phase of the building, the waste generated will consist mainly of packaging materials such as paper and carton, plastic, metal (aluminium cans), glasses, etc. as well as bulky waste such as end of life furniture and WEEE such as IT equipment. The implementation of a waste management system for the use phase can reduce the environmental impacts caused by waste generation. This plan should be based on the waste reduction, reuse and recycling and on waste separated collection, removal and storage.

Therefore, it is suggested as Core criterion that the building manager implements a waste management system that allow occupiers to make a basic segregation of paper, cardboard, and food and drink packaging (glass, plastic and tetrapak) for recycling. Batteries, ink and toner cartridges, IT equipment and furniture also have to be collected and arranged for re-use or recycling where permitted by the availability of services. Space provision for storage within the offices and bin stores shall be adequately planned for and clearly labelled.

In the case of the Comprehensive criterion, basic segregation shall be carried out by both the occupiers and the on-site catering services, including food/catering waste for recycling.

Finally, monthly data quantifying waste arisings as a proportion of the overall waste arisings from the building and in kg per waste fraction should be provided to the contracting authority.

2.4.1.2.2 Revised criteria proposal

Core criteria	Comprehensive criteria
TECHNICAL SPECIFICATION	
G3. Waste management system The building manager shall implement systems that allow occupiers to segregate paper, cardboard, food and drink packaging (glass, plastic and tetrapak) into separate streams for recycling. Batteries, ink and toner cartridges, IT equipment and furniture shall also be collected and arranged for re-use or recycling where possible. **Verification:** Facilities managers *or* DBO contractors shall submit a proposal for the systems to be used, including details of the waste streams, the segregation systems, working arrangements and contractors to be used.	**G3. Waste management system** The building manager shall implement systems that allow occupiers and on-site catering services to segregate paper (at least two grades), cardboard, food and drink packaging (glass, plastic and tetrapak) and food/catering waste into separate streams for recycling. Batteries, ink and toner cartridges, IT equipment and furniture shall also be collected and arranged for re-use or recycling where possible. **Verification:** Facilities managers *or* DBO contractors shall submit a proposal for the systems to be used, including details of the waste streams, the segregation systems, working arrangements and contractors to be used.
CONTRACT PERFORMANCE CLAUSE	
G5. Waste management system The building manager shall monitor and quantify on an ongoing agreed basis the overall waste arisings and recycling rate for the building(s). **Verification:** Facilities managers *or* DBO contractors shall provide the contracting authority with monthly data quantifying waste arisings as a proportion of the overall waste arisings from the building and in kg per waste fraction.	**G5. Waste management system** The building manager shall monitor and quantify on an ongoing agreed basis the overall waste arisings and recycling rate for the building(s). **Verification:** Facilities managers *or* DBO contractors shall provide the contracting authority with monthly data quantifying waste arisings as a proportion of the overall waste arisings from the building and in kg per waste fraction.

Summary rationale:

- During the use phase of the building, the generated waste will consist mainly of packaging materials. The development of a waste management system can reduce the environmental impacts caused by these waste.
- It is suggested as technical specification in the Core criteria that the building manager implements a waste management system that allows occupiers to make a basic segregation of paper, cardboard, and food and drink packaging (glass, plastic and tetrapak) for recycling. Batteries, ink and toner cartridges, IT equipment and furniture shall also be collected and arranged for re-use or recycling where possible.
- The collection of food waste is considered to be more specialised and is therefore proposed as a comprehensive requirement. In case of the Comprehensive criterion, the basic segregation therefore has to be carried out both by the occupiers and the on-site catering services, including food/catering waste for recycling.

2.4.1.3 At what stage of the procurement process are the criteria relevant?

The evaluation of space/design of facilities has been split into recyclable waste storage and waste management system, proposed both as technical specifications (both in Core and Comprehensive criteria). The criteria on recyclable waste storage shall be applied during the detailed design and performance requirements procurement phase. As contract performance clauses, during the practical completion and handover procurement phase, it shall be confirmed that dedicated storage space has been provided.

The criteria on implementation of a waste management system shall be applied during the facilities management procurement phase.

With reference to recyclable waste storage, the *design teams* or *contractors* shall provide plans of the building showing the space(s) that have been designated for waste segregation and collection as well as the

assumptions made in order to estimate the space provision. Moreover, during the practical completion and handover, the co*nstruction contractor*, the *Design & Build contractor* or the *DBO contractor* shall provide final detailed plans of the recycling facilities as-built.

With reference to the waste management system, the facilities managers *or* DBO contractors (dependant on the form of procurement) shall provide the contracting authority with monthly data quantifying waste arisings as a proportion of the overall waste arisings from the building and in kg per waste fraction.

The criteria classification, their reference numbers in the criteria document and the respective procurement phase can be cross-referenced as follows.

Title of the criterion	Procurement phase	Criterion classification	Criteria typology	Reference number in the criteria document
Recyclable waste storage	B. Detailed design and performance requirements	Core and Comprehensive	Technical specifications	B5.
Recyclable waste storage	F. Practical completion and handover	Core and Comprehensive	Contract performance clauses	F7.
Waste management system	G. Facilities management	Core and Comprehensive	Technical specifications	G3.
Waste management system	G. Facilities management	Core and Comprehensive	Contract performance clauses	G5

2.4.2 Water saving installations

2.4.2.1 Performance requirements for water saving installations

2.4.2.1.1 Background technical discussion and rationale

According to the estimation made by EUREAU[156], the average delivery of water for the non-domestic sector in 2012 in the EU28 was 9,881 Mm^3/yr (around one quarter of the total water delivered). However, the information on the split of water consumption in the non-domestic sector between different uses is limited.. An analysis on the water consumption split between different non-domestic activities and uses in the UK has been carried-out for Defra's Market Transformation Programme[157] and reported in Table 2.17. It is shown that in the case of office buildings, water is used basically for toilets and urinals, taps and, in some cases, for showers.

Table 2.17. Water use in the non-domestic sector in the UK

Activity	Water consumption (Mm^3/yr)	Toilets and urinals	Washbasin taps	Showers/ baths	Kitchen taps	Washing machines	Others
Food and drink	261.3	12%	1%	0%	0%	0%	87%
Retail	177.3	14%	2%	0%	1%	0%	83%
Hotels	127.3	8%	7%	9%	2%	0%	74%
Education	115.7	28%	3%	1%	4%	0%	64%
Health and social	29.7	45%	8%	0%	4%	0%	44%
Recreation, culture, sport	6.7	74%	4%	0%	0%	0%	22%
Public administration and defence	11.0	63%	2%	0%	5%	0%	30%
Others	1380.8	4%	1%	0%	0%	0%	94%
Total	2109.831	8.5%	2.0%	0.5%	0.8%	0.0%	88%

Additionally, from a life cycle perspective according to IPTS's preliminary LCA analysis, water use and management is less important when assessing the whole life of an office building. Also, less performance information can be found per building typology. Different factors (such as climate conditions, presence of water-saving equipment, number of occupants, applicable legislation, existing facilities, etc.) influence on the operational water use within office buildings.

156 EUREAU 2009.
http://eureau.org/index.php?eID=tx_nawsecuredl&u=0&file=fileadmin/user_upload/documents/8.%20Reports/EUREAU%20Statistics%20Overview%20on%20Water%20and%20Wastewater%20in%20Europe%20-%202008%20(Edition%202009).pdf&t=1410877211&hash=3e1c7e5224212b5701263fd0135e8e69021fd5a6

157 Defra's Market Transformation Programme 2011. http://efficient-products.ghkint.eu/spm/download/document/id/959.pdf

With reference to the MEErP Preparatory Study for Taps and Showers[158], currently under development by the JRC, water and related energy consumption have been evaluated taking into account water loss and energy demand for water supply system, energy losses in the water heating system and energy demand in waste water treatment system. Moreover, it has been underlined that water consumption from taps and showers is mainly a function of technology and user behaviour, so these should both be a focus for action. In the Task3 on users and system aspects, it has been preliminarily estimated that the total EU28 water saving potential from taps and showers, which could be achieved through a change of products and technology in the short-medium term, is on average equal to 2500 Mm^3/year. This saving would represent 11% of the total water abstraction for taps and showers in the EU28. 7% of this potential would be in the non-domestic sector.

Moreover, the energy saving from taps and showers in the EU28, which could be achieved a change of products and technology in the short-medium term, has been estimated to be 386 PJ of primary energy per year (131 PJ/year without considering system aspects), 4% of which would be in the non-domestic sector. This saving would represent 13% of the total system demand of primary energy for taps and showers in the EU28.

According to the MEErP study, the majority of the water and energy savings potential relates to the domestic sector. Moreover, a focus on certain typologies of non-domestic buildings, such as sport facilities or schools, could allow for greater water and energy savings than from office buildings.

In 2013, the EC published GPP criteria for sanitary tapware[159] and also for toilets and urinals[160]. Therefore, it is proposed that all sanitary and kitchen water facilities shall be equipped with water efficient fittings that are in compliance with the above-mentioned criteria.

2.4.2.1.2 Revised criteria proposal

Core criteria	**Comprehensive criteria**
TECHNICAL SPECIFICATION	
B6. Water saving installations All sanitary and kitchen water facilities shall be equipped with water efficient fittings that are in compliance with the criteria for sanitary tapware and toilets and flushing urinals. EU GPP criteria for sanitary tapware http://ec.europa.eu/environment/gpp/pdf/criteria/sanitary/EN.pdf EU GPP criteria for toilets and urinals http://ec.europa.eu/environment/gpp/pdf/criteria/toilets/criteria_Toilets_en.pdf **Verification:** See the respective EU GPP criteria documents.	**B6. Water saving installations** All sanitary and kitchen water facilities shall be equipped with water efficient fittings that are in compliance with the criteria for sanitary tapware and toilets and flushing urinals. EU GPP criteria for sanitary tapware http://ec.europa.eu/environment/gpp/pdf/criteria/sanitary/EN.pdf EU GPP criteria for toilets and urinals http://ec.europa.eu/environment/gpp/pdf/criteria/toilets/criteria_Toilets_en.pdf **Verification:** See the respective EU GPP criteria documents .

Summary rationale:

- From a life cycle perspective, water use and management is less important when assessing the whole life environmental impacts of an office building
- The available information on the split of water consumption in the non-domestic sector between different uses is limited. With reference to office buildings, an analysis on the water consumption split between different non-domestic activities and uses in the UK shows that in the case of office buildings, water is used mainly for toilets and urinals, taps and for showers

158 JRC ErP Preparatory Study for Taps and Showers: http://susproc.jrc.ec.europa.eu/taps_and_showers/stakeholders.html

159 EU GPP criteria for sanitary tapware: http://ec.europa.eu/environment/gpp/pdf/criteria/sanitary/EN.pdf

160 EU GPP criteria for toilets and urinals: http://ec.europa.eu/environment/gpp/pdf/criteria/toilets/criteria_Toilets_en.pdf

- With reference to the ErP Preparatory Study for Taps and Showers[161], currently under development by the JRC, water and related energy saving can be achieved by acting on both technology and user behaviour. According to this study, the main water and energy savings are related to the domestic sector. Moreover, other typologies of non-domestic buildings than office buildings could allow reaching greater water and energy savings.
- Given that EU GPP criteria have been published in 2013 both for sanitary tapware and for toilets and urinals it is proposed to include a cross-reference to them for consistency.

2.4.2.2 At what stage of the procurement process are the criteria relevant?

The evaluation of the water saving installations has been proposed both as technical specifications (both in Core and Comprehensive criteria). This criterion has to be applied during the detailed design and performance requirements procurement phase. The *tenderers* must provide technical specifications for the products to be installed that verify compliance with the appropriate GPP criteria.

The criteria classification, their reference numbers in the criteria document and the respective procurement phase can be cross-referenced as follows.

Title of the criterion	**Procurement phase**	**Criterion classification**	**Criteria typology**	**Reference number in the criteria document**
Performance requirements of water saving installations	B. Detailed design and performance requirements	Core and Comprehensive	Technical specifications	B6.

161 JRC ErP Preparatory Study for Taps and Showers: http://susproc.jrc.ec.europa.eu/taps_and_showers/stakeholders.html

2.5 Office environmental quality criteria

2.5.1 Thermal comfort conditions

2.5.1.1 Background technical discussion and rationale

In low energy or passive office buildings, the control of thermal comfort is an important factor. This is because uncontrolled thermal gain from natural lighting and ventilation, as well as insufficient thermal mass within a building's structure, can lead to uncomfortable conditions that may then require additional cooling energy. The recast EPD Directive 2010/31/EU specifically addresses overheating, stating that:

> *'...there should be focus on measures which avoid overheating, such as shading and sufficient thermal capacity in the building construction, and further development and application of passive cooling techniques, primarily those that improve indoor climatic conditions and the micro- climate around buildings.'*

Literature based on surveys suggests that although occupants may have a greater tolerance for hot and cold conditions in a low energy building, they also place a significance on being able to control their working conditions to within self-defined parameters [162].

EN standard 7730 addresses the ergonomics of thermal environments. It provides two metrics, which can be used to estimate occupant comfort (or discomfort) – Predicted Mean Vote (PMV) and Predicted Percentage Dissatisfied (PPD). Both of these metrics are based on a statistical probability of occupants feeling too hot or too cold. They are complex to calculate and interpret, with perception of thermal comfort being influenced by many different factors.

EN standard 15251 provides a simpler set of design parameters for the winter season and summer season, with categories for design minimum and maximum temperatures differentiated for offices with mechanical HVAC systems and passive cooling systems. The latter allows for greater temperature variations in summer.

2.5.1.2 Revised criteria proposal

Core criteria	**Comprehensive criteria**
TECHNICAL SPECIFICATIONS	
B7.1 Thermal comfort conditions Design indoor temperature values (minimum room temperature in winter, maximum room temperature in summer) for the office building shall comply with at least category II in accordance with EN 15251 or equivalent. Annex A1 shall be referred to for mechanically cooled buildings and A2 for passively cooled buildings. **Verification:** Design teams or the Design & Build contractor or the DBO contractor shall provide modelling data for the room temperatures.	**B7.1 Thermal comfort conditions** Design indoor temperature values (minimum room temperature in winter, maximum room temperature in summer) for the office building shall comply with at least category I in accordance with EN 15251 or equivalent. Annex A1 shall be referred to for mechanically cooled buildings and A2 for passively cooled buildings. **Verification:** Design teams or the Design & Build contractor or the DBO contractor shall provide modelling data for the room temperatures.

Summary rationale:

- Overheating is an important factor to control in low energy buildings because of the emphasis on the use of natural daylighting and passive ventilation systems.
- Thermal comfort is an important concept because it can influence occupiers acceptance of a low energy building.
- Standard metrics exist to predict thermal comfort but these are complex to calculate and may still not take into account all relevant factors.

162 Wagner.A et al, *Thermal comfort and workplace occupant satisfaction—Results of field studies in German low energy office buildings*, Energy and Buildings 39 (2007) 758–769

- It is proposed that a simplified approach based on maximum and minimum design temperatures is taken, requiring modelling of the thermal conditions within the office building.

2.5.1.3 At what stage of the procurement process are the criteria relevant?

The thermal comfort conditions requirement has been proposed as a technical specification (both for Core and Comprehensive criteria) to be applied during the detailed design and performance requirements procurement phase. *Design teams* or the *Design & Build contractor* or the *DBO contractor* shall provide modelling data for the room temperatures.

The criteria classification, their reference numbers in the criteria document and the respective procurement phase can be cross-referenced as follows.

Title of the criterion	Procurement phase	Criterion classification	Criteria typology	Reference number in the criteria document
Thermal comfort conditions	B. Detailed design and performance requirements	Core and Comprehensive	Technical specification	B7.1.

2.5.2 Daylighting and glare

2.5.2.1 Background technical discussion and rationale

In Section 2.1.1.2 the potential to use natural daylight to reduce the need for artificial lighting was highlighted. Natural light has also been shown to contribute to a more conducive and productive working environment and is preferred by office workers, who also tend to seek a window location. The plan depth of an office will dictate how much of the floor area can be illuminate with natural light. At a depth of more than 4-6 metres, a glazing ration of 30% and a ceiling height of 3 metres, natural light levels will fall below the level of 500 lux (lumens/m^2) necessary for a working environment – equivalent to a Daylighting Factor of 2% of outside light [163].

As a design parameter Daylighting Factors for a percentage of an office's floor area are set as a visual comfort criterion by the building assessment schemes HQE (France) and BREEAM International (EU-wide). Both these schemes stipulate that 80% of a daylit room shall achieve selected DF levels linked to credits to be awarded. HQE starts at DF 1.2 and BREEAM at DF 2.0.

However, without careful design, natural light can make a working environment uncomfortable and, potentially, result in more energy use than predicted in the original design. Whilst a design may achieve an ideal Daylighting Factor of 2% at a plan depth of 6 metres, this would result in unwanted glare and thermal gains near the windows. As a result, shading may be required to control natural daylight. Shading systems can be designed to either block light entering (e.g. blinds), thereby resulting in the need for artificial lighting or, as it can be seen in the best examples of passive design, to redistribute natural light deeper into the building by reflecting it onto the ceiling (e.g. light shelves).

Whilst standard EN 12464 provides a rating for glare from artificial lighting, it states that there is currently no standardised rating of discomfort glare from windows. Literature suggests that Daylight Glare Probability (DGP) could be used as interim metric, having been developed based on subjects in real office environments and assessed as being suitable for both direct and indirect natural light [164]. DGP estimates the number of occupants that may find the level of glare uncomfortable. A threshold of 0.35 relates to 'disturbing' levels of glare and 0.30 to 'perceptible' levels. In both cases the potential for unacceptable contrasts in luminance ratios is understood to be a probability.

163 Baker.N and K,Steemers (1999) *Energy and Environment in Architecture: A Technical Design Guide*, Taylor & Francis *and* European Commission (1994) *Daylighting in buildings*, THERMIE project

164 Wienold.A and J,Christoffersen, *Evaluation methods and development of a new glare prediction model for daylight environments with the use of CCD cameras*, Energy and Buildings 38 (2006) 743–757 *and* Harvard Design School, *The Use of Glare Metrics in the Design of Daylit Spaces:Recommendations for Practice*, 9th International Radiance Workshop; September 20-21, 2010

2.5.2.2 Revised criteria proposal

Core criteria	Comprehensive criteria
TECHNICAL SPECIFICATIONS	
B7.2 Daylighting and glare Offices and meeting rooms shall achieve a minimum Daylight Factor of 2.0% for 80% of the floor area and glare control corresponding to a Daylight Glare Probability value of 0.30. **Verification:** Design teams or the Design & Build contractor or the DBO contractor shall provide modelling data for daylighting conditions and glare control.	**B7.2 Daylighting and glare** Offices and meeting rooms shall achieve a minimum Daylight Factor of 2.0% for 80% of the floor area and glare control corresponding to a Daylight Glare Probability value of 30%. **Verification:** Design teams or the Design & Build contractor or the DBO contractor shall provide modelling data for the room temperatures, daylighting conditions and glare control.

Summary rationale:

- It is proposed that a criterion is set that requires that in office areas and meeting rooms the potential for natural daylighting is maximised by ensuring that they achieve a minimum Daylighting Factor. This implies that these areas are within a distance of windows of approximately 4-6 metres and that natural light is redistributed by some form of shading system at times of the year with high levels of daylighting.
- In order to ensure that glare is controlled, it is proposed that a second metric is introduced that measures the level of discomfort of occupants. A Daylight Glare Probability threshold of 0.30 is proposed as representing a level at which glare is perceptible but potentially not uncomfortable for many office workers.
- This criterion would complement the criterion on lighting control systems, which specifies the use of daylight-linked dimmers, thereby allowing the use of artificial lighting to be reduce in function of the availability of natural light. The *combined* savings potential has been estimated at 20-30% of artificial lighting requirements.

2.5.2.3 At what stage of the procurement process are the criteria relevant?

The daylighting and glare has been proposed as a technical specification (both for Core and Comprehensive criteria) to be applied during the detailed design and performance requirements procurement phase. *Design teams* or the *Design & Build contractor* or the *DBO contractor* shall provide modelling data for daylighting conditions and glare control.

The criteria classification, their reference numbers in the criteria document and the respective procurement phase can be cross-referenced as follows.

Title of the criterion	Procurement phase	Criterion classification	Criteria typology	Reference number in the criteria document
Daylighting and glare	B. Detailed design and performance requirements	Core and Comprehensive	Technical specification	B7.2.

2.5.3 Air quality

2.5.3.1 Ventilation and air quality

2.5.3.1.1 Background technical discussion and rationale

Building occupiers can be exposed to a range of potential sources of hazardous substances arising from building materials, furnishings, decorative materials, cleaning agents, humidity, combustion equipment and external air pollution. Studies have suggested that healthy indoor air quality is a factor that can improve productivity. Conversely, the problem of so-called 'sick building syndrome' can lead to reduced productivity and even lost time due to work-related illness.

As workers' salaries represent the greatest expenditure (significantly bigger than energy use), improvements in the quality of an office environment can be attributed a value. Research suggests that by increasing ventilation rates from 2.5 l/s to 10 L/s per person, productivity can be increased by around 5% [165]. Related to this, productivity has been observed to increase by approximately 1% for every 10% reduction in dissatisfaction with the indoor air quality.

Indoor air quality is an important measure of the health of a building. WHO IAQ guidelines exist for the level of indoor exposure levels for a number of contaminants, including PM2.5 particulates, CO, NO_2, formaldehyde, benzene and naphthalene. DG Health & Consumers identifies fine particulate matter from outdoor air pollution and indoor combustion equipment as the most significant source of indoor exposure [166]. This finding is supported by the European Collaborative Action (ECA) on 'Urban air, indoor environment and human exposure' and EU monitoring projects such as Officair.

Important factors that dictate the quality of intake air in an office are the external environment, the level of air filtration and the ventilation rate. EN standard 13779 specifies design criteria for ventilation systems to maintain indoor air quality, including specifications to reduce the intake of urban pollution and improve air filtration. Requirements from the standard are, to some extent reflected in the building certification scheme BREEAM, which contains a criteria that awards credits if the ventilation intakes are located over 20 metres from external sources and are over 10m apart to avoid recirculation.

Poor urban air quality is described in EN 13779 as where '*...pollutant concentrations exceed the WHO guidelines or any National air quality standards or regulations for outdoor air by a factor greater than 1,5*.' Because under the Air Quality Directive 2008/50/EC Member States are required to prepare air quality action plans and monitor pollution at a local level, it is anticipated that this information should be readily available from a local municipality or from reported data in the public domain.

2.5.3.1.2 Revised criteria proposal

Core criteria	**Comprehensive criteria**
TECHNICAL SPECIFICATIONS	
B7.3 Ventilation and air quality In locations with poor air quality, the ventilation systems of the building shall be designed to be in compliance with the following criteria in order to ensure that clean air is supplied to the offices: - Air intakes shall be located at least 20 metres from major sources of urban air pollution and shall be in compliance with guidance A2.2 in EN 13779:2007 or equivalent. - The ventilation system shall be specified to provide a level of filtration and a rate of air change that is in compliance with the specifications in table A.5 of EN 13779:2007 or equivalent. Poor air quality is defined as outdoor air (ODA) class 2 or 3 according to EN 13779-2007 or equivalent.	**B7.3 Ventilation and air quality** In locations with poor air quality the ventilation systems of the building shall be designed to be in compliance with the following criterion in order to ensure that clean air is supplied to the offices: - Air intakes shall be located at least 20 metres from major sources of urban air pollution and shall be in compliance with guidance A2.2 in EN 13779:2007 or equivalent. - The ventilation system shall be specified to provide a level of filtration and a rate of air change that is in compliance with the specifications in table A.5 of EN 13779:2007 or equivalent. Poor air quality is defined as outdoor air (ODA) class 2 or 3 according to EN 13779-2007 or equivalent.

165 Djukanovic et al, *Cost benefit analysis of improved air quality in an office building*, Proceedings: Indoor Air 2002

166 DG Health & Consumers (2011) *Promoting actions for healthy indoor air*.

Verification: The design team or the DBO contractor shall provide drawings and plans of the ventilation services detailing the air intake locations. These shall be provided at the detailed design stage and upon completion. They shall also obtain local air monitoring data from the local public authority enabling classification the location according to EN 13779-2007, or its equivalent, together with technical specifications for the air filter systems.	**Verification:** The design team or the DBO contractor shall provide drawings and plans of the ventilation services detailing the air intake locations. These shall be provided at the detailed design stage and upon completion. They shall also provide local air monitoring data from the local public authority enabling classification of the location according to EN 13779-2007, or its equivalent, together with technical specifications for the air filter systems.

Summary rationale:

- The intake by office ventilation systems of urban air pollution and contaminants has been identified as a contaminant of indoor air. Fine particulates from vehicle exhaust are of particular concern.
- The EN standard 13779 specifies technical standards for the location of air intakes to minimise the intake of polluted outdoor air and to filter air to a high standard. This approach is followed by the BREEAM building certification scheme.
- It is proposed as a technical specification (Core and Comprehensive) that in locations with poor air quality (as defined by EN 13779) the stipulated requirements on the location of the building's ventilation intakes and the level of filtration are met.

2.5.3.2 Selection of fit-out materials and finishes

2.5.3.2.1 Background technical discussion and rationale

As was highlighted in Section 2.4.3.1, building occupants may be exposed to a wide range of air borne contaminants. These may include volatile and carcinogenic organic compounds that are emitted from materials and products used in the finishing of building interiors. The most significant potential emissions sources are understood to be paints and varnishes, textile furnishings, floor coverings and fit-out incorporating particle board [167].

The monitoring and control of emissions from priority chemicals, including Volatile Organic Compounds (VOC's), has been the focus of action at EU level. Work is ongoing to support the CE marking of products under the Construction Products Regulation with two relevant areas of focus - the harmonisation of health-based evaluations of emissions from construction products and the development of an emissions performance class system for reporting to consumers.

This work led to the publication in early 2014 of harmonised and interim Lowest Concentration of Interest (LCI) values for VOC and SVOC substances and compounds of concern based on existing German AgBB and French ANSES systems [168]. Whilst LCI system provides a robust basis for substance-specific restrictions, there does not always appear to be equivalence between this approach and current product labelling schemes originating in Scandinavia, Germany, Austria, France and the USA, which combine substance-specific LCI's with overall thresholds for VOC and SVOC emissions [169].

Work facilitated by JRC IHCP is still ongoing to establish common performance classes for emissions from products. This would reflect the approach adopted by France as a legal labelling requirement for a range of interior products [170], which has four classes of performance. The French scheme comprises performance classes for Total VOCs (TVOC) and ten specific organic substances.

A further related development is the publication in 2013 of a harmonised European test method for emissions of volatile organic compounds from construction products into indoor air, CEN/TS 16516. This established a common method and test conditions based on a 'European reference room' in which products

167 Bluyssen et al, *European Indoor Air Quality Audit in 56 office buildings*, Indoor Air: 1996, 6(4), p-221-228

168 European Commission Joint Research Centre IHCP (2014) *Harmonisation framework for health based evaluation of indoor emissions from construction products in the European Union using the EU-LCI concept*, Report No. 29.

169 European Commission Joint Research Centre IHCP (2005) *Harmonisation of indoor material emissions labelling systems in the EU*, European Collaborative Action: Urban air, indoor environment and human exposure, Report No. 24.

170 Eurofins, *France: Compulsory VOC emissions labelling*, http://www.product-testing.eurofins.com/information/compliance-with-law/european-national-legislation/french-regulation-on-voc-emissions.aspx

are to be tested. The technical specification was developed in response to a mandate to address dangerous substances under the Construction Products Regulation.

2.5.3.2.2 Revised criteria proposal

<table>
<tr><th>Core criteria</th><th>Comprehensive criteria</th></tr>
<tr><td colspan="2">TECHNICAL SPECIFICATIONS</td></tr>
<tr><td>
D5. Selection of fit-out materials and finishes
Each material and finish selected for the fit-out of the offices shall comply with the following emissions limits in table e below. This requirement shall apply to:
- Ceiling tiles
- Paints and varnishes
- Textile floor and wall coverings
- Laminate and flexible floor coverings
- Wooden floor coverings

Table e Materials and finishes emission limits
<table>
<tr><td rowspan="2">Product</td><td colspan="2">Emissions limits (µg/m³)</td></tr>
<tr><td>3 days</td><td>28 days</td></tr>
<tr><td>TVOCs</td><td>10,000</td><td><2,000</td></tr>
<tr><td>Formaldehyde</td><td>-</td><td><120</td></tr>
</table>
Verification:
The main construction contractor or the DBO contractor shall provide compliant test results for each material or finish installed. The determination of emissions shall be in conformance with CEN/TS 16516 or equivalent product testing standards or labels, which use the European 'reference room' as the basis for testing.
</td><td>
D5. Selection of fit-out materials and finishes
Each material and finish selected for the fit-out of the offices shall comply with the following emissions limits in table f below. This requirement shall apply to:
- Ceiling tiles
- Paints and varnishes
- Textile floor and wall coverings
- Laminate and flexible floor coverings
- Wooden floor coverings

Table f. Material and finishes emission limits
<table>
<tr><td rowspan="2">Product</td><td colspan="2">Emissions limits (µg/m³)</td></tr>
<tr><td>3 days</td><td>28 days</td></tr>
<tr><td>TVOCs</td><td>10,000</td><td><1,000</td></tr>
<tr><td>SVOCs</td><td>-</td><td>100</td></tr>
<tr><td>Formaldehyde</td><td>-</td><td><10</td></tr>
<tr><td>Carcinogens
- trichloroethylene,
- benzene
- DEHP
- DBP</td><td><10 sum total of the four substances</td><td><1 for each substance</td></tr>
</table>
Verification:
The main construction contractor or the DBO contractor shall provide compliant test results for each material or finish installed. The determination of emissions shall be in conformance with CEN/TS 16516 or equivalent product testing standards or labels, which use the European 'reference room' as the basis for testing.
</td></tr>
</table>

<u>*Summary rationale:*</u>

- Emissions of Volatile Organic Compounds (VOC's) as well other hazardous substances of concern from construction products and interior finishes are a major area of focus for harmonisation work at EU level.
- Harmonised emissions levels for selected substances and compounds (LCI values) as well as a test method for determining emissions (CEN/TS 16516) have been published. A performance class system for reporting to consumers is still under development.
- A range of mature ecolabelling schemes for interior products exists in Scandinavia, Germany, Austria, France and the USA. These tend to combine substance specific LCI's with overall VOC and SVOC performance. The French scheme is mandated under national law.
- It is proposed that a technical specification is required reflecting the broad approach taken in current ecolabelling schemes for interior products, with the Core requirement focussing at a basic level on total VOC emissions and formaldehyde and the Comprehensive requirement introducing additionally SVOC's and four additional CMR (Carcinogenic, Mutagenic or toxic to reproduction) substances that are the subject of LCI values in the French national scheme.
- The performance for Core and Comprehensive are proposed to be aligned to 3rd and the 1st performance classes under the 2011 proposals for harmonised EU performance classes. These read across to B and A+ classes in the French scheme.

- The harmonised method described in CEN/TS 16516 is proposed for the verification.

2.5.3.3 Air quality testing

2.5.3.3.1 Background technical discussion and rationale

In addition to the testing of hazardous emissions at a product level there are various examples of building assessment schemes that specify the measurement of the total emissions to which an occupier may be exposed to at a building level [171]. These include LEED (International), BREEAM (EU-wide) and DGNB (Germany and Austria). A summary of the approaches taken is provided in Table 2.18 below.

Table 2.18: Summary comparison of post-occupancy testing of building Indoor Air Quality

Building scheme	Time frame	Test specification	Test method
LEED (2013)	Post construction, but pre-occupancy.	- Formaldehyde - Particulates (PM10 and 2.5) - Ozone - TVOC - CO - Specific target chemicals	ISO 16000-3 ISO 16000-6 ISO 7708 ISO 4224
BREEAM (2011)	Post construction, but pre-occupancy	- Formaldehyde - TVOC	ISO 16000-3 ISO 16000-6 ISO 16017-2
DGNB (2008)	Maximum 4 weeks post-construction	- Formaldehyde - TVOC	ISO 16000-3 ISO 16000-6 VDI 4300-6

Source: Eurofins (2013)

This form of testing is not mandatory in LEED and BREEAM, so is only likely to be chosen by the very best performing office buildings on the market. An indicative cost per test routine is €2,000 – €3,000 per building for two sample rooms and dependent on whether active or passive sampling is to be used. These costs would also need to be supplemented by any increased costs associated with the specification of low emission fit-out materials and products. The particulate element of the testing could be specified as an alternative to the proposed technical specification for fit-out materials and finishes and/or to cross-check that the proposed technical specification for ventilation results in lower exposure (see Section 2.4.3.2).

In relation to threshold levels for possible health effects, ongoing research by JRC-IHCP and WHO guidelines provide a reference point. Evidence from JRC-IHCP suggests that TVOC's concentrations of greater than 1000 mg/m^3 may result in occupants suffering sensory irritation but that levels greater than 25,000 mg/m^3 would be required before significant health effects became a concern [172]. For formaldehyde WHO recommends thresholds of 0.1 mg/m^3 for sensory irritation and 1.25 mg/m^3 for cancer effects [173]. For particulates WHO recommends the following as thresholds [174]:

- PM2.5: 10 µg/m^3 annual average, 25 µg/m^3 24-hour mean (no more than 3 days/year)
- PM10: 20 µg/m^3 annual average, 50 µg/m^3 24-hour mean

The threshold levels used by the three building assessment schemes can be seen to be in line with or below the thresholds described above.

171 Eurofins, *Post construction air quality in sustainable building programmes*, http://www.eurofins.com/product-testing-services/information/sustainable-buildings/indoor-air-quality-in-green-buildings/indoor-air-quality-by-program.aspx

172 European Commission Joint Research Centre IHCP (1997) *Total Volatile Organic Compounds (TVOC's) in indoor air quality investigations*, European Collaborative Action: Urban air, indoor environment and human exposure, Report No. 19.

173 WHO Europe (2010) *Selected pollutants: Guidelines for indoor air quality*.

174 WHO Europe (2013) *Health effects of particulate matter*.

2.5.3.3.2 Revised criteria proposal

<table>
<tr><th>Core criteria</th><th>Comprehensive criteria</th></tr>
<tr><td colspan="2">CONTRACT PERFORMANCE CLAUSES</td></tr>
<tr><td></td><td>
F8. Air quality testing

The lead contractor shall test the air quality within the building a minimum of four weeks following completion of the building fit-out, so as to ensure it conforms with the requirements in table g.

Testing shall be carried out for one representative office room, where the office consists predominantly of cellular office spaces, or selected sample locations where the office consists of open plan office spaces.

Table g. Parameters for office air quality testing
<table>
<tr><th>Substance(s) to be tested</th><th>Testing parameters</th></tr>
<tr><td>Total Volatile Organic Compounds (TVOC's)</td><td><500 µ/m³ (eight hour average) in accordance with ISO 16017-2 or equivalent</td></tr>
<tr><td>Formaldehyde</td><td><100 µ/m³ (30 minutes average) in accordance with ISO 16000-3 or equivalent</td></tr>
<tr><td>Particulates</td><td>An eight hour average for two particle sizes in accordance with ISO 7708 or equivalent:
PM10: 50 µ/m³
PM2.5: 15 µ/m³</td></tr>
</table>

Verification:

The lead construction contractor or the DBO contractor shall carry out testing and provide test results demonstrating compliance with the required parameters. All measurements shall be taken during normal occupied hours and under design ventilation conditions in which the systems have been running for at least 12-24 hours prior to testing.
</td></tr>
</table>

<u>*Summary rationale:*</u>

- Three major building assessment schemes measure the total level of hazardous substances in the indoor air of an office building prior to occupation. Substances tested for include TVOC's, formaldehyde and particulates.
- Such a criteria is not currently mandatory and is not understood to be a general practice even in the most innovative building projects. However, it does offer a more rigorous check that indoor air quality has been improved as a result of product selection and ventilation design.
- It is proposed that a simplified test routine for TVOC, formaldehyde and particulates for a representative office space, or a sample of office spaces, is offered as an option for contracting authorities, potentially as an alternative to the technical specification for fit-out materials and finishes.
- Such a criteria could be used either as an award criterion to encourage innovation in order to meet the emissions testing or as a contract performance clause to ensure that material and finish selection delivers improved indoor air quality.

2.5.3.4 At what stage of the procurement process are the criteria relevant?

The ventilation and air quality has been proposed as a technical specification (both for Core and Comprehensive criteria) to be applied during the detailed design and performance requirements procurement phase. The *design team* or the *DBO contractor* shall provide drawings and plans of the ventilation services detailing the air intake locations. These shall be provided at the detailed design stage and upon completion. They shall also obtain local air monitoring data from the local public authority enabling classification the location according to EN 13779-2007, or its equivalent, together with technical specifications for the air filter systems.

The selection of fit-out materials and finishes has been proposed as a technical specification (both for Core and Comprehensive criteria) to be applied during the construction of the building or major renovation works procurement phase. The main construction contractor or the DBO contractor shall provide compliant test results for each material or finish installed. The determination of emissions shall be in conformance with CEN/TS 16516 or equivalent product testing standards or labels, which use the European 'reference room' as the basis for testing.

Air quality testing has been proposed as a contract performance clause in comprehensive criterion to be applied during the practical completion and handover procurement phase. The *lead construction contractor* or the *DBO contractor* shall carry out testing and provide test results demonstrating compliance with the required parameters. All measurements shall be taken during normal occupied hours and under design ventilation conditions in which the systems have been running for at least 12-24 hours prior to testing.

The criteria classification, their reference numbers in the criteria document and the respective procurement phase can be cross-referenced as follows.

Title of the criterion	**Procurement phase**	**Criterion classification**	**Criteria typology**	**Reference number in the criteria document**
Ventilation and air quality	B. Detailed design and performance requirements	Core and Comprehensive	Technical specification	B7.3.
Selection of fit-out materials and finishes	D. Construction of the building or major renovation works	Core and Comprehensive	Technical specification	D5.
Air quality testing	F. Practical completion and handover	Comprehensive	Contract performance clause	F8.

2.6 Conclusions

For ease of/better readability of the document and to facilitate the cross reference with the GPP criteria document, the complete list of the GPP criteria with their classification and reference number in the criteria document is provided as follows.

Title of the criterion	Procurement phase	Criterion classification	Criteria typology	Reference number in the criteria document
1. Energy related criteria				
1.1 Energy performance				
Performance requirements: minimum energy performance Minimum Energy performance	B. Detailed design and performance requirements	Core and Comprehensive Core and Comprehensive	Technical specification Award criteria	B1. B8.
Installation and commissioning of building energy systems	D. Construction of the building or major renovation works	Core and Comprehensive	Technical specification	D2.
	F. Practical completion and handover	Core and Comprehensive	Contract performance clause	D5.
Quality of the completed building fabric	D. Construction of the building or major renovation works	Core and Comprehensive	Technical specification	F1.
	F. Practical completion and handover	Core and Comprehensive	Contract performance clause	F3.
1.2 Lighting				
Performance requirements: lighting control systems	B. Detailed design and performance requirements	Comprehensive	Technical specification	B2.
Commissioning and handover of lighting control systems • Installation and commissioning of building energy systems • Lighting control systems	D. Construction of the building or major renovation works F. Practical completion and handover	Core and Comprehensive Comprehensive	Technical specification Technical specification	D2. F4.
1.3 Building Energy Management System (BEMS)				
Building energy management system	B. Detailed design and performance requirements	Core and Comprehensive	Technical specification	B3.
Commissioning and handover • Installation and commissioning of building energy systems • Building energy management system	D. Construction of the building or major renovation works F. Practical completion and handover	Core and Comprehensive Core and Comprehensive	Technical specification Technical specification	D2. F5.
1.4 Low or zero carbon energy sources				
Performance requirements for energy supply systems • Low or zero carbon energy sources	B. Detailed design and performance requirements	Core and Comprehensive Comprehensive	Technical specification Award criterion	B4. B9
Commissioning of energy supply systems				

• Installation and commissioning of building energy systems	D. Construction of the building or major renovation works F. Practical completion and handover	Core and Comprehensive Core and Comprehensive	Technical specification Award criterion	D2. F2.
Heating systems including Combined Heat and Power (CHP)	E. Installation of energy systems and the supply of energy services	Core and Comprehensive	Technical specification	E1.
Installation and commissioning of low or zero carbon energy sources	F. Practical completion and handover	Core and Comprehensive	Contract performance clause	F6.
1.5 Facilities energy management				
Building energy management system	G. Facilities management	Core and Comprehensive	Technical specification	G1.
Energy performance contract	G. Facilities management	Core and Comprehensive	Contract performance clause	G2.
	G. Facilities management	Core and Comprehensive	Contract performance clause	G4.
2. Resources efficient construction				
2.1 Life cycle performance				
Performance requirements of the main building elements	B. Detailed design and performance requirements	Core and Comprehensive	Award criterion	B10.1
2.2 Recycled content				
Incorporation of the recycled content • Incorporation of recycled content • Monitoring the recycled content	B. Detailed design and performance requirements D. Construction of the building or major renovation works	Core and Comprehensive Core and Comprehensive	Award criterion Contract performance clauses	B10.2 D6.
2.3 Wood				
Legal sourcing timber by the lead construction contractor	D. Construction of the building or major renovation works	Core and Comprehensive	Selection criterion	D1.
Legal sourcing of timber	D. Construction of the building or major renovation works	Core and Comprehensive	Contract performance clause	D7.
2.4 Waste management plan				
Demolition waste audit and management plan	C. Strip-out, demolition and site preparation works	Core and Comprehensive	Technical specifications	C1.
Site waste management plan	D. Construction of the building or major renovation works	Core and comprehensive	Technical specifications	D3.
Site waste management	D. Construction of the building or major renovation works	Core and comprehensive	Contract performance clauses	D8.
3. Other environmental criteria				
3.1 Space/design of facilities				
Performance requirements for recyclable waste storage • Performance requirements of recyclable waste storage • Completion and handover of recyclable waste storage	B. Detailed design and performance requirements F. Practical completion and handover	Core and Comprehensive Core and Comprehensive	Technical specifications Contract performance clauses	B5. F7.
Waste management system	G. Facilities management	Core and Comprehensive	Technical specifications	G3.

	G. Facilities management	Core and Comprehensive	Contract performance clauses	G5.
Water saving installations				
Performance requirements of water saving installations	B. Detailed design and performance requirements	Core and Comprehensive	Technical specifications	B6.
4. Quality of the office environment				
4.1 Thermal comfort conditions	B. Detailed design and performance requirements	Core and Comprehensive	Technical specification	B7.1.
4.2 Daylighting and glare	B. Detailed design and performance requirements	Core and Comprehensive	Technical specification	B7.2.
4.3 Air quality				
Ventilation and air quality	B. Detailed design and performance requirements	Core and Comprehensive	Technical specification	B7.3.
Selection of fit-out materials and finishes	D. Construction of the building or major renovation works	Core and Comprehensive	Technical specification	D4.
Air quality testing	F. Practical completion and handover	Comprehensive	Contract performance clause	F8.
5. Competencies of the design team and contractors				
5.1 Competencies of the project manager and the design team	A. Selection of the design team and contractors	Core and Comprehensive	Selection criteria	A1.
5.2 Competencies of the lead construction contractor, specialist contractors and/or property developers	A. Selection of the design team and contractors	Core and Comprehensive	Selection criteria	A2.

The possible chronological order of the GPP criteria is shown in the following table.

Core criteria	**Comprehensive criteria**
A. Selection of the design team and contractors	
SELECTION CRITERIA	
A1. Competencies of the project manager and design team	A1. Competencies of the project manager and design team
A2. Competencies of the lead construction contractor, specialist contractors and/or property developers	A2. Competencies of the lead construction contractor, specialist contractors and/or property developers
B. Detailed design and performance requirements	
TECHNICAL SPECIFICATIONS	
B1. Minimum Energy performance	B1. Minimum Energy performance
B2. Lighting control systems	B2. Lighting control systems
B3. Building energy management system	B3. Building energy management system
B4. Low or zero carbon energy sources	B4. Low or zero carbon energy sources
B5. Recyclable waste storage	B5. Recyclable waste storage
B6. Water saving installations	B6. Water saving installations
B7.1 Thermal comfort conditions	B7.1 Thermal comfort conditions
B7.2 Daylighting and glare	B7.2 Daylighting and glare.
B7.3 Ventilation and air quality	B7.3 Ventilation and air quality
AWARD CRITERIA	
B8. Minimum Energy performance	B8. Minimum Energy performance
	B9. Low or zero carbon energy sources
B10.1 Performance of the main building elements	B10.1 Performance of the main building elements
B10.2 Incorporation of recycled content	B10.2 Incorporation of recycled or re-used content
C. Strip-out, demolition and site preparation works	
TECHNICAL SPECIFICATIONS	
C1. Demolition waste audit and management plan	C1. Demolition waste audit and management plan
D. Construction of the building or major renovation works	

SELECTION CRITERIA	
D1. Legal sourcing of timber by the lead construction contractor	D1. Legal sourcing of timber by the lead construction contractor
TECHNICAL SPECIFICATIONS	
D2. Installation and commissioning of building energy systems	D2. Installation and commissioning of building energy systems
D3. Site waste management	D3. Site waste management
D4. Selection of fit-out materials and finishes	D4. Selection of fit-out materials and finishes
CONTRACT PERFORMANCE CLAUSE	
D5. Installation and commissioning of building energy systems	D6. Installation and commissioning of building energy systems
D6. Incorporation of recycled content	D6. Incorporation of recycled or reused content
D7. Legal sourcing of timber	D7. Legal sourcing of timber
D8. Site waste management	D8. Site waste management
E. Installation of energy systems and the supply of energy services	
TECHNICAL SPECIFICATIONS	
E1. Heating systems, including Combined Heat and Power (CHP)	E1. Heating systems, including Combined Heat and Power (CHP)
F. Practical completion and handover	
TECHNICAL SPECIFICATIONS	
F1. Quality of the completed building fabric	F1. Quality of the completed building fabric
AWARD CRITERIA	
F2. Installation and commissioning of low or zero carbon energy sources	F2. Installation and commissioning of low or zero carbon energy sources
CONTRACT PERFORMANCE CLAUSES	
F3. Quality of the completed building fabric	F3. Quality of the completed building fabric
F4. Lighting control systems	F4. Lighting control systems
F5. Building energy management system	F5. Building energy management system
F6. Installation and commissioning of low or zero carbon energy sources	F6. Installation and commissioning of low or zero carbon energy sources
F7. Recyclable waste storage	F7. Recyclable waste storage
	F8. Air quality testing
G. Facilities management	
TECHNICAL SPECIFICATIONS	
G1. Building energy management system	G1. Building energy management system
G2. Energy performance contract	G2. Energy performance contract
G3. Waste management system	G3. Waste management system
CONTRACT PERFORMANCE CLAUSE	
G4. Energy performance contract	G4. Energy performance contract
G5. Waste management system	G5. Waste management system
PROPOSED TECHNICAL ANNEXES	
Annex 1 - Supporting guidance for criterion B10.1: Option 1 – Aggregation of EPDs *Annex 2 - Supporting guidance for criterion B10.1: Option 2 - LCA analysis* *Annex 3* - Brief for LCA technical evaluator	

3 THE CHALLENGES OF PROCURING OFFICE BUILDINGS

3.1 Reflecting the complexity of the procurement process

Designing and procuring an office building with a reduced environmental impact, whether it be new-build or a major renovation, is a complex process. As was highlighted by the SCI (Sustainable Construction and Innovation through Procurement) Network in their guide for European Public Authorities, the form of procurement can have a significant influence on the outcome. This is because each type of contract brings with it distinct interactions between the procurer, the contracting authorities internal team, the building design team, the contractors used and the future occupants and facilities managers. Moreover, they each can have advantages and disadvantages in seeking to procure an improved environmental performance.

It is therefore important to identify the main points in the sequence of procurement activities where GPP criteria should be integrated. This guidance is structured to reflect the key activities and decision points in the procurement process, as well as some of the common contract forms that are used in the European Union. Specific reference is made to the International Federation of Consulting Engineers' (FIDIC) contracts for construction works (Red Book), design and build (Yellow Book) and design, build and operate (Gold Book).

3.2 Reflecting different potential sequences of procurement activities

The process of constructing a new office building or carrying out a major office renovation tends to consist of a distinct sequence of procurement activities. Each contract relates indicatively to distinct phases of activity as a project proceeds:

- Preliminary scoping and feasibility;
- Detailed design and applications for permits;
- Strip-out, demolition and site preparation works;
- Construction of the building or major renovation works;
- Installation of energy systems and the supply of energy services;
- Completion and handover;
- Facilities management.

Depending on the procurement route adopted, some of these contracts may be awarded to the same contractor but in most cases they are let separately. Some contracts may be integrated in a design and build (DB) or a design, build and operate (DBO) arrangement, with the detailed design process, the main construction contract, the installation of energy services and even facilities management all potentially co-ordinated by one contractor.

The following sections describe each of these phases in turn, highlighting factors to consider in seeking to incorporate GPP criteria into contracts.

3.2.1 Preliminary scoping and feasibility

Early decisions will be made about the siting of the building at this stage. It may entail a decision between renovating or demolishing an existing site (see Section 3.2.1.3), or it may be a choice between several locations within the public estate. This stage would generally involve the estates department and capital programmes.

3.2.1.1 Creating the project definition

The project definition clearly sets out the strategic aims of the building project. Its objective is usually to create a clear brief for the internal project team, including the procurer. The project definition should include

the environmental priorities of the contracting authority, as reflected in policies and plans, at a corporate level and in local planning policies. It can also be used to bring together initial information about the site and summarise the design requirements of the relevant departments that will occupy the building.

3.2.1.2 Choosing the site and location

One of the first considerations relating to the siting of the project will be whether an existing building is to be selected for renovation in order to improve performance or whether a new building will be constructed. An appraisal of different options may be necessary to inform decision-making (see 3.2.1.3)

The location of an office building will also have a significant influence on the mode of travel for people working in the building and the consequential environmental impact. This may be the subject of an Environmental Impact Assessment (see 3.2.1.3).

In general, locations that are better served by public transport (measured in terms of the level of connectivity), car club services for daytime business travel and local strategic cycle networks, as well as being near to local shops and services, have been shown to reduce the workforce's dependence on private car use. It is therefore recommended to carry out a scoping analysis of the locational options and projected travel patterns.

Another important consideration relates to whether the site is greenfield or brownfield. Choosing a greenfield site may result in the loss of productive agricultural land. On brownfield sites the previous uses require consideration, especially if they were industrial, as they may incur additional resources to remediate and/or remove contaminated top soils as well as to make safe any below ground basements and workings.

3.2.1.3 Concept design and options appraisal

Before moving into the detailed design phase (see Section 3.2.2), an appraisal of different options is usually carried out in order to inform the business case for the project. This may include decision-making about whether to renovate an existing building or construct a new building.

An outline design concept for the building form, structure and services would usually be developed at this stage. This could include the identification of building(s) renovation options (see below). Design concepts and options would then be appraised for their costs based on industry standard yardsticks, schedules of rates and initial assumptions about how the building will be constructed or renovated.

Establishing environmental performance objectives

It is important that minimum technical requirements and possible areas of focus for award criteria are established during this preliminary phase. This will ensure that they are clearly communicated throughout the tendering process and will help building a common understanding. Initially the focus could be on strategic environmental requirements, for example, related to energy performance and the target lifespan of the building. The scope could then be broadened in later procurements steps.

Renovation or new-build?

The decision to retain and renovate an existing building or to demolish and/or construct a new building may be finely balanced in terms of the costs and environmental benefits. The renovation of a building can have significant environmental benefits as a result of avoided impacts from the manufacturing of new construction materials. For example, the entire structural frame of a building could be re-used in situ. This may however be outweighed by the potential life cycle cost savings from the improvements in energy efficiency obtainable from a new building.

It is therefore important to first appraise whether, given the physical form and structure of the existing building, the building's environmental performance and, if necessary, internal working environment can be improved sufficiently in order to meet the contracting authorities requirements. For instance, certain features of a building such as heat loss from structural elements (so-called 'thermal bridging') may preclude a cost effective level of improvement when compared to the minimum local legal requirements or the GPP criteria.

Given the emerging market for energy efficient building renovation, external expertise could be used to identify state-of-the-art and cost effective solutions.

Environmental planning considerations

Where the decision is made to construct a new building (or buildings), environmental planning issues relating to the site would be subject to a screening decision. This would be used to determine whether the project is significant enough to be subject to an Environmental Impact Assessment under Article 4(2) Annex II of the EIA Directive 2011/92/EU. This could include, for example, the assessment of traffic impacts, air quality, noise and water and waste management.

Putting the team together: preliminary stages

At the preliminary stage the aim should be to draw upon internal expertise to support the procurer. Using internal expertise will ensure greater ownership of the project. The internal project team will in this way be better informed when managing external contractors, being able to maintain better control over the environmental specifications it requires.

Where possible, personnel with relevant expertise should be identified and assigned to the project. This might include, for example, representatives from estates, capital projects, finance, highways, energy and environmental management. Some authorities may also have in-house architects and designers.

Experience also suggests that the involvement of end-users of the building, for example representatives from departments as well as future facilities managers, can help to ensure that the building is designed to meet their needs and, particularly if new and unfamiliar systems are incorporated, is practical to operate and maintain.

Preliminary appraisals and outline designs may be carried out in-house with support from external consultants to make up gaps in expertise. Support to be procured could include Environmental Impact Assessments, Transport Assessments, Life Cycle Costing and renovation options appraisals.

Early assumptions about capital and life cycle costs

At this stage, initial assumptions about the cost of environmental improvements can be integrated into the cost planning for the project. Life Cycle Costing (LCC) is a technique that can be used to inform decisions on the cost and benefit of requiring specific GPP criteria (see the description of LCC below).

Reference office building concepts used internally to appraise the possible costs may be included in the Invitation To Tender (ITT) for design teams and construction contracts. Provided that they include a bill of construction materials, they could be used as the basis for comparative assessments of environmental improvement options for the construction.

Life Cycle Costing (LCC)

Life Cycle Costing is a technique that *'enables comparative cost assessments to be made over a specified period of time, taking into account all relevant economic factors both in terms of initial capital costs and future operational and asset replacement cost'* (Davis Langdon 2005). It is particularly relevant to achieving an improved environmental performance because higher initial capital costs may be required to achieve lower life cycle running costs. LCC exercises should be carried out with reference to ISO 15685-5 or equivalent.

Applying LCC requires specialist technical skills that should be procured by the contracting authority (if it does not exist in-house) to support initial appraisals and development of the Invitation To Tender (ITT) for main construction contract. Cost consultants will tend to be able to offer this expertise.

LCC can play a particularly significant role in Design, Build and Operate arrangements, which can be structured in order to incentivise the contractor to minimise long-term operating costs, including energy, water and waste management costs. It is also relevant to forms of Energy Services where a contractor is selected to renovate a building, usually recovering their capital investment from savings on the occupiers'

energy bills.

A number of tools and software programs are available to assist with Life Cycle Costing for new buildings and major renovations. Further information about LCC is available from the EU GPP website: http://ec.europa.eu/environment/gpp/lcc.htm

3.2.2 Detailed design and applications for permits

3.2.2.1 Specifying the design brief and performance requirements

Under conventional contracting arrangements

In a conventional contracting arrangement, a design is procured for the building project and a contractor is procured to construct this design (also referred to as an 'employer design' contact [175]) In the first step in this process a brief is therefore required, setting out the contracting authorities design requirements. These would usually be expressed in terms of GPP performance in order to provide designers with flexibility (for instance, energy use in terms of kWh/m^2), but they may also refer to specific GPP requirements (for instance, the use of timber from sustainably forestry). This brief would form the basis for the Invitation To Tender (ITT) for a design team, which could optionally be run as a design competition in order to encourage innovation.

Under integrated design and construction arrangements

Where design and construction are to be procured together (in "design and build" or "design, build and operate" contracts) the contracting authorities performance requirements assume a greater importance. This is because they will form the basis for the ITT for the main construction contractor and their design team. It is therefore important in these two types of contracts that GPP criteria are fully addressed within the performance requirements. It may be necessary to procure expertise at this stage in order to prepare the performance requirements.

Putting the team together: developing performance requirements and designs

As the project enters the detailed design stage, the contracting authority may wish to procure an external project manager with experience in innovative construction projects. The project manager's role could include supporting the development of the brief and/or the performance requirements as the basis for the ITT. They could also support the procurer by helping to troubleshoot issues or barriers to the implementation of GPP requirements.

Experience suggests that the core design team will require experience and expertise in a number of key areas which are identified in more detail in the GPP Selection Criteria:

- Architect: Knowledge and experience of designing and specifying environmentally improved buildings, ideally supported by evidence from post-occupancy surveys.
- Service engineers: Knowledge and experience of designing and specifying low energy heating, cooling, ventilation and lighting systems, ideally supported by evidence from post-occupancy surveys, as well as carrying out specialist analysis such as energy modelling.
- Specialist environmental consultants: Knowledge and experience in providing advice on innovation in areas such as materials sourcing, waste management and certification schemes, as well as the capacity to carry out specialist analysis such as LCA.
- Cost consultant: Knowledge and experience of environmentally improved specifications and construction systems, as well the capacity to carry out specialist analysis such as Life Cycle Costing (LCC).

It is important that experience and expertise is verified by references from clients and/or recognised certifications and qualifications. The criteria should be included in the ITT for all forms of contract.

175 Under the International Federation of Consulting Engineers (FIDIC) this would be equivalent to a Red Book contract.

3.2.2.2 Running a design contest for integrated design and build contracts

Where the design and build [176] are to be integrated in one contract, there tends to be less direct control over the final design. The performance requirements to be communicated to potential contractors are therefore important in formally specifying GPP requirements. These will then be used by the selected design and build contractor's design team to develop a detailed design as described in Section 3.2.2.3.

There is, however, still the potential to influence the design before the contract is signed. The main design and build construction contractor can be procured on the basis of a design contest. This can bring a number of benefits, particularly if the contracting authority is unsure about the cost and risk of meeting GPP criteria. This can be run in two stages, moving from concept designs to detailed designs. This option is briefly discussed in the box below.

The value of design contests in stimulating innovative design solutions

Design contests are a valuable tool that can be used to bring forward innovative designs (and design teams) and cost effective solutions on a competitive basis in response to performance requirements.

Integrated design and build contracts can be procured in two stages, incorporating a design contest. At the first stage, a qualification and shortlisting can be made based on expertise and an outline design concept. At the second stage the final selection can be based on detailed designs that have been fully costed by bidders.

The benefit in both cases is that the contracting authority has the opportunity to ensure the selected design cost-effectively integrates GPP requirements.

3.2.2.3 Commencing detailed design

Detailed design is carried out by a design team, the members of which can either be individually selected, called down from a framework contract or selected on the basis of a design competition. The process varies according to the form of contract:

- In a *conventional construction contract*, where there is a separation between the designer and the construction contractor [177], the design team is instructed by the architect who is accountable to the contracting authority.
- In a *design and build or a design, build and operate contract*, the design team is usually controlled by the main construction contractor, although it may be possible to 'novate' (transfer) the contracting authority's design team to the chosen contractor.

As we described in Section 3.2.2.3, the core design team will generally include an architect, project manager, cost consultant, consulting engineers (civils, structures and services) and specialist environmental consultants. Technical tools used by this team to meet GPP requirements should include building energy modelling and Life Cycle Assessment (LCA) software (see the summary for LCA below).

Life Cycle Assessment (LCA)

Life Cycle Assessment is a tool that can be used to analyse the environmental impacts of different building designs and specifications. It is specified in the GPP criteria as a means of quantifying improvements in the environmental impacts of buildings. LCA analyses for office buildings should be carried out in accordance with ISO 14040 and ISO 14044.

Using LCA requires specialist technical skills that should be procured, if not available in-house, as part of the design team. This technical capability should go hand in hand with practical knowledge and experience of the available improvement options, their material composition, their availability in the supply chain and their cost and design implications. If a GPP requirement to carry out an LCA of a building design is included, the technical expertise within the internal team and the procurement panel also becomes important. This is because bidders will need to follow pre-defined rules and guidance in order to ensure that they are comparable. Moreover, LCA reports submitted as part of bids will need to be subject to a critical review by an expert evaluator.

176 Under the International Federation of Consulting Engineers (FIDIC) this would be equivalent to a Yellow Book contract.

177 Under the International Federation of Consulting Engineers (FIDIC) this would be equivalent to a Red Book contract.

3.2.2.4 Applying for planning permission and building permits

The outcomes of the detailed design process (as described in Section 3.2.2.3) are important in seeking to meet GPP requirements. This is because they are generally used to demonstrate conformity with urban planning policies and to obtain building control permits, which usually require the submission of energy modelling showing that the building meets national minimum requirements for energy performance and, where relevant, incorporates low or zero carbon energy generation technologies. Local urban planning policies may also contain their own environmental requirements. In each case there is likely to be an overlap with GPP criteria.

3.2.2.5 Preparation of the tender documentation in a conventional contract

The detailed design forms the basis for the tender specification which will be used to procure the main construction contractor. It is therefore important that it incorporates GPP requirements. This could include requirements relating to:

- Target design life and upgradeability/recyclability;
- Design performance, such as energy and water consumption;
- Material specifications, such as specific combinations of building elements identified by LCA analysis and timber from sustainably managed forestry;
- Execution of the contract, including site waste management, handover of Building Energy Management Systems and testing of the building fabric.

There is evidence that reference is increasingly being made by procurers to performance benchmarks associated with multi-criteria building certification schemes and assessment tools. Contracting authorities and their procurers may therefore have questions as to how these may relate to the EU GPP criteria .

The potential relationship between the EU GPP criteria and existing schemes and tools is discussed further in the box below.

Working with existing building certification schemes and assessment tools

A number of existing building assessment and certification schemes are in operation across the EU. These include schemes that are being used across Member States together with a range of assessment tools that have been developed at a national or regional level. The more mature schemes and tools can provide a familiar reference point for private sector partners and contractors, and are generally third party verified.

The EU GPP criteria address the key areas of environmental impact along the life cycle of an office building, as well as addressing issues relating to health and comfort in the working environment. Existing schemes and tools tend to have areas of overlap with the EU GPP criteria, however the equivalence and weighting of the criteria can vary.

The contracting authority may also require the bidder to carry out a Life Cycle Cost assessment. Bids may then be compared on the basis of the 'Most Economically Advantageous Tender' (MEAT) considering life cycle costs. This should include the long-term cost of maintenance, utilities and waste management. It is recommended that the LCC is assessed as a global figure (i.e. all lifetime costs added together) and not as a separately weighted award criterion.

3.2.3 Strip-out, demolition and site preparation works

A range of works contracts may be required to prepare a building for renovation or a site for new construction. In either case the GPP criteria require that contractors carry out a pre-demolition/strip-out audit in order to determine what can be re-used, recycled or recovered.

This audit could take place at an earlier stage in order to maximise opportunities for the potential re-use of major structural elements of the building and to inform the decision to renovate or demolish (see Section 3.2.1.3).

The materials, products and elements identified shall then be itemised in a Strip-out *or* Demolition Bill of Quantities [178]. A waste management plan shall identify how recovery for re-use or recycling will be maximised.

3.2.3.1 Stripping out of buildings for renovation

The strip-out and selective demolition of existing structures on the site, including buildings intended for major renovation, may be let as a separate contract prior to the main construction contract. At this stage it should be specified that, based on the findings of a strip-out audit, materials shall be recovered for re-use and recycling according to a plan, with monitoring systems implemented to verify performance. The works should be carried out in accordance with the detailed design for the major renovation.

3.2.3.2 Demolition and clearance of sites

The demolition of existing structures on the site, as well as excavations and backfilling, may be let as a separate contract prior to the main construction contract. The specialist treatment of hazardous waste and contaminated land may also be contracted separately. At this stage it should be specified that, based on the findings of a demolition audit, materials shall be recovered for re-use and recycling according to a plan and in a closed loop if possible. Monitoring systems shall be implemented to verify compliance and, in the case of award criteria being set, the level of performance.

3.2.4 Construction of the building or major renovation works

3.2.4.1 Selecting the main construction contractor

Conventional contracts

In a conventional contract (also referred as employer design), a 'lump sum' is usually agreed with the selected main construction contractor. This price is usually based on the contractor's competitive response to the detailed tender specification but, allowing for some uncertainty during the build programme, it is not usually a fixed price.

In single stage tender it is important that the contractor has a clear understanding of the GPP performance requirements and has the capability to respond to them. The potential to include award criteria should already have been explored earlier in the process by the design team, but the nature of the contract will still allow for contractors to identify cost effective and innovative responses.

A main contractor may also be procured through a two stage tender process. In this process a main contractor is selected with whom a pre-construction agreement is signed. In the second stage the contracting authority and the main contractor tender most of the main sub-contracts in order to firm up the pricing of the project. This can in-turn allow for greater involvement by the contracting authority in selection of sub-contractors.

Integrated design and build contracts

In a contract with integrated design and build, the contractor will have been selected at an earlier stage on the basis of their capabilities and their design team's response to the contracting authority's performance requirements. The main advantage of this contract form is that it integrates the design team and the construction contractor, which can help to minimise risk and uncertainty in delivering innovative specifications. It also affords the contractor greater flexibility in meeting the performance requirements, but this places a strong emphasis on ensuring that performance requirements are carefully defined.

Design, Building and Operate (DBO) contracts

In a Design, Build and Operate contract [179] that include project financing, the risks associated with the project are transferred to the operator (the contractor), who is usually responsible for the building over a 20-30 year

178 European Commission, *Reference document on best environmental management practices in the building and construction sector*, JRC-IPTS, September 2012 see Chapter 7, Building end of life

timeframe or 'concession'. The contracting authority sets out its functional requirements for the building in a specification. Bidders are invited from potential operators with the appropriate financial strength and technical capabilities. Operators are usually a consortia or Special Purpose Vehicle (SPV) bringing together construction contractors, investors, specialist sub-contractors and services providers. Once a bidder is selected, a contract is agreed which includes the financial arrangement for use of the building by the contracting authority.

A potential advantage of a DBO arrangement is that facilities management and the ongoing performance monitoring of the building are integrated within the contract. Life Cycle Costing therefore become an important consideration because the contractor will seek to minimise running costs. This can be further incentivised in how the operating fee is structured. For example, a formula can be agreed for energy use in which savings are shared and increases are penalised.

The disadvantage is that the contractor will seek to minimise upfront investment costs. GPP requirements such as those relating to construction materials should therefore be prioritised during contractor selection. The DBO consortium's knowledge and experience of how to appraise and manage the supply chain to meet GPP requirements is important. DBO contractors that are experienced in meeting environmental specifications may, for instance, have developed cost effective construction systems and energy services.

Renovations carried out as 'energy services'

A relatively new form of design, build and operate contract that is attracting increasing interest is where renovations are carried out under a so-called Energy Performance Contract arrangement with a so-called Energy Services Company (ESCo). These third party ESCo's are invited to bid to provide a package of renovation works to reduce the energy consumption and/or CO_2 emissions of a building [180]. These works would tend to include physical measures such as new windows and insulation but could also include energy generation and supply technologies such as solar photovoltaics or biomass heating.

The works would be designed, installed and financed by the successful bidder on the basis of the energy savings that will be made by the building occupier over a medium to long-term time frame. The contracting authority would then contract to pay service charges calculated on the basis of the capital works carried out and the avoided energy costs.

3.2.4.2 Monitoring and reporting of progress on site

A number of GPP criteria require the contractor to monitor performance and report on progress as the build progresses. Site waste management, for example, requires ongoing data collection to determine how much waste has been recovered for re-use and/or recycling, before final reporting upon completion of the building. It is therefore important that requirements such as these are clearly communicated in the Invitation To Tender (ITT) and that agreement is reached on any interim monitoring as construction progresses.

3.2.5 Installation of energy services

The installation of mechanical and electrical services to supply power, heat and cooling to an office building can be procured in a number of different ways. These options are briefly discussed in this section.

3.2.5.1 Selecting energy service contractors

In many cases the design and installation of energy services to supply heating and cooling to the building will be integrated within the responsibilities of the design team and the construction contractor respectively. A separate procurement exercise is therefore not required.

179 Under the International Federation of Consulting Engineers (FIDIC) this would be equivalent to a Design, Build and Operate contract.

180 *See for example* Berlin Energy Agency, Germany, http://www.berliner-e-agentur.de/en/consulting-information/energy-saving-partnerships-berlin *and* RE:FIT, London, http://www.refit.org.uk/what-refit/

There is, however, increasing public sector interest in the procurement of third party providers such as Energy Services Company (ESCo) under Energy Performance Contracting (EPC) arrangements [181]. In this case the design, installation and operation of renewable or high efficiency energy generating equipment to supply the building become the responsibility of a specialist contractor.

ESCo arrangements may be extended to include the financing of the energy supply equipment or even a complete package of renovation works to a building, financed by energy savings made by the building owner. The procurement of an ESCo to carry out renovation packages was briefly discussed in Section 3.2.4.1.

Whilst this requires an additional procurement exercise, it creates an opportunity to invite the market to bring forward low or zero carbon emission solutions . The main potential advantages are lower upfront capital costs and the transfer of risk to the contractor. Examples of technologies that could be provided under this arrangement include cogeneration, district heating and cooling, biomass heating and solar photovoltaics.

3.2.5.2 The installation and commissioning of energy services

Experience internationally with the operation of low energy office buildings shows that innovative new forms of heating, cooling and ventilation systems can, if not designed, installed, commissioned and operated correctly, lead to higher than predicted energy use [182]. A GPP criterion has therefore been included that specifically addresses this issue. This criterion can be incorporated into the ITT for either the construction contractor or an energy services provider.

3.2.6 Practical completion and handover

3.2.6.1 The building manual and handover training

The building manual should be completed as part of the handover process. An upgrading plan to maintain, for example, high levels of energy efficiency during the service life of the building may also form part of a DBO contract. If a Building Energy Management System and other forms of intelligent control systems such as for lighting are specified, training on how they work, supplemented by information in the building manual, should be provided by the contractor and/or their design team.

3.2.6.2 Testing of the building fabric

Achieving an air tight and contiguous building fabric is a critical step in seeking to reduce heating and cooling demands. Experience in Europe with low energy office buildings suggests that this requires careful detailing by the architect and quality control on the construction site [183]. Designers and contractors can potentially be selected based on their track record as evidenced by performance data and surveys of completed buildings.

Prefabricated building systems are also a demonstrated means of ensuring quality and precision [184]. They can also bring additional environmental benefits such as, for example, reductions in factory and site waste.

The GPP criteria may therefore include technical specifications for testing the integrity of the building fabric using thermal imaging and air pressure tests. These requirements can be incorporated into the ITT for the construction contractor.

181 Under the International Federation of Consulting Engineers (FIDIC) this would be equivalent to a Silver Book contract.

182 IEA (2004) *Commissioning tools for improved energy performance*, ECBCS Annex 40 project, http://www.iea-ebc.org/projects/completed-projects/ebc-annex-40/

183 See for example Hannover *quality control scheme*, EU Concerto project, http://www.concerto-act2.eu/fichier/t_download/51/download_fichier_en_quality.assurance_en_130322.ds_act2.pdf

184 WRAP, *Current practices and future potential in modern methods of construction*, Final report, UK, January 2007

3.2.7 Facilities management

3.2.7.1 The role of the facilities manager

The ongoing management and maintenance of the office building may be carried out by the public authority or may be let as a separate contract to a specialist company. This would tend to include the operation of energy, water and waste management systems. The relevant GPP requirements should therefore be incorporated into the ITT.

3.2.7.2 Incentivising energy management

In Design, Build and Operate arrangements, the role of facilities manager is assumed by the contractor over a 20-30 year time frame. GPP contract performance criteria relating to the management of energy, water and waste should therefore be incorporated into the main contract with the DBO operator. These criteria also propose incentives and penalty clauses.

3.2.8 Post Occupancy Evaluation

3.2.8.1 Learning lessons from the project

The implementation of new specifications to improve the environmental performance of a building is often a learning process for design teams. Studies in a number of countries have shown that there can be significant value in diagnosing and sharing the lessons from what worked and what did not on building projects [185]. This is often termed a Post Occupancy Evaluation (POE).

A POE is generally carried out a minimum of one year after the building has been fully occupied. It tends to focus on the functional and technical performance of the building, as well as the management process. A POE generally consists of:

- Data collection to compare design and actual performance;
- Interviews with occupiers to evaluate their experience of using the building and aspects of the design and specification;
- Interviews with the design team to evaluate project performance as a whole, with a focus on the integration of environmental performance specifications.

Best practice would be for a POE to be carried out by a third party, which could be a University or specialist consultancy, and using a standardised methodology such as BUS (Building User Survey) [186].

The value of carrying out a POE is potentially two-fold. In the short-term, it can help optimising the performance of a building and identifying any remedial measures. In the medium-term, the learning can be used to make improvements to the design, specification, management and procurement processes on future projects. This is particularly important for the public sector where this learning can be carried forward to subsequent capital projects in order to obtain better value and performance.

185 See for example EnOB, *Research for energy optimised building*, Germany http://www.enob.info/en/analysis/analysis/details/workplace-satisfaction-and-comfort/

186 BUS methodology, http://www.busmethodology.org.uk/

3.3 LCC

Introduction to Life Cycle Costing (LCC) [187]

LCC analysis is a method for assessing the total cost of the product group. It takes into account all costs of acquiring, owning, and disposing of a building. The purpose of an LCC is to estimate the overall costs of project alternatives and to select the design that ensures the facility will provide the lowest overall cost consistent with its quality and function. The LCC should be performed early in the design process.

There are numerous costs associated with acquiring, operating, maintaining, and disposing of a building or building system. Building-related costs usually fall into the following categories:

• *Initial Costs*: Initial costs may include capital investment costs for land acquisition, construction, or renovation and for the equipment needed to operate a facility. Land acquisition costs need to be included in the initial cost estimate if they differ among design alternatives.

• *Fuel Costs*: Operational expenses for energy, water, and other utilities are based on consumption, current rates, and price projections. Because energy, and to some extent water consumption, and building configuration and building envelope are interdependent, energy and water costs are usually assessed for the building as a whole rather than for individual building systems or components. Energy costs are often difficult to predict accurately in the design phase of a project. Assumptions about use profiles, occupancy rates, and schedules impact on energy consumption. At the design stage, data on the amount of energy consumption for a building can be derived from ENERGY PLUS. Quotes for current energy prices from local suppliers should take into account the rate type, the rate structure, summer and winter differentials, block rates, and demand charges in order to obtain an estimate as close as possible to the actual energy cost. The energy prices are assumed to increase or decrease at a rate different from general price inflation. This differential energy price escalation needs to be taken into account when estimating future energy costs.

• *Operation, Maintenance, and Repair Costs* (OM&R)*:* Non-fuel operating costs, and OM&R costs are often more difficult to estimate than other building expenditures.

• *Replacement Costs*: The number and timing of capital replacements of building systems depend on the estimated life of the system and the length of the study period. Usually, the same sources that provide cost estimates for initial investments are used to obtain estimates of replacement costs and expected useful lives.

• *Residual Values*: the residual value of a system (or component) is its remaining value at the end of the study period (50 years), or at the time it is replaced during the study period. As a rule of thumb, the residual value of a system with remaining useful life in place can be calculated by linearly prorating its initial costs.

• *Finance Charges—Loan Interest Payments*: For public projects, finance charges are usually not relevant but may be relevant for public:private arrangements.

Only those costs within each category that are relevant to the decision and are of a significant amount are needed in order to make a valid investment decision. All costs are entered as base-year amounts in today's euro; the LCCA method escalates all amounts to their future year of occurrence and discounts them back to the base date to convert them to present values.

Moreover, several parameters for a Net Present-Value Analysis should also be considered. These parameters are mainly:

• *Discount Rate*: In order to be able to add and compare cash flows that are incurred at different times during the life cycle of a project, they have to be made time-equivalent. The interest rate used for discounting is a rate that reflects an investor's opportunity cost of money over time, meaning that an investor wants to achieve a return at least as high as that of her next best investment. Hence, the discount rate represents the investor's minimum acceptable rate of return.

• *Length of investment period*: The investment period begins with the base date, the date to which all cash flows are discounted. The study period includes any planning/construction/implementation period and the service or occupancy period. The study period is the same for all alternatives considered.

• *Service period*: The service period begins when the completed office building is occupied. This is the period over which operational costs and benefits are evaluated.

[187] Sources: http://www.wbdg.org/resources/lcca.ph

• *Treatment of Inflation*: An LCC can be performed in constant euro or current euro. Constant-euro analyses exclude the rate of general inflation, and current-euro analyses includes the rate of general inflation in all euro amounts, discount rates, and price escalation rates. Both types of calculation result in identical present-value life-cycle costs.

Constant-euro analysis is recommended for all public projects. The constant-euro method has the advantage of not requiring an estimate of the rate of inflation for the years in the study period. Alternative financing studies are usually performed in current euro's if the analyst wants to compare contract payments with actual operational or energy cost savings from year to year.

The LCC calculation is carried out after identifying all costs by year and amount and discounting them to present value, they are added to arrive at total life-cycle costs for each alternative:

LCC = I + Repl — Res + E + W + OM&R + O

LCC = Total LCC in present-value (PV) euro of a given alternative

I = PV investment costs (if incurred at base date, they need not be discounted)

Repl = PV capital replacement costs

Res = PV residual value (resale value, salvage value) less disposal costs

E = PV of energy costs

W = PV of water costs

OM&R = PV of non-fuel operating, maintenance and repair costs

O = PV of other costs (e.g., contract costs for ESPCs or UESCs)

Supplementary measures of economic evaluation are Net Savings (NS)[188], Savings-to-Investment Ratio (SIR)[189], Adjusted Internal Rate of Return (AIRR)[190], and Simple Payback (SPB)[191] or Discounted Payback (DPB)[192]. NS, SIR, and AIRR are consistent with the lowest LCC of an alternative if computed and applied correctly, with the same time-adjusted input values and assumptions. Payback measures, either SPB or DPB, are only consistent with LCCA if they are calculated over the entire study period, not only for the years of the payback period. All supplementary measures are relative measures, i.e., they are computed for an alternative relative to a base case.

Decisions about building-related investments typically involve a great deal of uncertainty about their costs and potential savings. Performing an LCC greatly increases the likelihood of choosing a project that saves money in the long run. Yet, there may still be some uncertainty associated with the LCC results.

Findings from LCC analysis of an example base-case

In the preliminary background study a life cycle cost assessment was carried out for a base-case office building defined as an example. This LCC exercise demonstrated that it is important not to consider investment cost in isolation, but instead the life cycle cost including energy and water use over the product's life. The LCC approach allows public bodies to explore the costs and benefits of different office building not just according to their investment costs but also their operational cost. The calculations above show that the costs of energy, especially those of electricity dominate the LCCs for office buildings.

Lighting and control systems

[188] NS = Net Savings: operational savings less difference in capital investment costs NS > 0 (for determining cost-effectiveness)

[189] SIR = Savings-to-Investment Ratio: ratio of operational savings to difference in capital investment costs. SIR > 1 (for ranking projects)

[190] AIRR = Adjusted Internal Rate of Return: annual yield from an alternative over the study period, taking into account reinvestment of interim returns at the discount rate. AIRR > discount rate (for ranking projects)

[191] SPB = Simple Payback: time required for the cumulative savings from an alternative to recover its initial investment cost and other accrued costs, without taking into account the time value of money

[192] DPB = Discounted Payback: time required for the cumulative savings from an alternative to recover its initial investment cost and other accrued costs, taking into account the time value of money

SPB, DPB < than study period (for screening projects)

The assessment shows that just by changing energy consumption in lighting, and keeping all other aspects equal, savings ranging from 17,800€ to 13,000€ euros can be achieved per office building for the base-case examples over their lifetime. Even if investment costs were 4 times higher across all examples, the savings in each case would still exceed the increase in investment cost.

If an office building has additional lighting control systems, the life cycle costs can be expected to drop even further, as electricity for lighting forms the most cost-intensive factor along the product life cycle (nevertheless, the calculation of this saving is difficult due to the variability of daylighting depending on the location and design of the building under study). Moreover, it is clear that given the large possible variation in designs, functions, investments and use patterns across Europe, the inputs for the LCC assessment will need to be considered by purchase authorities on a case by case basis.

Window specifications

The greatest financial savings in heating and cooling can be made through the improvement of windows. This aspect is of especial importance for office buildings located in middle to colder climatic zones. The investment strategies should therefore be developed to specify lower U-value windows, such as double and triple glazing windows, in order to minimise the life cycle costs of office building. Improved insulation of external walls can provide further savings but it strongly depends on the location and design of the office building, as external classing systems can have very substantial capital costs.

Insulation levels

Increasing the insulation levels on existing buildings, which generally have poor insulation, is a measure which can provide large energy savings, particularly related to the reduction on space heating demand. The costs of this measure in existing buildings are relatively large, as besides the insulation material costs; there are also other related costs, such as those related to labour and equipment to access the building facades or internal walls, significantly increased the overall investment cost of the insulation technique used. However, if the insulation works are carried out together within an integral refurbishment strategy, as it is usually the case, the costs allocated for the insulation could be diminished. If this is the case, the estimated costs for the insulation and the IRR values presented in the chart change significantly, obtaining better values.

The savings that can be achieved by using the above mentioned measures depend on the use pattern for offices in public buildings, for example an office building devoted to beaurocratic work such as that of a ministerial office building or a council building compared to an office building devoted to post services, where storage facilities, reception desks/counters and other kind of facilities must be close to the employees desks. The expected use will need to be considered carefully by the purchasing authority in order to calculate the LCC accurately.

The installation, repair and maintenance costs used in the above analysis are not considered. Depending on the type of installations, the function of the office building or level of repair and maintenance these costs will vary case by case. Nevertheless, repair and maintenance costs are likely to be relatively low in the overall life cycle costs. Likewise installation replacement cost of some buildings elements is neither considered. These costs such as the replacement costs of windows or external doors will depend on whether it is part of larger refurbishment work or not so large.

A comparison of the proposed improvement measures from the environmental and financial points of view was carried out. The comparison was based on the percentage of reduction of the environmental impact per thousand euro invested and its internal rate of return (IRR). Figure 3.1 shows the results for the base cases located in London. Those measures, whose ratios are in the upper-right corner, such as lighting control options or triple glazing windows are highly beneficial from both economic and environmental perspective.

Improvement measures which have larger associated costs compared to the environmental savings would appear lower in the graphic and to the left if the investment is not recovered. This is the case of the increased insulation when the investment costs should be entirely recovered by the energy savings. However, when a major renovation is decided, mainly due to other reasons such as a new layout of the offices, the investment needed is much lower and consequently the ratios shift toward the upper-right part of the chart.

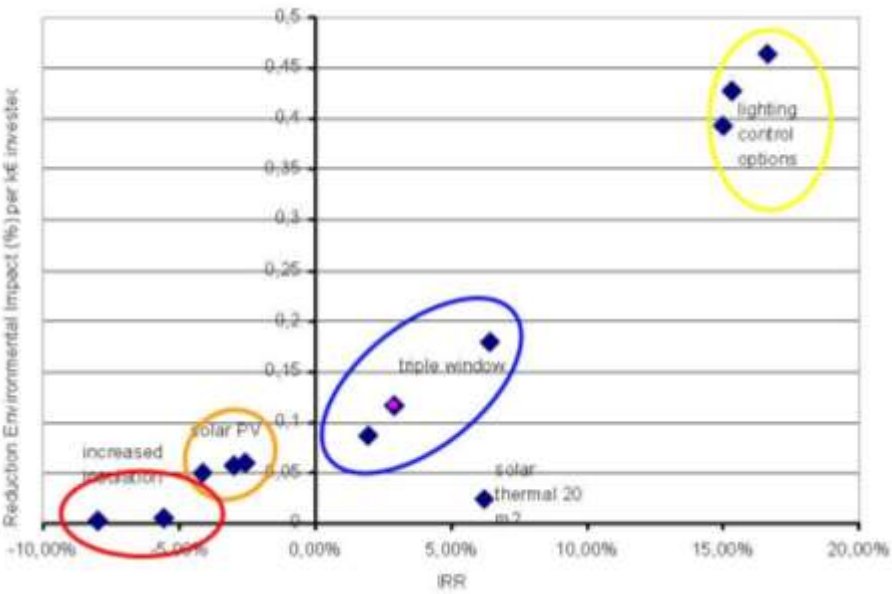


Figure 3.1: Comparison of the percentage of reduction of the environmental impact per thousand euro invested and its internal rate of return (IRR) for several improvement measures analysed in this section,