Green Public Procurement

Office buildings

Technical Background Report

Report for the European Commission – DG-Environment by JRC IPTS, 2011

Owner, Editor: European Commission, DG Environment-C1, BU 9, 1160 Brussels.

Table of contents

List of Tables **5**
List of Figures **6**
introduction **7**
1. Definition, scope and background **9**
1.1 Definition 9
1.2 Scope and background 9
2. Market overview **11**
2.1 Economic and market analysis of the office buildings 11
3. Key Environmental impacts **14**
3.1 Environmental Impact assessment of office buildings - analysis 15
3.1.1 Setting up the Base-case 15
3.1.2 Product specific inputs 15
3.1.3 Environmental impact assessment 16
3.1.3.1 Environmental impacts related to the resources and waste 16
3.1.3.2 Environmental impacts related to the emissions to air and water 18
3.1.4 Environmental impacts assessment for office buildings - summary 19
3.2 Analysis conducted in the framework of EU Ecolabel criteria development and the GPP criteria development for construction 19
3.2.1 Energy efficiency, less polluting energy sources and energy monitoring system 19
3.2.2 Selection of construction materials 25
3.2.3 Use/avoidance of hazardous substances 30
3.2.4 Water saving and water management plan 33
3.2.5 Waste management 35
3.2.6 Other key environmental areas 37
3.2.6.1 Information to the users 37
3.2.6.2 Promotion of bicycles 38
3.3 Additional aspects relevant for the Green Public Procurement 39
3.4 Improvement potential 39
3.4.1 Preliminary calculations of the improvement potential based on the results of the study 40
4. Cost considerations **42**
4.1 Introduction to Life Cycle Cost (LCC) 42
4.2 Green Public Procurement of office building 44
4.3 Life Cycle Costs for office buildings 45
4.3.1 LCC analysis considering only the improvements in the external walls 46
4.3.2 LCC analysis considering only the improvements in the external walls and windows 48

4.3.3 LCC analysis considering the improvements in the lighting control system 49
4.3.4 LCC analysis considering water saving products 52
4.4 Life cycle costs assessment - Summary 53
5. Public Procurement Needs 55
5.1 Procurement considerations 55
5.1.1 Project development 55
5.1.2 Preliminary design / architects competition 55
5.1.3 Submission of the planning 56
5.1.4 implementation planning 56
5.1.5 Construction work and implementation of building services 56
5.2 Purchasing demands 56
5.3 Purchasing phases 57
5.3.1 Preliminary design / architects competition 57
5.3.2 Tendering for the building construction 57
5.3.3 Tendering for the building services 58
5.3.4 Experience of the construction contractor and/or property developers 58
5.5 Other aspects to be considered 59
5.5.1 Sustainable site and building design 59
5.5.1.1 Indoor air quality 59
5.5.1.2 Behavioural aspects 60
5.5.1.3 Promotion of renovation work 60
6. Proposal for core and comprehensive criteria 61
7. Verification issues 75
8. Conclusions and summary 76
9. Existing Standards, Ecolabels and other information sources 78

List of Tables

Table 1. Parameters that define the generic building simulated in this work

Table 2. Percentage of the environmental impacts depending on the location and phase of the buildings

Table 3. Energy performing of the office building with the 20% best energy performance

Table 4. Environmental and economic results of the improvement measures.

Table 5. Inputs of the LCC

Table 5a. Costs along the office building life cycle for the B1-N-01 building

Table 5b. Life cycle cost per life cycle stage for the B1-N-01 building

Table 6. Economical parameters considered in this study

Table 7. Cost analysis of improvement measures for the reduction of the U value of external walls in London, Madrid and Tallinn for several base cases

Table 8. Cost analysis of improvement measures for the reduction of the U value of external walls and windows in London, Madrid and Tallinn for several base cases

Table 9. Cost analysis of improvement measures for inclusion of lighting control systems in new office buildings in London, Madrid and Tallinn for several base cases

Table 10. Cost analysis of improvement measures for inclusion of PV systems and PV electricity is consumed in new buildings located in London, Madrid and Tallinn

Table 11. Cost analysis of improvement measures for inclusion of PV systems and PV electricity is sold to the grid in new buildings located in London, Madrid and Tallinn

Table 12. Cost analysis of improvement measures for inclusion of thermal solar panels (20, 40 or 60m^2) in new buildings located in London, Madrid and Tallinn

Table 13: Key environmental impacts for construction works

Table 14: Background study and environmental aspects for construction works

Table 15: Swiss Minergie Categories

Table 16: The mandatory Code for sustainable homes.

List of Figures

Figure 1. Generic building used in this study

Figure 2. Energy consumption distribution of an office building during the use phase without considering the office equipment energy consumption

Figure 3. Typical breakdown of water usage in office buildings

Figure 4. Breakdown of the costs for the B1-N-01 building

Figure 5: GPP proposed areas for developing criteria regarding construction works

Introduction

Green Public Procurement is a voluntary instrument, which basic concept relies on "having

1. clear,
2. verifiable,
3. justifiable and
4. ambitious environmental criteria for products and services, based on a
5. life-cycle approach and
6. scientific evidence base"[1].

Moreover in general – due to Procurement Rules – the criteria should:

1. be proportionate
2. have a clear objective and
3. provide equal access for tenderers to the tender offer

The European Commission has presented so far several sets of recommended GPP criteria for a range of different products and services, which are available at the dedicated website: http://ec.europa.eu/environment/gpp/gpp_criteria_en.htm.

The following Technical Background Report presents the proposed Green Public Procurement criteria developed for the product group of **'Office buildings'**. It also contains background information on the environmental impacts of office buildings and describes the most important European legislation and labelling schemes relevant to this product group.

This report, together with associated **EU GPP criteria proposal** (which contains proposed purchasing criteria and supplementary information for green tender specifications) constitute the working material for the ad-hoc Working Group meeting and a starting point for discussion on these criteria.

This background product report aims at complementing the Product Sheet on Office buildings, by providing more in-depth information on why the purchasing recommendations included in the Product Sheet have been set. Where possible the criteria presented will be based on the criteria of EU Ecolabel for Office buildings. Where the EU Ecolabel does not cover a need of the GPP criteria for office buildings, other sources have been used.

For the GPP of Office Buildings two sets of criteria are presented:

- **Core criteria**: these are designed to be used by any European contracting authority. They address the most significant environmental impacts, and are designed to be used with minimum additional verification effort or cost increases. This set of criteria can be used as minimum criteria to develop the tender.

[1] http://www.ec.europa.eu/environment/gpp

- **Comprehensive criteria**: these are intended for use by authorities who wish to purchase the best environmental products available on the market, and may require additional administrative effort or imply a slight cost increase as compared to the purchase of other products fulfilling the same function. The comprehensive criteria can be used as incentives for the market to gain added value based on Total Cost of Ownership (LCC).

Generally speaking, for construction and therefore for office buildings different forms of procurement exist that are only predominately used. Tenders following these GPP criteria are recommended to cover the different construction organization forms and the different contract forms determining in which extend responsibilities and risks are shared with the market.

1 Definition, Scope and Background

1.1 Definition

This document covers procurement of office buildings by public authorities. The definition of this product group was agreed in the criteria development process in the framework of the Ecobuilding project, as follows:
"An **office building** is a building which **contains administrative, financial, technical and bureaucratic activities as core representative activities**. The office area must make up a vast majority of the total buildings gross area dedicated to this purpose providing a service to other companies or to individuals. Therefore, it could have associated other type of spaces, like meeting rooms, training classes, staff facilities, technical rooms, etc". Excluded from this definition are parking areas that are not counted in this total buildings gross area.

Due to the various locations and designs of office buildings throughout the last years, the category of office buildings is divided into new and to be renovated buildings and existing buildings. This last kind of office buildings is not considered into the scope of these guideline. Additionally it should be taken into account that the design of the office buildings depends on their location. Due to this fact, additional differentiation of the buildings has been carried out with reference to the climatic zones where they may be located.

1.2 Scope and background

The European Commission aims at developing an EU Ecolabel for the "Buildings" product group. Against this background, the Italian Competent Body commissioned intensive research activities that result in draft criteria for the EU Ecolabel for "Buildings". This study, presented in August 2010, grouped buildings under "new" and "existing ones", and slightly different criteria for each type were proposed.

The European Commission announced that it would evaluate the draft criteria against the background of a number of comments from stakeholders. As main result of this evaluation, it was proposed to limit the scope of the project to office buildings (new and existing office buildings) and to exclude in this initial phase residential buildings. The main reasons were the high environmental impacts of this type of buildings, its large aggregated stock figures in EU and expectation of growth, the high harmonization potential with regard to other product policies such as GPP and the high effective potential of the EU Ecolabel. Companies are generally the owners of office buildings and have a high interest in communicating their environmental commitment to the public. There is also a high potential for harmonization with existing labeling schemes at Member State level.

In addition, an analysis and evaluation of the Ecolabel criteria included in the draft criteria document was carried out. From this analysis some improvements and modifications were raised. Among them, the set up of a stricter benchmark for the total energy consumption of the building depending on the climatic area, altitude or age of the building, the promotion of renewable energy systems, lower

consumption lighting, reduction of water consumption and collection and sorting for proper valorization of the waste are some of the most prominent ones.

Finally, and after the first AHWG meeting for the development of EU Ecolabel and GPP criteria the **scope of this study** was restricted to **new and major renovated office buildings**. Moreover, during this meeting the main environmental criteria areas, where the EU Ecolabel and GPP criteria are expected to be developed were agreed. These key **environmental criteria areas** are:

- Energy consumption
- Selection of building materials
- Indoor air quality and well-being
- Waste management
- Water consumption and management
- Facilities
- Corporate criteria

2 Market overview

The following section presents market data based on the information obtained from different sources. The information extracted is aggregated for office buildings across Europe, and the values referring to public procurement are separately indicated. However, it should be taken into account that data presented may be incomplete or approximate, due to a lack of availability of data in this product group.

In the framework of the "**Office building project**" a detailed market analysis for office buildings for the EU-27 was conducted. Official EU statistics data were collected to analyse the construction within the EU and individual member states (MS). In addition, the existing stock was calculated and an estimation of future constructions was carried out.

Detailed results of this analysis are available in the Economic and market analysis report, accessible at the project's website[2]. A summary of the main points is given below. It should be however 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.

Furthermore, information related to the current financial situation in Europe is linked to the market of office buildings. Research papers were revised to explore links between the macroeconomic parameters and the trends in the office building market. To complete the analysis, some evidence to know whether demand for ecolabelled office buildings is likely to be higher or lower than demand for non-ecolabelled office buildings is provided.

2.1 Economic and market analysis of the office buildings

Unfortunately, to the best of the authors´ knowledge, there is no official data on office buildings stock in EU-27. Estimates have been found from different sources for only a few countries. Moreover, data on the office sector are often outdated and assembled from sector estimates, as a result of which their statistical validity can be doubted. Furthermore, the comparability of data between countries may be low because different definitions may have been used in the different countries. To sum up, office building data are not official and rarely harmonized between countries.

In terms of main results, first of all, office buildings are part of the non-residential building stock which represent 1% of the total building sector. Most of them are concentrated in the moderate climatic zones (4,382.2 million of m^2), are large office buildings (4,278.7 million of m^2) and were mainly erected before 1975 (6,277.2 million of m^2).

Office rents and vacancy ratios are basically obtained from changes in national Gross Domestic Product (GDP), inflation and unemployment rates. Economic indicators show a scenario of clear economic recovery from the crash experienced in 2009 (since GDP growth is positive and higher in 2010 with respect to 2009), which can be interpreted as a sign of short term recovery of office building demand. However, investment component-which is the component more related to the office building

[2] Economic and market analysis report available online at: http://susproc.jrc.ec.europa.eu/buildings/stakeholders.html

market- is still decreasing for the EU-27 (-0.6%), which can be interpreted as an absence of economic recovery consolidation. That is, recovery is unstable at this moment. The absence of a clear inflationary pattern (although it seems that EU-27 has avoided deflation risk) and higher and difficult to reduce unemployment rates, reinforce this point. Obviously, a higher dispersion is found when individual countries are analyzed. Thus, Germany, Luxembourg, Malta, Poland, Slovakia, Finland, Sweden and the United Kingdom show a stable economic recovery (that is a higher probability of demand for office buildings), while Portugal, Italy, Greece, Spain, Ireland, Bulgaria, Romania, Latvia, Lithuania, Hungary and Slovenia show recession or stagnation scenario (that is a lower probability of demand for office buildings). Office Market indicators from cities from up to 17 of the EU-27 countries show rising availability (higher than 10%), weak demand and widespread rental declines (18%) across Europe since 2008 for office buildings

In terms of short-term indicators for the construction sector, the presented information describes a sector with lower and decreasing demand (and, therefore wages). In this sense, a continuous adjustment to the construction sector is expected for years 2011 and 2012 with an eventual recovery in year 2013 because, as forecasted, 2011 and 2012 will be the years for the overall economic recovery. The construction sector is a pro-cyclic sector with some lag with respect to overall economy, so the recovery of the construction sector is expected to take place later on. In terms of the office building sector, this fact implies that new office building construction is also expected for 2013. That is, this lag in the construction sector in relation to overall activity is expected to be lower for the office building sector. Thus, and due to its close relationship to economic evolution, it can be expected that the reduction of availability of space will start in 2011 and 2012.

In addition, in terms of short-term indicators for, specifically, the office building sector, an important decrease in the number of permits in the office building sector in 2009 (32.41%) can be observed. This decreasing pattern is particularly significant in: Lithuania (74.38%), Slovakia (50.81%), Spain (46.22%) and Bulgaria (40.89%). It is expected that during 2010-2011 the scenario for building permits will change from decline accelerating to decline slowing and, for some countries, a growth accelerating scenario will start. In this sense, as economic growth in the EU-27 is expected to be accelerated over the 2010-2015 period from the forecasted 1.7% (2011) to a 2.4% GDP annual growth, this will result in an increased office employment in the EU-27 by an annual growth of 1.2%.

Demand for ecolabelled office buildings is likely to be higher than demand for non-ecolabelled office buildings since a significant positive relationship between occupancy rate and the ecolabel is found. Fuerst and McAllister found a significant positive relationship between occupancy rate and the ecolabel[3]. Depending on local market characteristics and methods, an ecolabel premium in vacancy rates could, based on studies from the USA, range from 2% to 18%. This would imply that owners of green buildings would see a higher income return from their portfolio, as they would have greater success in converting theoretical rental value into actual rental income from occupied property.

Finally, **public activity** is a crucial element to be considered. The EU-27 average size of government expenditure was 46.9% of GDP. In terms of functional distribution, the EU-27 environment expenditure

[3] [Fuerst & McAllister, 2009]

represents 0.8% of GDP (1.7% of government expenditure) while EU-27 expenditure in construction and housing accounts for 1.4% of GDP (3.0% of government expenditure). Moreover, not only governments' expenditure but also the percentages of GDP spent on environment and construction works and housing expenditure have remained stable from 2000 in EU-27, although, environment expenditure growth has been slightly higher than other aggregates. In this sense, one can also argue that 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 budgets constraints. **The percentage of office buildings from the government and municipalities for some EU-27 countries e.g: The Netherlands (3%), Germany (20%), France (30%), Austria (17%) and Finland (11%).**

As a result, 2010 was the year of EU's debt crisis. Some countries have developed intensive fiscal austerity policies and EU's Finance Ministers have 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, the amount of money spent on environmental policy will be the one observed in the years before the financial crisis. So, we can expect that in next few years subsidies from the governments to promote green buildings will be reduced, since even though environmental policies will not loose relative importance, its importance will be reduce in absolute budgetary terms.

3 Key Environmental Impacts

The environmental performance of this product group was assessed by applying the LCA tool. LCA tool shows various potential environmental impacts related directly or indirectly to the product life cycle. In addition, this study was completed by using other techniques such as the revision of existing member states labels or the revision of published scientific documentation. In this study, which is streamlined LCA tool, all the life cycle phases of the office buildings including raw material extraction, production, construction, use phase, demolition and dismantling phase are analysed[4].

For the purpose of the project one generic office building (base-case) with flexible parameters was identified and investigated. In this environmental assessment the focus was placed on identifying which product life phases (i.e. production, construction, use or end of life phase) contribute most to the overall environmental impacts of office buildings and which are the most relevant environmental aspects. The entire analysis and detailed results can be found in the Technical analysis report (available online at the product website). In this report also all the necessary assumptions, which are made regarding setting the system boundaries and estimating the user behaviour, are given. The main points of analysis and its outcomes are summarised below.

For each life cycle phase information was collected from available sources, e.g. existing studies, reports and stakeholder's feedback. The calculation of energy consumption in the use phase strongly depends on user behaviour, a number of assumptions had to be made in order to estimate the average typical user behaviour and to calculate the average breakdown (heating, cooling, auxiliary equipments, lighting and hot water) energy consumption, taking into account the variability across various Member States (three locations Madrid, London and Tallinn were selected as representative of the three climatic zones and user behaviours across Europe). The calculation procedure and all assumptions used are presented in detail in the technical analysis report. The aim of this study is to identify the key environmental impacts and to develop the most appropriate EU Ecolabel and GPP criteria at European level. However, national methods and tools could give clear insight in the impact of measures in each Member State. It is recommended to check them when possible.

The impacts are shown for each identified base-case. Several environmental impacts were assessed: total energy consumption, non-hazardous and hazardous waste generation, greenhouse gases emissions, acidification and eutrophication, water consumption, etc. The results obtained are presented below. The results show clearly that for the majority of the environmental impact categories the use phase has the highest impact, dominating the entire life cycle impact of the office building. This is explained due to the multiplication of the yearly environmental impacts of the annual use of an office building with a life span ranging over 50 years, as given in Table 2.

For the majority of the numerous environmental impact categories the use phase clearly has the highest impact. In particular, consumption of energy is dominating the entire life cycle impact of this

[4] A detailed analysis and result interpretation of the results of environmental assessment of office buildings was conducted in the frame of the project's Technical analysis. The following section constitutes a part of this report. The complete report is available at the project's website

product group. The environmental impacts related to the use phase account for more than 73% and for some categories even more than 98% of the total impacts. Only the environmental impact of ADP (Abiotic Depletion Potential) is not outstanding in the use phase

3.1 Environmental Impact Assessment for office buildings – Analysis[5]

3.1.1 Setting up the Base-case

To understand where in the product life cycle the impacts occur an example office building has been used to generate an indication of the life cycle impacts over the different life cycle phases. A generic office building model with flexible parameters is considered to simulate the currently available office buildings on the market, although it should be noted that each office buildings is unique due to its design, location, size, etc. A picture of the office building model is shown in Figure 1.

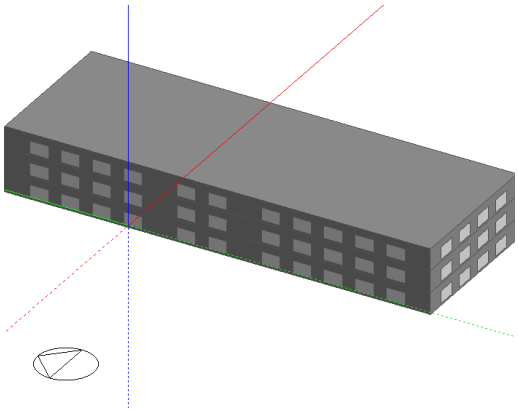

Figure 1. Generic building used in this study

3.1.2 Product Specific Inputs

The characteristics of the generic office building were considered to be the following ones:

Table 1. Parameters that define the generic building simulated in this work

Parameter	
Size	4620m²
Lay-out	3 floors
Geometry	Rectangular shape
Orientation	East-west
Glazing area	30-50%
Water consumption	55l/p/day

However, the construction details are difficult to set at EU-27 level, as they are strongly dependent on the location and regional regulations. For this reason, for each location the regional regulations were taken into consideration to estimate the thermal transmission values and isolation (U values).

The inputs of the use phase were calculated depending on the location and some additional assumptions such as the amount of glazing, the lighting control, the type of fuels, the use or not of

[5] This section constitutes a part of the Base-case assessment report, available online: http://susproc.jrc.ec.europa.eu/buildings/stakeholders.html

renewable energies, etc. Taking into account these parameters, the energy consumption of the office buildings was estimated by using the freely available software Energyplus, a whole building energy simulation software.

The product lifetime is based on the information provided by the Energy Performing Building Directive 2002 and set up as 50 years until the first major renovation. However, other information sources[6] consider that the replacement and renewal of building main installations takes place, normally, also for economical reasons, every 25-30 years. For this reason, and although the analysis was carried out considering 50 years, a staged approach is suitable to be followed for this kind of products and consequently for the development of the tender. The lifetime of the different parts of a building can enormously vary and it is likely that the performance and technologies used can improve drastically during the next years.

- primary elements like load bearing constructions have a lifetime of 50-75 years
- secondary elements like facades, HAVAC delivering elements, etc have a lifetime of 25-30 years
- tertiary elements like lighting, sun shading, ceilings, floor covering, non-structure walls, HVAC generating components, sanitary, etc have a lifetime of 10-20 years

3.1.3 Environmental Impact Assessment

3.1.3.1 Environmental impacts related to the resources and waste

A summary of the data generated by the LCA study, based on the inputs described above, is provided Technical Analysis report that can be found on the official website of this project. The environmental impacts calculated per each of the locations and base case office building models are provided in the following Table 2.

Table 2. Percentage of the environmental impacts depending on the location and phase of the buildings

Impact Category	Units (%) kg xx equiv	MADRID, 30% glazing			
		Product	Construction	Use	End of life
GWP	kg CO_2	8,30	0,06	91,22	0,42
ODP	kg CFC 11	12,07	0,00	87,88	0,05
AP	kg SO_2	0,59	0,02	99,31	0,09
EP	kg $(PO_4)^{3-}$	4,06	0,20	94,91	0,82
POF	kg Ethene	1,18	0,04	98,45	0,33
ADP	kg Sb	94,23	0,00	5,76	0,01
PEC	MJ	5,51	0,06	94,14	0,28
WC	m^3	0,87	0,00	98,92	0,21
Impact Category	**Units (%) kg xx equiv**	**LONDON, 30% glazing**			
		Product	**Construction**	**Use**	**End of life**
GWP	kg CO_2	14,56	0,06	84,98	0,40
ODP	kg CFC 11	25,45	0,00	74,51	0,04
AP	kg SO_2	0,62	0,02	99,27	0,09
EP	kg $(PO_4)^{3-}$	4,39	0,20	94,55	0,85
POF	kg Ethene	1,27	0,04	98,36	0,33
ADP	kg Sb	94,83	0,00	5,16	0,01
PEC	MJ	5,95	0,06	93,69	0,29
WC	m^3	0,95	0,00	98,84	0,21

[6] Dutch Building Decree http://www.irbnet.de/daten/iconda/CIB1759.pdf

Impact Category	Units (%) kg xx equiv	TALLINN, 30% glazing			
		Product	Construction	Use	End of life
GWP	kg CO_2	13,65	0,05	85,92	0,38
ODP	kg CFC 11	26,34	0,00	73,62	0,04
AP	kg SO_2	0,62	0,02	99,27	0,09
EP	kg $(PO_4)^{3-}$	4,29	0,20	94,69	0,83
POF	kg Ethene	1,25	0,04	98,38	0,33
ADP	kg Sb	94,77	0,00	5,22	0,01
PEC	MJ	5,47	0,06	94,20	0,27
WC	m^3	0,96	0,00	98,83	0,21

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

Table 2 provides the three cases and life cycle phases to illustrate the comparison between the locations for the different environmental impact categories. It should be noted that for the majority of the environmental impact categories the use phase clearly has the highest impact, dominating the life cycle impact of the product.

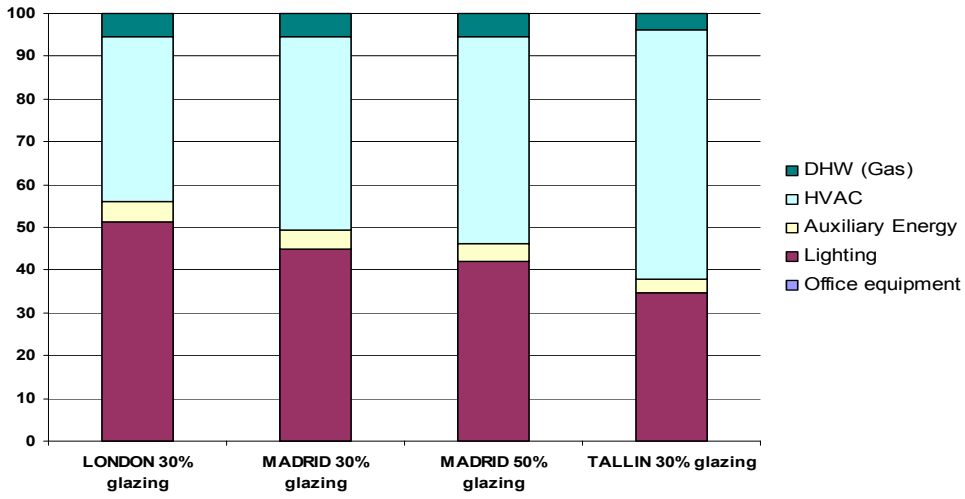

Figure 2. Energy consumption distribution of an office building during the use phase without considering the office equipment energy consumption

The total energy consumption is dominated by the energy use for lighting and HVAC in the use phase, as reported in Figure 2. The energy consumption breakdown is similar for most of the base cases simulated, regardless of the location or design characteristics. Especially in the cases where no lighting control is considered, the lighting energy consumption reaches around 30-50% of the overall energy consumption of the office building.

The breakdown of the energy consumption was checked by revising published documentation. For example, in a new office building in Netherlands lighting is responsible of 25-30% of the energy consumption of the building. Other consumers are the fans for the venting system (around 30%). Together with heat loss the ventilation covers 30-40% of the energy demand.

Due to the high energy consumption in lighting, the introduction of partial or total lighting control was studied. The lighting control reduces drastically the energy consumption of electricity for lighting and the environmental impacts associated with. The reduction reaches 12-25% of the total in some cases.

The total energy consumption in the production phase is also significant; however, this is minor in comparison to that of the use phase.

Waste is generated in all the life cycle phases. The kind of waste generated is completely different from one life cycle phase to another one. During the construction phase the waste generated consists basically of building materials such as concrete, metals, gypsum, wood, packaging, paints, etc. On the other hand, during the use phase, the waste generated consists of packaging material such as paper and carton, plastic, metal (aluminium cans), glasses, etc. And finally, the demolition phase generates large amounts of waste including building materials, dismantled equipment, etc

All the phases generate mainly non-hazardous waste. The main environmental impacts associated with the waste generated by the construction and the end-of-life phases are related to its landfilling. This waste causes mainly eutrophication and photochemical ozone formation although it is estimated to be much less important than other phases. The hazardous waste should be separated and treated in the proper way to minimise the environmental impacts that may cause. Therefore, once the Construction & Demolition (C&D) waste is generated their management and treatment should be ensured.

3.1.3.2 Environmental impacts related to the emissions to air and water

The impacts from the global warming potential are related to the consumption of energy and therefore they are dominated by the lighting and HVAC energy consumptions. Significantly lower levels of emissions will occur in the production phase and almost insignificant ones in the construction and demolition phases.

The water consumption of the office buildings is not so considerable as in other type of buildings e.g. sport facilities or residential buildings. However, it is also consumed in all the life cycle phases. The amount of water consumed during the use phase by the end users of the office building amounts to the highest consumption. The water consumption during the other life cycle phases is insignificant compared to this one. The water consumption in the use phase mainly causes acidification as environmental impact.

3.1.4 Environmental impacts assessment for office buildings – Summary

It is clear from the above analysis that the use phase is the key one. There is no impact category where the use phase does not dominate, apart from abiotic depletion potential. Table 2 clearly demonstrates this conclusion for the office buildings located in the three different locations and with 30% of the glazing surface. The same trends are shown for other designs and specifications considered in this study, which are reported in detail in the Technical background report.

3.2. Analysis conducted in the framework of EU Ecolabel criteria development and the GPP criteria development for construction

After the environmental assessment of the base-cases (presented above), an analysis of the environmental and other product related aspects was conducted. The main results and outcomes from this analysis are presented below. The aim of the analysis was the development of the EU Ecolabel criteria for office buildings and consequently no economical aspects are considered in this section.

3.2.1 Energy efficiency, less polluting energy sources and energy monitoring system

The outcomes of the study for developing EU Ecolabel criteria and the review of the existing research confirm that an increase of the energy efficiency and a reduction of the pollution coming from fossil fuel energy sources used are the most important aspects in the life cycle of the office buildings. Therefore, the three important criteria related to energy efficiency and the sources of energy to be used are proposed in the draft criteria set for the EU Ecolabel and also suggested to be considered in this GPP criteria set.

The criteria aim at reducing the overall energy demand and its associated GreenHouse Gas (GHG) emissions through application of various already known and innovative technologies or the use of less pollutant energy sources. Nevertheless, it cannot be forgotten that the application of these criteria should neither decrease the end-user comfort nor the well-being of the users of the building. Because of the importance of end-user's behaviour, the monitoring of the energy consumption and the provision of information on best practice to the workers/employees are proposed to ensure an optimal energy performance of the office building during the use phase.

According to the aim of the EU Ecolabel and GPP policy tools, freedom is left to the designers and architects to choose the most suitable technologies and design for each location. No trade restriction should be created through technology discrimination and therefore any kind of technology, building material or construction technique will be promoted by EU Ecolabel for office buildings.

Criterion 1 – Energy efficiency of the office buildings

The first criterion aims at designing office buildings in a way that reduces the overall energy consumption during its use phase. The overall energy consumption of the office building shall account for all the demands of the office building independently of the energy source. The purpose of this criterion is the promotion of high energy efficiency office buildings.

The EPBD 2002 was developed to promote the construction of highly energy efficient buildings, according to the objectives of Europe and the Kyoto Protocol. Under this Directive, the Member States must apply minimum requirements as regards the energy performance of new and existing buildings, ensure certification of their energy performance and require the regular inspection of boilers and air conditioning systems in buildings.

As a result of the lack of harmonization among the Member States (each Member State itself is responsible for determining what the indicators and calculation methods for determining energy

performance should be and to set out their own minimum standards), the setting of European-wide criteria clearly requires indicators and calculation methods that make a common standard almost impossible. Therefore, and due to the difficulties in developing a harmonized calculation methodology across Europe for the assessment of the energy performance of the office building, two alternative options are proposed:

a) the use of stepped national certificates of energy performances (CEP), if they exist and

b) the estimation of the energy performance of the office building simulated by specific software.

Certificates rate the energy efficiency of the buildings on a scale A or better (A^+ or A^{++}) to G (being classes A, A^+ or A^{++} the best energy performing buildings). The certificates usually use the same scale to define the environmental impacts that buildings have on the environment being the better-energy-rated buildings those that have lower environmental impacts. Despite the differences between the Member States methods (they do not include exactly the same energy demands e.g. HVAC, hot water, etc or they do not measure the energy demand in the same units), the selection of this option brings some advantages. Firstly, every five years the energy performance of the new buildings should be reviewed to investigate if it is possible to tighten the outstanding energy performance at the moment. Secondly, the office building is compared to the buildings that are located close to them and therefore in each region the same key aspects that influence the overall energy consumption of the office building such as climatic conditions, needs of cooling, etc are considered and finally, the energy calculation method of each MS complies with the national legislation, what should also be regarded to develop the tender under this GPP guidelines.

The second option is based on existing software tools which were developed and tested over time. These tools are well-recognized in the construction sector for calculating the energy performance of the buildings and meet the following requirements: freely available, recognized by the construction sector experts and comparable according to a range of tests listed under the Bestest lists.

Under the assumptions considered to develop the EU Ecolabel criteria, the 20% top best energy performing office buildings have average energy consumption lower or equal to 53kWh/m^2a in final energy. This option is not considered as appropriate for the GPP criteria due to the difficulties in evaluating the designs by the authorities that launch the tender.

Criterion 2 – Use of less polluting energy sources

The second energy related criterion aims at limiting the overall CO_2 emissions, what will reduce the environmental impacts caused by the energy consumed during the use phase. The amount of CO_2 emissions strongly depends on the primary energy source. In this sense, fossil fuels are considered to emit higher amounts of kg_{eq} of CO_2 per kWh delivered than other less polluting energy sources such as renewables. This criterion aims at complementing the previous one by promoting the use of less polluting energy sources while maintaining the high efficiency energy performance of the building.

The EU Ecolabel criterion proposes maximum CO_{2eq} emissions of 20kg CO_{2eq}/m^2a. This benchmark was suggested after evaluating the LCA results and the inclusion, as a reference case, of solar

technologies in the generic building model. This assumption does not mean that solar technology is the best option for all the locations and designs as, e.g. in the Northern countries the use of wind or water related renewable energy sources can be a better option.

The installation of localised renewable and low CO_2 emitting energy sources, such as heat pumps and district heating, reduces in general the overall environmental impacts of the office. Depending on the location and design of the office building, there may be an optimum or variable share of renewable or low CO_2 emitting energy sources, and technologies. According to the study reported in Technical analysis report at least 5% of the final energy demand of the office building could be replaced by renewable sources, so improving the environmental performance. Usual rates of replacement of fossil fuels by renewable energy sources are between 5 and 20% of the energy demand. Moreover, similar studies also suggest that the replacement of the electricity grid mix by cleaner electricity significantly improves the overall environmental performance of the office building.

Criterion 3 – Energy monitoring system

Finally, the third energy related criterion aims at identifying the improvement potential of the office building during the use phase. It is well-known that the energy performance of office buildings can significantly differ from the estimated energy performance at the design phase, due to mainly the user's behaviour. The identification of the improvement potential is proposed through the installation of monitoring systems, comparison against the design values and communication and feedback of the information to the end-users / manager of a building. Moreover, monitoring allows guarding of the building and installation performance.

In this sense, the training of the building manager and of all the end users on energy efficient operation of the building would be desirable. Many office buildings, especially those whose floor area is large, have complicated and high tech installations design and control systems, which are often not appropriately understood and maintained. It results in energy annihilation and loss of indoor condition performance (e.g. dirty filters, heating one room and cooling another, wrong temperature set points, wrong flows, etc). Adequate instructions and documentation should be provided for the manager in an easy understandable way.

Similar criteria were proposed in the *GPP for construction*. The energy efficiency of the construction sector is addressed by two mandatory core criteria and one awarded criteria:

> 1) *Energy consumption standards*: the overall (net/final/primary) energy demand of the building (including cooling, hot water, ventilation and electricity) is (X)% lower than the maximum defined in (insert the relevant national legislation).
>
> The choice of the net, final or primary energy demand will depend on the indicators used for defining energy performance provided in national legislation. The contracting authority should clearly state the applicable legislation (see Annex I on the Construction background report).

When evaluating the incoming bids contracting authorities must verify the correct use of the applicable calculation method. This might need external/internal expert.

The percentage level (ambition level) to insert highly depends on the ambition level of the maximum energy performance defined in national legislation. It is recommended to aim for at least 20% lower than the existing national standard demands

2) *Energy efficiency training*: a training session must be given to the building manager on the energy efficient use of the building following the completion of construction/renovation works. The bidder must outline the content of the training.

And additionally an awarded criterion is provided

3) *Lowest energy consumption and use of localised RES sources and/or high efficiency cogeneration*: lower energy consumption than that demanded in the specifications, based on the overall (net/final/primary) energy demand of the building (including heating, cooling, hot water, ventilation and electricity). Points will be awarded on the bases of a sliding sale between the best and worst bids.

Moreover, the comprehensive criteria that are proposed in the GPP for construction are proposed as two different options. In addition to selecting one of these the contracting authority should also include a general criterion on energy performance:

Passive house requirements: Passive houses aim to achieve a very high energy performance in buildings by using as much passively generated heating, cooling and ventilation as possible and thereby reducing energy consumption significantly compared to average building. The contracting authority will need to define the most appropriate criteria to apply. The following Passive house specifications can be used as a base line: Passive Haus institute standard (Germany), Minergie-P (Switzerland), PassivHausUK (UK), CEPHEUS project (EU) and European Passive Houses (EU).

Low energy and Passive House Standards are terms generally used. The meaning of the term "low-energy house" has changed over time, and will certainly change in the future. When the GPP criteria for construction were developed, it was generally considered to be in the range from 30kWh/m^2a to 20kWh/m^2a. In comparison, at that time the German PassivHaus ultra-low energy standard had a maximum space heating requirement of 15kWh/m^2a. The concept has subsequently begun to be applied to other building types such as offices.

<u>Option 1 of the existing GPP for construction</u>

1.1) *Energy performance standard*

1.1.1) *The energy performance* must meet the criteria underlying a low-energy or passive house standard (include name and internet addressed of a relevant passive house specifications)

1.1.2) *Energy efficiency training*: a training session must be given to the building manager on the energy efficient use of the building following the completion of construction/renovation works. The bidder must outline the content of the training.

Option 2 of the existing GPP for construction

2.1) *Localised RES (l-RES):* A minimum of X% of (net/final or primary) energy demand must be provided by localised renewable energy sources (l-RES). L-RES means renewable energy source generating capacity within the building site itself e.g. solar panels, biomass boilers, wind turbines, etc)

The contracting authority will need to determine the appropriate minimum % l-RES. This will largely depend on the climatic conditions and the experience with l-Res installation. Typically this should be between 5-20%

2.2) *Energy consumption standards*: the overall (net/final/primary) energy demand of the building (including cooling, hot water, ventilation and electricity) is (X)% lower than the maximum defined in (insert the relevant national legislation)

2.3) *Energy efficiency training*: a training session must be given to the building manger on the energy efficient use of the building following the completion of construction/renovation works. The bidder must outline the content of the training.

And additionally awarded criteria is provided

2.4) *Innovative energy efficient building services*: Bidders must submit specific proposals for achieving energy efficient lighting, heating, cooling, high-efficiency cogeneration and ventilation in the building. Additional points will be awarded for the proposed approach, by evaluating the estimated energy savings (in comparison to standard systems) and the use of passive components (e.g. insulation, daylight use)

2.5) *Lower energy consumption*: lower energy consumption than that demanded in the specifications, based on the overall (net/final/primary) energy demand of the building (including heating, cooling, hot water, ventilation and electricity). Points will be awarded on the bases of a sliding scale between the best and worst bids.

And as a core criterion under the section contract performance clauses, information to the building manager should be provided.

1) *Book-keeping*: the contractor must provide a regular book-keeping service for the first three years that will provide the building manager with monthly figures on energy consumption for heating, cooling, ventilation, hot water and electricity

The comparison of both schemes outlines the following issues:

- the criteria suggested/proposed by both schemes aim at decreasing the environmental impacts caused by the energy consumption of the building during its use phase. The reduction of these environmental impacts is achieved by:

  - encouraging lower overall energy consumption (since in both schemes a maximum energy consumption is proposed)

  - encouraging the use of renewable sources and/or less polluting technologies

- encouraging the training and information to the end-users / managers

Despite these common points, there are some differences in the ambitions levels proposed in the criteria as well as in the formulation of those criteria. Differences are logically expected as the criteria proposed in the EU Ecolabel for office buildings have a narrow scope, not only because this scheme is limited to the office buildings, but also because it is developed just for new and major renovated office buildings.

Taking into account the information provided by both schemes under evaluation and the respective technical analysis reports, some important aspects come out. First of all, **the maximum energy performance** seems to be recommended to be based on the national calculations proposed and is important from the environmental and economical viewpoints. However, the passive house requirements, although ensuring higher performance and good design are not a common strategy for offices, but for residential buildings. The reason why this approach is not worth in office buildings is because the building envelope and the gain of solar energy are less important for office buildings (in fact high isolated envelops might even work opposite by causing extra energy demand for cooling as it was found out in this study).

The **reduction of CO_2 emissions** is proposed to be achieved by establishing a minimum share of renewable energy sources on-site, apart from the passive components that the designers can propose to reduce the energy demand of the building. The proposals to achieve lower energy demand buildings can be divided into:

- energy saving envelope (from insulation, high performance glazing and air tightness)

- total building performance including the installation of high efficient systems for HVAC and lighting and integrated renewable sources.

- awarding of energy exchange and local shared sources in the nearby area (like district heating/cooling, cogeneration, etc)

In this sense, it should be considered that both the selection of the most suitable share of renewable energy sources and their type as well as the most suitable passive components (e.g. insulation, daylight use) are highly dependant on the location and design.

Finally, the **energy monitoring and the training of the building manager** should be considered as an important criterion in this area. The monitoring of all the flows which exceed 5% of total (expected) energy consumption is suggested in some Member State's schemes[7]. Additional requirement of investigation and/or measures if real consumption is over 25% designed performance can be a helpful criterion too.

3.2.2. Selection of construction materials

Regarding that EPBD 2010 proposes the construction of "nearly-zero-energy-buildings" by 2018 in the case of public buildings and by 2020 for other buildings, a building that is expected to last 50 years

[7] Dutch Energy Performance Standard (EPG, NEN7210, NVN7125)

until its first major renovation should have a low energy consumption and therefore the material component will gain quickly in relevance.

The environmental impact assessment conducted throughout LCA studies along the office building life cycle, showed that the construction phase is the second, after the use phase, with the highest environmental impacts. Hundreds of different materials and products are used in the construction of a building, making it very difficult both to set and to verify benchmarks directly related to the environmental impact of this life cycle phase.

On the other hand, criteria should take into account the performance of products during their entire life cycle. And they should be compared on the basis of a common functional unit, i.e. considering aspects such as technical performance, durability, recyclability, required maintenance, etc. In addition, construction products cannot be assessed separately without taking into account their functional performance at the building level over their service life.

For all these reasons, it is not recommended to establish criteria only focused on the environmental impact associated to the production of construction products, but to consider other indirect measures that may contribute to reduce the environmental impact of construction products throughout their entire life cycle.

The EU Ecolabel proposed criteria are considered to be applicable to new office buildings and only to the new materials needed for the major renovation of the office buildings.

Criterion 4 – Use of low environmental impact materials

Evaluations of the life cycle environmental impacts of the construction products show that generally some construction products bring more environmental impacts than others. This is, because the production of some building materials needs more energy and nature resources than others. For the selection of construction products with a low environmental impact a set of construction product labels were developed. The use of labelled construction materials is proposed for at least 80% of the cost of the major building elements. Major building element is considered as those which in their totality constitute the office building: external and internal walls, slabs, windows and doors and floors (including coverings, etc).

A well-recognised label that recognises the low environmental impact of construction materials are those classified according to ISO 14024 as Type I Ecolabels. The Type I Ecolabels take into account the environmental impacts caused by the entire life cycle of the products. Other labels were developed according to ISO 14025, ISO 21930 and EN15804. The Type III Ecolabels do not prove that the awarded product is environmentally friendlier but, generally speaking, these products have a better environmental performance than the non-labelled ones and are externally verifiable. The main reason is that the information provided for the labels Type III by the manufacturers helps them to improve their processes and for the consumers it helps them make scientifically based comparisons between the different building solutions.

However, the most important construction materials are mostly not yet covered by many ecolabels, and the availability of ecolabelled products varies significantly between countries. This fact highlights the need of a second alternative to assess the environmental performance of the building products. In these situations, when the previous options are not possible, an LCA assessment of the construction products shall be performed. At present, there is a lack of universally valid LCA construction work but a number of sophisticated tools can help in calculating the full environmental impact of the materials used in construction using LCA. Most of these software's are designed for performing environmental assessment consisting in database, data for energy sources, etc. These software tools should be developed in accordance with the TC/CEN 350 standards. However, it must also be recognised that there are barriers to the widespread use of LCA on construction projects such as cost and access to expertise – particularly for SME's. This second option can require the evaluation of an expert when considered as a GPP criterion.

Criterion 5 – Material recovery potential of the building materials

Raw materials for the building sector are extracted, processed, transported, added in the construction phase and finally disposed. All these stages imply a number of environmental impacts, which are significant due to the enormous amount of materials involved. Moreover, the environmental impacts of the end-of-life phase due to the landfill of the C&D waste are because of the large space needed and the long duration of this phase.

Although the LCA studies on office buildings across Europe show that the influence of the end-of-life phase cannot be considered outstanding from a life cycle perspective, the relative importance of different extreme scenarios was checked out. Two extreme scenarios 100% of the waste landfilled or recycled were considered having a difference in the overall environmental impact of around 3%. However, keeping in mind the continued reduction of energy consumption by new buildings other life cycle phases will gain more importance and therefore this difference is expected to be higher in future. In addition, the increasing depletion of natural resources in the upcoming years, will force the adoption of measures to ensure materials recycling at the end of life phase.

Recycling and reuse of C&D waste materials can bring environmental benefits, such as avoiding new raw materials extraction, savings in energy consumption, lower land use and contamination of groundwater, etc. For these reasons, the recovery of construction products is an objective of the Waste Framework directive. This Directive proposes to reach 70% of preparation for reuse, recycling and other forms of materials recovery. However, from a quantitative point of view, the best practices in Europe show that generally speaking recycling and reuse rates over 80-90% are feasible.

This benchmark (80% wt of the construction materials to be potentially recovered) is proposed as an EU Ecolabel criterion and as a comprehensive GPP criterion.

Criterion 6 – Recycled and reuse content in the building materials

As abovementioned, on one hand buildings are responsible for the consumption of huge amounts of raw materials, and on the other hand, it is expected that the majority (70%) of these materials will be recycled and reused once the building is demolished. Due to the long service life of construction products (several decades), it may not always be possible to establish close-loop recycling strategies, but it does not prevent buildings from being prepared for participation in future closed-loop and open-loop recycling schemes. Nowadays, some materials commonly used in buildings are already extensively recycled/reused and new construction products content a high share of recycled/reused material. The Ecolabel criterion proposed that for the materials used in the office building, at least 50% in cost of the building components should be formed by products containing at least 30% of recycled/reused.

Criterion 7 – Responsible sourcing of wood and wood-based materials

The use of wood and wood-based construction materials is, in some areas, outstanding. For this reason, a specific criterion for wood and wood-based materials is proposed. Wood and wood-based construction materials are renewable raw materials the continued availability of which should be preserved from the very beginning of the production process to ensure the future supply. In the case of these materials if the forest is not managed well today, there will not be enough wood and wood-base materials for later generations. The importance of ensuring that most if not all the wood and wood-based materials used in the construction and renovation of the buildings are coming from responsible sources is clear and compliance with several available certification schemes is therefore proposed in the EU Ecolabel criteria set.

The selection of building components is another field addressed in the *GPP criteria for construction*. Under the *core GPP criteria of the construction sector* the following criteria and explanations are proposed and provided

1) *Timber* used in the building shall come from legal sources

And in addition, as an award criteria:

2) *Use of construction materials and products complying with certain environmental criteria*: bidders must indicate the percentage of (insert relevant product types, e.g. windows, paints, insulation materials) to be used in construction (by value) that are produced in compliance with the standards underlying a Type I ecolabel according to ISO standard 14024 or provide clear and transparent information on the product performance based on type II product declarations.

It is proposed to use this criterion in the award phase as the contracting authority will likely not have sufficient knowledge of the market availability and price of such products. If the contracting authority has good market knowledge minimum percentages for certain product types could be included in the specifications.

A minimum requirement should be 5% of recycled/reused content. If award criteria dealing with LCA comparison of building materials are used, a relatively low percentage should be set. Where the contracting authority is unable to define the recycled/reused content of a material, this criterion could instead be used in the award phase.

The availability of LCA data on building materials varies considerably from country to country. The contracting authority will need to consider whether sufficient data exists to apply this award criterion. The contracting authority will also need to determine which LCA tools are most appropriate for the region/type of construction work. A list of suitable LCA tools is available in section 6 of the construction background report. Where LCA tools are available, it may replace the most specific requirements on building materials (as they would be covered by the LCA tool).

Additional award criteria considered within the *core GPP criteria for the construction sector* include:

3) *Use of construction materials based on renewable raw materials*: bidders must indicate the percentage of (insert relevant product types, e.g. windows, paints, insulation materials) to be used in construction (by value) that are based on renewable raw materials.

4) *Sustainable forestry sources*: wood products coming from forests that are verified as being managed so as to implement the principles and measures aimed at ensuring sustainable forest management, on condition that these criteria characterize and are relevant for the product. In Europe, these principles and measures shall at least correspond to those of the pan-European Operational Level Guidelines for Sustainable Forest management, as endorsed by the Lisbon Ministerial Conference on the Protection of Forests in Europe (2-4 June 1998). Outside Europe they shall at least correspond tot eh UNCED Forest Principles (Rio de Janeiro, June 1992) and, where applicable, to the criteria or guidelines for sustainable forest management as adopted under the respective international and regional initiatives (ITTO, Montreal Process, Tarapoto Process, UNEP/FAO Dry-Zone Africa Initiative).

Moreover, the core GPP criteria are completed by the *GPP comprehensive criteria* in this field

1) *Steel:* (applicable for renovation work) for the purpose of cleaning, derusting and removing paint from steel products, silicon-blasting agents must not be used. Residual materials must be disposed of according to relevant national legislation.

2) *Use of construction materials based on renewable raw materials*: bidders must indicate the percentage of (insert relevant product types, e.g. windows, paints, insulation materials) to be used in construction (by value) that are based on renewable raw materials

3) *Competition around R-values (combination of lambda and thickness of insulation products) of the proposed insulation*: Bidders must provide the R-values of the proposed insulation materials. Points will be awarded on a sliding scale between the best and worst bids. R-values describes the insulation properties of certain building insulation materials and lambda is a value for measuring the thermal conductivity of a material.

The comparison of the proposed EU Ecolabel criteria and those coming from the GPP criteria for construction outlines several common points. Firstly, and because Europe is heading towards nearly zero building, **construction materials that comply with certain environmental criteria** become of importance. The compliance of several environmental criteria defined in accordance with TC/CEN 350 standards and ISO 14024 are summarized in the labels of Type I. Moreover, labels classified as Type III and developed according to these standards provide trustful environmental information that can help designers in the selection of the best environmental performing materials . A similar criterion is related to the **use of wood and wood-based materials coming from responsible and sustainable sources**. Certifications like FSC, PEFC or any other equivalent means of proof is proposed to ensure the compliance with this requirement.

In spite of the common points, there are some criteria that are not present in both schemes. Some examples are the criteria that benchmark the use of recycled and reuse content in the building materials, the recycling and reuse potential of the building materials used, the requirements of steel used in renovation works and competition around R-values of the proposed insulation. This rough comparison suggests that the EU Ecolabel criteria are stricter from an environmental viewpoint, which could be considered to be reasonable due to the narrower scope of the Ecolabel scheme. For these reasons and the required external expertise to evaluate the information provided in case the competent authority does not have a proper knowledge of the market, the criteria related to the recycling potential and the recycled/reused content are proposed to be considered as comprehensive criteria.

3.2.3. Use/avoidance of hazardous substances

The avoidance of hazardous substances in the EU Ecolabel criteria set is proposed under two criteria

Criterion 8- Hazardous substances and materials in the building component

Criterion 9 – Substances listed in accordance with Article 59(1) of Regulation (EC) No 1907/2006

Although the selection of building components and construction materials criteria should be formulated at building level rather than at building component level, the avoidance of hazardous substances in the construction materials should be regarded as a priority criterion. The uses of hazardous substances for producing the construction components, not only those that are in the building products but also those that are used during the manufacture processes, are of key importance. Moreover, the use of hazardous materials in the building components selected influences the overall environmental impact of the building because they can be released causing health and environmental damages.

Eventually, this selection influences the environmental impact caused during the end-of-life phase of the building. The environmental impact caused during the end-of-life of the office buildings can be reduced if the construction materials chosen do not contain hazardous substances that should be treated with care.

The avoidance of certain hazardous substances and materials in the construction products is addressed in the GPP criteria for office buildings under *core GPP criteria*, as follows:

1) *Exclusion of certain materials:* bidders must declare that the following materials/substances will not be used in the building:

- products which contain sulphurhexafluoride (SF_6)

- indoor paints and varnishes with a content of solvents (VOCs with a boiling point of 250C maximum) higher than:

  - for wall paints (according to EN 13300): 30 g/l (minus water)

  - for other paints with a spreading rate of at least 15m^2/l at a hiding power of 98% opacity: 250g/l (minus water)

  - for all other products (including paints that are not wall paints and that have a spreading rate of less than 15m^2/l, varnishes, wood stains, floor coatings and floor, paints and related products): 180 g/l (minus water)

2) *Volatile Organic Compounds (VOC):* the VOC emissions form the building products used must not exceed the respective values outlined in the European standard for the determination of emissions from building products EN ISO 16000-9 to -11 or equivalent (for instance the building products must adhere to the test values set in the German AgBB scheme in order to meet the minimum requirements of the building codes for health protection with regard to VOC emissions)

These criteria overlap with the *EU Ecolabel criteria related to the indoor air* quality and well-being. In this last scheme further criteria to ensure the top best environmental performance of the building are proposed, as follows:

Criterion 10 – Indoor air quality (IAQ)

The assessment of the IA in office buildings is a challenging task because of the different chemicals, particles and biological materials with potential health effects that can be found inside buildings. Moreover, it is also influenced by different perceptions of air quality depending on the exposure, cultural aspects and habits of the end users and energy saving concerns that will make office buildings more airtight. Furthermore, the lack of availability of standards and the high costs of the measurements related to the quality of the indoor air mean that harmonization among the existing labels and standards to assess the IAQ is not an easy task.

On the other hand, the IA pollutants are for the most part considered to originate from non-major building components since most of those components are considered inert materials or to which occupiers may not be exposed. Moreover, according to the literature covering LCA assessments in office buildings, the influence of IAQ of the office buildings on the environmental impacts is considered to be extremely low. In this sense, the related IAQ environmental aspects have not even been considered in this work and consequently their related environmental impacts cannot be quantified.

Keeping in mind the abovementioned discussion three alternative options are proposed for this criterion:

- Option A developed IAQ benchmarks based on the existing German and French IAQ schemes (AgBB and AFSSET, respectively). In order to develop a harmonized criterion the strictest benchmark for each pollutant is proposed. However, these benchmarks on individual pollutants are insufficient to guarantee good indoor health quality and a minimum ventilation rate is proposed to avoid pollutant accumulation in the working rooms.

- Option B set up a minimum ventilation rate that ensures the IA pollutants are not concentrated inside the building

- Option C considers that the IAQ is mainly determined through factors belonging to the use phase of the building (such as e.g. imaging equipment, computers, furniture, etc) and therefore is out of the scope of this label. Consequently it is proposed to leave out this criterion from this scheme.

Criterion 11 – Visual comfort

Visual comfort based on balanced illumination without appreciable interferences and sufficient illumination levels shall be guaranteed in the permanent workplaces is proposed in the EU Ecolabel draft criteria proposal. The following checklist shall be considered following the respective national best practice daylighting guides

1- Availability of daylighting: The availability of daylight through the building's entire usable area shall be equal or higher than 2% (DF), excluding service areas, staircase, parking, storage. All regularly used office workspaces and occupied areas must be provided with adequate daylight, depending of the task to be carried out.

2.-Views to the outside: Each permanent workplace shall be provided with a view to the outside or equivalent measures like atrium.

3. Glare prevention in daylight: Workplace shall be provided in absence of glaring from daylight. Windows shall be equipped with a sufficiently adjustable shading mechanism which allows the intensity of the daylight reaching the workstation with display to be reduced.

4. Preventing glare in artificial light: Preventing glare in artificial light shall be achieved in each permanent workstations in accordance with EN 12464, part 1

5. Light distribution in artificial lighting conditions: Workplaces shall be provided with illuminance and uniformity of artificial lighting in accordance with EN 12464, part 1

6. Colour rendering: Colour rendering and light colour in daylight and artificial light conditions shall have a colour rendering index of Ra equal or higher than 80 for artificial lighting in regularly used areas.

Criterion 12 – Separate room for printers and office equipment

Imaging equipment has been identified as a product group with significant environmental impacts, because of the release of volatile organic compounds (VOC), persistent organic compounds (POP), heavy metals (in air and water), polycyclic aromatic hydrocarbons (PAH) and particulate matter (PM) are not only important from the environmental point of view but also from the healthy one. In addition, the office and imaging equipment is characterized by being noisy equipment. The provision of a room devoted to this kind of equipment will isolate the employees from this noise.

The provision of a separate room for this kind of equipment will avoid the release of these pollutants in the office rooms where the employees spend most of their time. Moreover, these rooms prepared for the location of the imaging equipments and especially when separated from working space by airtight constructions and doors and operating under pressure in the venting system may allow a reduction of the overall energy consumption of the whole building.

However, this criterion should only be considered if the size of the building is significant or the design allows it. In some cases, it can be completely impossible to separate the office equipments

Once again the number and strictness of the EU Ecolabel proposed criteria seem to be higher than those of the GPP criteria for construction. This is logical since the time that employees spend inside this type of buildings is much longer than in any other kind of construction. Moreover, the comfort of workers is a key issue from an economical point of view as long as the productivity of the employees is closely related to their comfort.

Several criteria seem to be especially important to be included in the GPP for office buildings. First, a good indoor air quality should be provided. The quality of the indoor air is achieved by limiting the emission of indoor air pollutants from the sources (e.g. construction materials) or avoiding their accumulation in the rooms. This GPP for office buildings guidelines propose: on one hand, the control of pollutants at the source by the **exclusion of materials whose emission of indoor air pollutants exceeds certain values** and the **use of a separate room for office and imaging.** The exclusion of construction materials which content substances of very high concern and classified as "SVHC" and those that release indoor pollutant exceeding the respective values outlined in the European standard for the determination of emission from building products EN ISO 16000-9 to -11 or equivalent is proposed. On the other hand, a criterion based on avoiding the accumulation of indoor air pollutants inside the rooms is proposed. This criterion is based on the national standards that ensure the indoor air quality. Secondly, a good **visual comfort** should be achieved for the employees. This criterion is based on the standards EN 12464 and the **GPP for lighting** that ensures an optimal point of performance from both economical and environmental points of view.

Finally, criteria related to the acoustic and thermal comfort are not proposed but can be included if the authority considers it is recommendable. Thermal and acoustic comfort originate a vast amount of complaints in existing buildings and therefore it is recommended that new and major renovated office buildings should try to avoid these problems.

3.2.4. Water saving and water management plan

Although the use of water in the office buildings is not comparable to that of other types of buildings such as those in the residential sector or those devoted to sport facilities, some criteria related to the water saving and water management are proposed in the EU Ecolabel criteria set

Criterion 13 – Maximum water consumption

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. In the case of office buildings, water is used basically for taps, toilets and drinking, and for showers in some cases.

A limited number of studies or statistical data are available concerning current operational water consumption within office buildings. In this field, information is provided by Member States Ecolabel schemes that set current performance levels between 11 to 100 l/p/day, while the best practice scenarios range between 5.5 to 20 l/p.d. This last value is proposed in the EU Ecolabel criterion although the use of showers is not included. Through the application of water-saving equipments and/or the reuse of rainwater and/or grey water, it is possible to achieve significant annual water savings.

Criterion 14 – Water saving management system

Like the energy consumption of the office building during the use phase, water consumption can actually be higher than estimated. These differences are mainly due to user's behaviour. In this sense, the better way to identify where the improvement potentials are, is the water monitoring followed by a comparison to the estimated/calculated values during the design phase. The comparison of both real and estimated values allows the identification of the mismatches and the inappropriate user's habits or construction problems that cause the higher water consumption.

One of the ways to save water in office buildings is to set up a water management plan. This management plan consists of applying several measures to identify where the possibilities to save water are. Some of these measures are:

- flow monitoring: water audits routinely identify undetected leaks representing (10-50%) of consumption. Rectification of these usually provides good savings at remarkably low cost.

- system pressure data can be requested from the supplier. However, expert advice may be needed, especial for high rise buildings as adequate pressures must be maintained at the upper levels. Excessive pressure is best evidenced by excessive basin spout flows for only small tap movements.

- billing and charges: data need to be collected to ensure comprehensive water consumption information is obtained.

- information to the users: a detailed description of best practices shall be communicated at least to maintenance staff with detailed information on how to inform the end users.

The water saving criteria in the GPP criteria for construction are addressed as *one core GPP criterion*

1) *Water saving installations*: all sanitary and kitchen water facilities must be equipped with the latest water saving technologies available on the market.

- dual flush WCs should be use a maximum of 6l/full flush and 3l/urine flush
- waterless urinals have to either use a biodegradable fluid or operate completely without fluid
- water saving devices fitted into cisterns must demonstrate a water saving of at least 30% for toilet flushing
- tap inserts should have at least 50% of water compared to normal tap use

In order to set the specifications and verify compliance, the contracting authority should have an overview of available technologies such as tap attachments and water flow restrictors in the market. The criteria can be adapted as necessary to fit market availability.

The level of ambitious (x%) strongly depends on the market availability of the demanded technologies in the specific European region. Where the contracting authority is unfamiliar with the market situation, it is recommended to use this criterion in the award phase to ser a realistic demand.

and *one comprehensive GPP criterion for construction*

1) at least x% of the number of urinals and toilets must use waterless technologies

plus an *award criterion* as follows:

2) *Rainwater and grey-water use*: bidders must provide a proposal on how to maximise the use of rainwater and grey-water in the water supply and return system of the building . Additional points will be awarded based on the proposal submitted. The proposal will be rated according to the following criteria:

- design and quality of the technology including adaptability to the building design
- estimated percentage of overall water supply form rainwater and grey-water sources
- maintenance costs and durability of the product (installation and maintenance costs)

It is also possible to set minimum percentages of the overall water supply supplied from rainwater and grey-water sources; however, the potential will vary considerably according to climatic conditions and grey water availability may be limited because of the nature of water use within office buildings. Therefore local expertise would be needed to set appropriate levels.

In this environmental criteria area, some criteria are common for both schemes under evaluation although their wording looks like different. First, **lower water consumption** is promoted. In the case of the EU Ecolabel maximum water consumption is proposed while the GPP for construction scheme proposes the purchase of the latest water-saving technologies available on the market.

GPP for construction scheme is in this aspect stricter. It proposes very specific criteria such as the installation of waterless toilets while EU Ecolabel better addresses the overall performance of the building without promoting any technology. In addition, GPP for construction schemes proposes the use of rainwater and grey water for toilets what, according to some experiences, the efforts required are not proportionate to the environmental benefits. The importance of using rainwater and grey water differs from country to country and therefore it is advisable to be considered just as an award criterion.

The criterion related to the **water saving management system** is proposed with the aim of avoiding mismatches between the estimated maximum water consumption and the real one. The water saving management plan should allow the identification of leakages, plan the inspection of the water facilities and deliver information to the manager of the building about the best practice related to the installed water technology.

3.2.5. Waste management

Waste is generated during all the phases of the office building although the type of waste generated is significantly different among the office building life cycle phases. For example, during the construction phase the waste generated consists of building materials such as concrete, metals, gypsum, timber, packaging, paints, etc. On the other hand, during the use phase the waste generated will consist mainly of packaging materials such as paper and carton, plastic, metal (aluminium cans), glasses, etc. Finally, the end-of-life stage generates huge amounts of waste including building materials, dismantled equipment, etc. The recovery processes and the waste management differ notably depending on the type of waste to be treated and therefore each of the proposed criteria addresses one of the office building life-cycle phases.

Criterion 15 – Recycling facilities and waste management plan

During the use phase the waste generated does not attend to be large in variety and therefore its management seems to be suitable for developing a criteria. The development of a waste management plan for the use phase of the office building can reduce the environmental impacts caused. The waste management plan should be based on the reduction, reuse and recycling of the waste generated and once it is generated, on the separated collection, removal and storage of the waste. Finally, the monitoring and communication of best practices to the end-users should be considered.

Most of the waste will consist of paper and carton, plastic, metal and glasses that can be recovered (recycled or reused). Nevertheless the recycling of these materials is only possible if the office building is provided with suitable facilities to separate them and is the local municipality or privately contracted service providers would be responsible for recycling the materials.

Criterion 16 – Demolition and Construction waste management plan

Although according to LCA results the environmental impacts caused by C&D waste generation and management do not significantly contribute to the overall environmental impacts, they are related to a phase within the building's lifecycle in which the reduction, diversion, reuse and recycling play an important role. For this reason, some criteria were proposed. The purpose of the waste management plan is to ensure firstly a reduction of the C&D waste generation and secondly a suitable treatment of the unavoidable C&D waste generated to ensure that it causes the lowest environmental impact.

First of all, it is considered of high importance the minimisation of C&D waste generation. It can be achieved by a number of means including the training of all employees by contractors, the avoidance of waste wherever possible during design and procurement, supply chain co-ordination, the avoidance of the mishandling or over-ordering of materials delivered to sites, the avoidance of operational mistakes related to the operations necessary to build the structures.

Once C&D waste is generated a proper management and treatment should be ensured. Among the different alternatives, the reuse of waste has been identified as one of the most environmentally friendly measures. However, this technique could be constrained due to tight time schedules, transport costs, operational costs, etc. Another recovery technique for C&D waste proposed as environmentally friendly is the recycling. Both techniques are proposed to form part of the management plant.

This criterion is also addressed under the *GPP criteria for construction as core criteria*, as follows:

1) *Waste management*: the contractor must put appropriate measures in place to reduce and recover (reuse or recycle) waste that is produced during the demolition and construction process. It is required to have a recovery rate of at least 60% related to weight percentage segregation.

The contracting authority must set up a proper monitoring and evaluation system during the construction process that, besides general quality control issues, also focuses on the monitoring of the waste management system.

2) Transport and recycling of building materials:

- the contractor should set a minimum and a target level for the use of reusable containers to transport the necessary building materials to, on and from the construction site

- suppliers of building materials must set a minimum and a target level for packaging waste (to be achieved for instance through a system of take back, recycle and reuse of packaging that comes with the building materials)

Comparing both schemes, several aspects should be considered in the GPP guidelines for office buildings. During the use phase and the demolition and construction phases the minimization of the waste generated and its proper management, once it is generated should be considered. To comply with this objective the development of a waste management plan and the provision of proper facilities are needed.

3.2.6. Other key environmental areas

Apart from the criteria already discussed, the EU Ecolabel for office buildings identified other criteria that are needed to benchmark the buildings with the best environmental performance. These environmental criteria areas and criteria are summarized as follows:

3.2.6.1 Information to the users

Due to the fact that a key factor in the area of sustainable office buildings is the end-users behaviour, the provision of appropriate information to employees and/or the facility manager is of high importance. Thus, beside the information concerning the technologies installed in the office building (ventilation system, heating and cooling systems, lighting controls, etc), information concerning rational energy and water use and recommendations concerning potential savings in general and with regard to the building use shall be attached to it. Moreover, the delivery of information like operating instructions, materials used, safety concept, detailed calculations, etc is also recommended

This information shall also contain reference to the potential reduction of the environmental impacts due to waste generation and the explanation, preferably by institutive and permanent means like stickers, how these environmental impacts can be reduced due to the reduction, reuse and/or recycling of the waste generated.

Furthermore, importance of refurbishment and preventing heat losses and dripping water from sanitary tapware and toilets shall be emphasised as this contributes to increasing electricity and fossil fuel use and to high losses of unused water which can be easily be avoided.

Information concerning the advantage and potential for using more sustainable modes of transport shall be provided and the environmental consequences of using the private car shall be pointed out. The provision of up-to-date public transportation timetables and the location of the nearest stops and stations close to the office building are recommended .

This point is addressed in the GPP criteria for construction under different environmental areas as for example the energy consumption where the training of the building manager is proposed as a core GPP criterion.

3.2.6.2. Promotion of bicycles

A quarter of all car trips are made by people getting to and from work and many of these are relatively short journeys of less than five miles (8 km), that could easily be cycled. Considering the number of workers and daily trips, the shift from car to bikes could have a remarkable effect in the prevention of urban contamination[8]. Cycling is a highly efficient mode of transportation providing a wide range of benefits including energy conservation, improved air quality, reduction in costs and improved personal health. Depending on the case, the amount of energy use for the transportation of workers may be higher than the energy used inside the building. A new office building built according to modern energy

[8] http://www.dft.gov.uk/topics/sustainable/cycling/cycling-to-work-guarantee/

codes such as ASHRAE 90.1-20049 may, depending on the location and the availability of different modes of transport, have an energy use associated with workforce transportation nearly 2.4 times greater than the direct energy use of the building.

The energy consumption that is spent in workforce commuting is not taken into account within the LCA boundaries as it is not related to the building itself but the user's behaviour. However, and due to the importance of this energy consumption in comparison to the overall energy consumption during the use phase, it is important to develop an Ecolabel criteria in this area.

Several factors influence the commuting of workers, among them, all the issues related to safety, security, and accessibility are of great importance. Regarding the accessibility of the building, access to public transportation, the walkability of communities and access to safe pathways for walking and cycling are critical in promoting this kind of commuting. Moreover, support for bicycle use in the form of secure parking (opportunities for locking wheels or frame and the accessories of a bicycle to a fixed rack or structure) protected against vandalism and weather conditions and located close to the entrance of the building is also needed to encourage the greatest amount of use. Similar or equivalent measures to reduce private car transport like car pooling, electrical cars, etc could be considered as well. In addition, showers and lockers at the work-place are necessary to encourage regular bicycle commuting. Lockers should be installed adjacent to the showers in a safe and secure area.

3.3 Additional aspects relevant for the Green Public Procurement

Apart from the criteria, which are under consideration for the EU Ecolabel scheme, there are additional aspects which are of importance for the GPP sphere and which require setting some additional (GPP specific) requirements. These aspects are related to the activity of contracting by the public procurers of the service of construction itself. In this case, it is important that the contractor who will undertake the construction has suitably qualified and experienced personnel.

The GPP of buildings is extremely complex due to the competition between the difference phases: architectural design, construction works and the building services in terms of the variety of materials and services procured. All these phases and the sections involved are summarized in section 5 of this working document.

However, before starting the GPP process for any public building the contractor shall also ensure that **the more efficient accommodation of personnel is considered (reduction of the size of the building while providing the same function) and the employment of existing offices better in order to avoid new building, in accordance with the LCC study results of this possibility**. Empty office buildings do not always meet the government's wishes for qualitatively high-grade office buildings in grade A locations, with good accessibility by public transport. This document describes the criteria to be applied once the decision for new building/major renovations has been made. The

[9] http://www.energycodes.gov/training/pdfs/ashrae_90_1_2004.pdf

considerations to come to this choice fall outside the scope of the document, but it shall be the first option in the procurement process.

3.4 Improvement potential

There are various solutions which can be applied to improve the energy and water efficiency of the office buildings. Among them the increase of the insulation performance of the external walls, windows and external doors, lighting controls, use of aerators in the taps, restrictions of the water flow delivery, temperature controls in the office rooms, shadings in the windows, etc can be outlined.

Due to the complexity of the analysis of user behaviour and the variety of use habits it is not easy to calculate exactly the savings which can be achieved due to application of the saving solutions proposed in the following Table. Various values can also be found in the literature sources. The study "Campus Energy 21 as a new company headquarters[10]" indicates that the application of energy saving measures and construction systems (concrete core activation, geothermal heating, heat recovery, daylight-controlled illumination) to the office buildings allows for approximate reduction of 50%of the energy demand and up to 60% of the CO_2 emissions.

3.4.1 Preliminary calculations of the improvement potential based on the results of the study

Based on the calculations conducted in the frame of the project and the necessary assumptions made, the potential to save energy has been estimated. On average, the respective energy and water consumption by a statistical EU-27 office building amounts approximately 55.5l/p/day and according to the simulations carried out and reported in the Technical analysis report the energy consumption amounts between 45 and 121 kWh/m^2/a. Nevertheless, it should be remembered that very high regional and national differences exist.

Table 3. Energy performing of the office building with the 20% best energy performance

Energy consumption **(kWh/m^{2}a)**	10% best energy Performing office building	20% best energy performing office building
Lighting	19	15
Auxiliary energy	3	3
Heating	20	23
Cooling	7	8
Domestic Hot Water	4	4
Total energy consumption	53	53

[10] http://www.enob.info/en/new-buildings/project/details/campus-energy-21-as-a-new-company-headquarters/

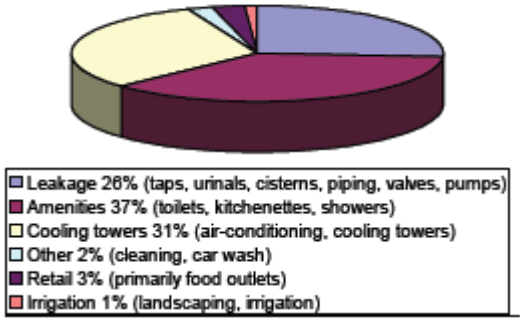

Figure 3. Typical breakdown of water usage in office buildings

Based on the review of the literature information concerning the saving potential due to the installation of lighting control, it was assumed that its installation would decrease from 30-40% of the total energy consumption to around 10-25%. This assumption is rather conservative, as in the literature values of only 7kWh/m^{2}a are proved to be enough for lighting and building services equipment[11]. This fact demonstrates the environmental benefits of applying lighting control while the economical results of are shown in the Table 4.

Table 4. Environmental and economic results of the improvement measures.

Improvement measure	Effect	% of environmental impact variation	% of operating cost variation
Installation of lighting control systems	Energy consumption reduction: lighting	From -27 to -40 %	From - 17.5 to -30.1%

Similarly, literature provides information about the energy savings due to the installation of external walls with a lower U-value. For example, the energy-based modernization of the office towers is based on a considerably improved thermal insulation: Facade: U-value from 1.1 to 0.28; windows: U-value from 2.9 to 1.4; roof: U-value from 0.79 to 0.21 among other energy saving measures getting an energy performance improvement of more than 200% (reduction of the overall energy demand to less than half of the initial energy demand)[12].

The values collected in the literature and concerning the energy savings due to the installation of water efficient products have an effect on both the water consumption and the energy used for hot water. The installation of this kind of products would results in 20-30% saving of water and energy needed for water heating[13]

[11] http://www.enob.info/en/refurbishment/projects/details/general-refurbishment-to-create-an-office-building-to-the-passive-house-standard/
[12] http://www.enob.info/en/refurbishment/projects/details/revitalising-office-towers/
[13] GPP for water using products http://susproc.jrc.ec.europa.eu/ecotapware/stakeholders.html

4 Cost Considerations

4.1 Introduction to Life Cycle Costs (LCC) [14]

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.

[14] Sources: http://www.wbdg.org/resources/lcca.ph

• *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 the Present-Value Analysis should 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 study period*: The study 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.

• *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)[15], Savings-to-Investment Ratio (SIR)[16], Adjusted Internal Rate of Return (AIRR)[17], and Simple Payback (SPB)[18] or Discounted Payback (DPB)[19]. 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.

4.2 Green Public Procurement of office buildings

Office buildings represent a large expenditure of the public sector. However, there is a large range of designs, so many as office buildings to choose from, which vary in terms of design, function, price and performance. The base-case assessment highlighted that while office buildings may have similar intended use, the use patterns do differ between the member states and specifically the functions of an office building.

Thus it is inappropriate to propose universal standards, which can be directly applied in all cases. Instead a series of concrete guidelines have been developed providing alternative approaches which can be used. The public authority wishing to use these guidelines will need to determine which alternative is most appropriate for their situation. The guidelines principally apply to the energy performance and the use of low environmental impact building materials whilst taking into account the costs in the whole life cycle of the office building.

Therefore the results of the LCC analysis have been included for the base-cases of Madrid, London and Tallinn (as representative of the climate zones) and those with 30 and 50% of glazing.

[15] NS = Net Savings: operational savings less difference in capital investment costs NS > 0 (for determining cost-effectiveness)
[16] SIR = Savings-to-Investment Ratio: ratio of operational savings to difference in capital investment costs. SIR > 1 (for ranking projects)
[17] 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)
[18] 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
[19] 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)

4.3 Life Cycle Costs for office buildings

The base-case assessment analysis identified that the investments in lighting control (to reduce the need for electricity) and in water saving products are among those measures that bring the highest environmental benefits and the highest economic savings. For these reasons, the LCC analyses studied are reported in this section.

Information concerning investment costs, cost of installations, electricity and fuel price, economic parameters, etc has been collated and used as inputs for the assessment of the life cycle costs. The differentiation between office buildings constructed with different construction techniques and those with different construction materials has not been made as initial calculations. This indicates that rather than investment price is the cost of energy and water over the building lifetime what offers the potential for savings.

The inputs for office buildings are summarised in Tables 5 (a&b). These are based on information gathered as part of the "Market and economical analysis" and further information collected in the "Technical analysis report". This analysis is carried out for the generic office building model located in London, considered to be new and with 30% glazing

Table 5. Inputs of the LCC

Table 5a. Costs along the office building life cycle for the B1-N-01 building

PRODUCT AND CONSTRUCTION PHASE		AMOUNT (m^2)	COST (€/m^2)	TOTAL (thousand €)
Exterior walls	Gypsum plastering	1,314.00	11.17	14.68
	XPS	1,314.00	10.43	13.71
	Concrete block	1,314.00	29.21	38.38
	Brick	1,314.00	48.81	64.14
Interior walls	Lime-gypsum	2,184.00	37.58	82.07
Roof	Bitumen	1,541.00	26.69	41.13
	Gypsum plasterboard	1,541.00	59.35	91.46
	XPS	1,541.00	10.43	16.07
Floors/ceilings	Timber flooring	4,623.00	41.50	191.85
	Roof screed	1,541.00	26.88	41.42
	Gypsum plasterboard	3,082.00	59.35	182.92
	XPS	1,541.00	10.43	16.07
Windows	Wooden frame double-glazing	576.00	464.78	267.71
Structure	Reinforced concrete (kg)	3,228,000.00	101.53	138.63
	Concrete (kg)	907,000.00	117.59	45.11
USE PHASE		CONSUMPTION	COST (2011)	TOTAL (thousand €)
Electricity (lighting, auxiliary energy and cooling)		1,21 E+07 kWh	0.12 €/kWh	1,689.98
Natural gas (DHW and heating)		4,87 E+06 kWh	0.06 €/ kWh	301.56
Water		3,67 E+05 m^3	2.64 €/m^3	1,090.21
END OF LIFE PHASE		AMOUNT	COST (€/m^3)	TOTAL (thousand €)
Demolition		2149.87 m^3	41.28 €/m^3	88.75
Transport		2149.87 m^3	2.63 €/m^3	5.65
Landfill		2149.87 ton	32.00 €/ton	68.80

Table 5b. Life cycle cost per life cycle stage for the B1-N-01 building

Life cycle stage	Total cost (thousand €)	Cost per functional unit (thousand €/m^2y)	Percentage
Production and construction	1245.36	13.48	27.2
Use	3081.75	33.35	67.2
End of life	257.04	2.78	5.6
TOTAL	**4584.15**	**49.61**	**100.0**

According to this data, 65% of the LCCs are related to the use phase of the building, whereas almost a third of the LCCs are due to the construction of the new building. Costs related to the end-of-life phase are much lower. Figure 4 shows a breakdown of the costs considered for the base case in this study

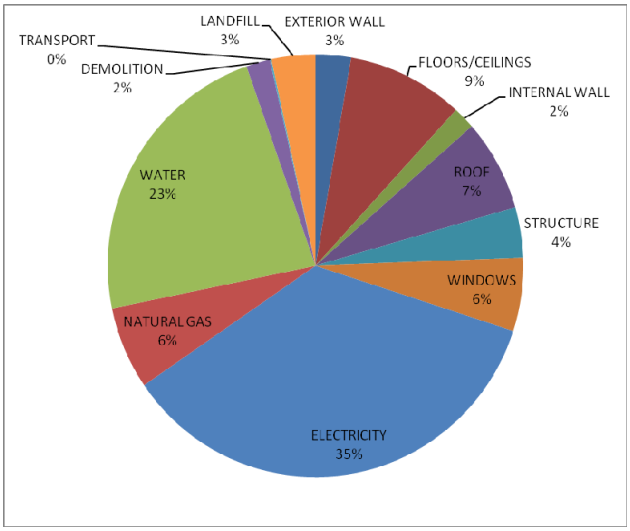

Figure 4. Breakdown of the costs for the B1-N-01 building

Figure 5 points out the importance of the electricity, water and natural gas costs. These three costs occur mainly during the use phase. The share of the costs related to the construction phase accounts for 31% of the total costs while the end-of-life phase is just 5% of the estimated costs.

Moreover, some economic parameters have been considered in this analysis. The most important ones are summarized in Table 6.

Table 6. Economical parameters considered in this study

Economical parameter	
Period of recovery	20 years
Discount rate	3%
Base year	2011
Price PV electricity (sold to the grid)	34€cts/kWh
Service period	50 years
Loan interest payments	--
Water (€ $_{2011}$)	2.64€/m3
Electricity (€ $_{2011}$)	0.124€/kwh
Natural gas (€ $_{2011}$)	0.055€/kWh
Analysis carried out in constant euros	

4.3.1 LCC analysis considering improvements in the external walls

According to the introduction of this section, only the differences between the alternatives should be considered to estimate the best option. In this section an improvement in the external walls is considered. Table 7 summarized the results of the economic assessment for the different scenarios and for the generic buildings located in the three different climatic zones.

Table 7. Cost analysis of improvement measures for the reduction of the U value of external walls in London, Madrid and Tallinn for several base cases

London, new, 30% glazing	U_{wall}= 0.3 W/m²K	U_{wall}= 0.18 W/m²K	U_{wall}= 0.12 W/m²K
Electricity use (€/year)	51,595.79	51,759.45	51,846.60
Gas use (€/year)	5,355.08	5,010.77	4,844.63
Investment Cost (€)	--	6,570	13,140
NPV (20 years)	**--**	**-3,171**	**-8,255**
London, new, 50% glazing	U_{wall}= 0.3 W/m²K	U_{wall}= 0.18 W/m²K	U_{wall}= 0.12 W/m²K
Electricity use (€/year)	52,733.98	52,874.61	52,949.12
Gas use (€/year)	5,587.25	5,335.68	5,208.70
Investment Cost (€)	--	5,130	10,260
NPV (20 years)	**--**	**-3,043**	**-7,185**
London, existing, 30% glazing	U_{wall}= 0.45 W/m²K	U_{wall}= 0.18 W/m²K	U_{wall}= 0.12 W/m²K
Electricity use (€/year)	50,008.78	51,759.45	51,846.60
Gas use (€/year)	8,729.69	5,010.77	4,844.63
Investment Cost (€)	--	78,840	105,120
NPV (20 years)	**--**	**-41,807**	**-66,600**
London, existing, 50% glazing	U_{wall}= 0.45 W/m²K	U_{wall}= 0.18 W/m²K	U_{wall}= 0.12 W/m²K
Electricity use (€/year)	50,635.65	52,874.61	52,949.12
Gas use (€/year)	9,439.89	5,335.68	5,208.70
Investment Cost (€)	--	61,560	82,080
NPV (20 years)	**--**	**-26,465**	**-45,997**

Madrid, new, 30% glazing	U_{wall}= 0.66 W/m²K	U_{wall}= 0.29 W/m²K	U_{wall}= 0.15 W/m²K
Electricity use (€/year)	57,293.46	57,512.44	57,612.03
Gas use (€/year)	4,284.83	3,783.23	3,587.45
Investment Cost (€)	--	6,570	13,140
NPV (20 years)	**--**	**-1,252**	**-6,013**
Madrid, new, 50% glazing	U_{wall}= 0.66 W/m²K	U_{wall}= 0.29 W/m²K	U_{wall}= 0.15 W/m²K
Electricity use (€/year)	59,041.23	59,274.44	59,373.23
Gas use (€/year)	4,329.08	3,963.69	3,821.27
Investment Cost (€)	--	5,130	10,260
NPV (20 years)	**--**	**-2,643**	**-6,952**
Madrid, existing, 30% glazing	U_{wall}= 0.80 W/m²K	U_{wall}= 0.29 W/m²K	U_{wall}= 0.15 W/m²K
Electricity use (€/year)	57,208.08	57,512.44	57,612.03
Gas use (€/year)	5,103.90	3,783.23	3,587.45
Investment Cost (€)	--	78,840	105,120
NPV (20 years)	**--**	**-59,718**	**-84,188**
Madrid, existing, 50% glazing	U_{wall}= 0.80 W/m²K	U_{wall}= 0.29 W/m²K	U_{wall}= 0.15 W/m²K
Electricity use (€/year)	59,165.39	59,274.44	59,373.22
Gas use (€/year)	5,122.91	3,963.69	3,821.27
Investment Cost (€)	--	61,560	71,820
NPV (20 years)	**--**	**-41,801**	**-51,240**

Tallinn, new, 30% glazing	U_{wall}= 0.2 W/m²K	U_{wall}= 0.14 W/m²K	U_{wall}= 0.10 W/m²K
Electricity use (€/year)	50,198.16	50,266.38	50,311.67
Gas use (€/year)	14,480.72	14,106.38	13,851.72
Investment Cost (€)	--	6,570	13,140
NPV (20 years)	**--**	**-810**	**-3,441**
Tallinn, new, 50% glazing	U_{wall}= 0.2 W/m²K	U_{wall}= 0.14 W/m²K	U_{wall}= 0.10 W/m²K
Electricity use (€/year)	51,242.02	51,303.65	51,345.53
Gas use (€/year)	15,057.25	14,773.47	14,583.24
Investment Cost (€)	--	5,130	10,260
NPV (20 years)	**--**	**-950**	**-3,289**
Tallinn, existing, 30% glazing	U_{wall}= 0.25 W/m²K	U_{wall}= 0.14 W/m²K	U_{wall}= 0.10 W/m²K
Electricity use (€/year)	49,947.94	50,266.38	50,311.67
Gas use (€/year)	16,641.59	14,106.38	13,851.72
Investment Cost (€)	--	78,840	105,120
NPV (20 years)	**--**	**-37,131**	**-59,471**
Tallinn, existing, 50% glazing	U_{wall}= 0.25 W/m²K	U_{wall}= 0.14 W/m²K	U_{wall}= 0.10 W/m²K
Electricity use (€/year)	50,908.76	51,303.65	51,345.52
Gas use (€/year)	17,758.88	14,773.47	14,583.24
Investment Cost (€)	--	61,560	82,080
NPV (20 years)	**--**	**-12,819**	**-30,547**

The increased investment cost is not recuperated in any of the above studied base-case. A negative value for the NPV implies that the cost of the improvement measure is not recuperated within the period analysis, as it is the case of the external walls.

This result is due to the increase in the electricity demanded for additional cooling when the external walls of the office building become more isolated.

4.3.2 LCC analyses considering only the improvements in the external walls and windows

In this section an improvement in the external walls is considered. Table 8 summarized the results of the economic assessment for the different scenarios and for the generic buildings located in the three different climatic zones. The Table shows the differences from the base case which assumed a U-value for the windows of 3.157 W/m^{2}K

Table 8. Cost analysis of improvement measures for the reduction of the U value of external walls and windows in London, Madrid and Tallinn for several base cases

London, new, 30% glazing	U_{wall}= 0.3 (W/m^{2}K) U_{window}= 1.776 (W/m^{2}K)	U_{wall}= 0.18 (W/m^{2}K) U_{window}= 1.776 (W/m^{2}K)	U_{wall}= 0.12 (W/m^{2}K) U_{window}= 1.776 (W/m^{2}K)
Electricity use (€/year)	49,843.75	49,906.97	49,950.72
Gas use (€/year)	14,124.15	13,743.23	13,488.59
Investment Cost (€)	11,520	18,090	24,660
NPV (20 years)	**9,059**	**2,562**	**-3,711**
London, new, 50% glazing	U_{wall}= 0.3 (W/m^{2}K) U_{window}= 1.776 (W/m^{2}K)	U_{wall}= 0.18 (W/m^{2}K) U_{window}= 1.776 (W/m^{2}K)	U_{wall}= 0.12 (W/m^{2}K) U_{window}= 1.776 (W/m^{2}K)
Electricity use (€/year)	50,716.68	50,774.72	50,814.37
Gas use (€/year)	14,485.63	14,196.80	14,003.35
Investment Cost (€)	17,280	22,410	27,540
NPV (20 years)	**11,942**	**6,878**	**1,807**
Madrid, new, 30% glazing	U_{wall}= 0.66 (W/m^{2}K) U_{window}= 1.776 (W/m^{2}K)	U_{wall}= 0.29 (W/m^{2}K) U_{window}= 1.776 (W/m^{2}K)	U_{wall}= 0.15 (W/m^{2}K) U_{window}= 1.776 (W/m^{2}K)
Electricity use (€/year)	57,606.07	57,879.44	57,879.44
Gas use (€/year)	3,642.09	3,149.51	3,149.51
Investment Cost (€)	11,520	18,090	24,660
NPV (20 years)	**-5,309**	**-13,072**	**-21,451**
Madrid, new, 50% glazing	U_{wall}= 0.66 (W/m^{2}K) U_{window}= 1.776 (W/m^{2}K)	U_{wall}= 0.29 (W/m^{2}K) U_{window}= 1.776 (W/m^{2}K)	U_{wall}= 0.15 (W/m^{2}K) U_{window}= 1.776 (W/m^{2}K)
Electricity use (€/year)	59,650.70	59,952.67	60,082.78
Gas use (€/year)	3,425.84	3,075.21	2,936.23
Investment Cost (€)	17,280	22,410	27,540
NPV (20 years)	**-11,753**	**-18,454**	**-24,238**
Tallinn, new, 30% glazing	U_{wall}= 0.2 (W/m^{2}K) U_{window}= 1.776 (W/m^{2}K)	U_{wall}= 0.14 (W/m^{2}K) U_{window}= 1.776 (W/m^{2}K)	U_{wall}= 0.10 (W/m^{2}K) U_{window}= 1.776 (W/m^{2}K)
Electricity use (€/year)	49,843.75	49,906.97	49,950.72
Gas use (€/year)	14,124.15	13,743.23	13,488.60
Investment Cost (€)	11,520	18090	24660
NPV (20 years)	**1,857**	**-4,495**	**-11,036**
Tallinn, new, 50% glazing	U_{wall}= 0.2 (W/m^{2}K) U_{window}= 1.776 (W/m^{2}K)	U_{wall}= 0.14 (W/m^{2}K) U_{window}= 1.776 (W/m^{2}K)	U_{wall}= 0.10 (W/m^{2}K) U_{window}= 1.776 (W/m^{2}K)
Electricity use (€/year)	50,716.68	50,774.72	50,814.37
Gas use (€/year)	14,485.63	14,196.80	14,003.35
Investment Cost (€)	17,280	22,410	27,540
NPV (20 years)	**3,360**	**-1,608**	**-6,635**

The improvement of the office building external walls and windows is only recommended in the case of very cold locations, whereas it is not recommended in warm climatic zones such as the climatic zone C2.

This fact is due to the high internal heat load of the office building. The improvement in the insulation requires higher cooling needs and consequently a higher demand of electricity increasing the costs along the life cycle of the office building.

4.3.3 LCC analyses considering improvements in the lighting control system

The installation of a lighting control system that controls 100% of the floor area of the office building is considered. Table 9 summarises the results of the economic assessment for the different scenarios and for the generic buildings located in the three different climatic zones.

Table 9. Cost analysis of improvement measures for inclusion of lighting control systems in new office buildings in London, Madrid and Tallinn for several base cases

London, 30% glazing	U_{wall}= 0.3 W/m²K	U_{wall}= 0.18 W/m²K	U_{wall}= 0.12 W/m²K
Electricity use (€/year)	37,881.70	37998.54	38061.86
Gas use (€/year)	6,567.06	6,176.10	5,976.05
Investment Cost (€)	69,300	69,300	69,300
NPV (20 years)	**165,932**	**167,691**	**168,777**
London, 50% glazing	U_{wall}= 0.3 W/m²K	U_{wall}= 0.18 W/m²K	U_{wall}= 0.12 W/m²K
Electricity use (€/year)	36,624.33	36,726.60	36,779.81
Gas use (€/year)	7,093.52	6,799.22	6,655.65
Investment Cost (€)	69,300	69,300	69,300
NPV (20 years)	**205,468**	**206,994**	**207,707**
Madrid, 30% glazing	U_{wall}= 0.66 W/m²K	U_{wall}= 0.29 W/m²K	U_{wall}= 0.15 W/m²K
Electricity use (€/year)	38,414.40	38,528.20	38,579.86
Gas use (€/year)	5,639.43	5,055.17	4,819.76
Investment Cost (€)	69,300	69,300	69,300
NPV (20 years)	**260,429**	**263,963**	**265,611**
Madrid, 50% glazing	U_{wall}= 0.66 W/m²K	U_{wall}= 0.29 W/m²K	U_{wall}= 0.15 W/m²K
Electricity use (€/year)	38,833.81	38,981.63	39,043.34
Gas use (€/year)	5,731.22	5,292.27	5,120.90
Investment Cost (€)	69,300	69,300	69,300
NPV (20 years)	**284,528**	**287,519**	**288,761**
Tallinn, 30% glazing	U_{wall}= 0.2 W/m²K	U_{wall}= 0.14 W/m²K	U_{wall}= 0.10 W/m²K
Electricity use (€/year)	37,449.01	37,493.24	37,524.31
Gas use (€/year)	15,883.94	15,488.67	15,223.30
Investment Cost (€)	69,300	69,300	69,300
NPV (20 years)	**144,178**	**145,023**	**145,492**
Tallinn, 50% glazing	U_{wall}= 0.2 W/m²K	U_{wall}= 0.14 W/m²K	U_{wall}= 0.10 W/m²K
Electricity use (€/year)	36,511.24	36,555.39	36,585.34
Gas use (€/year)	16,774.30	16,476.02	16,275.94
Investment Cost (€)	69,300	69,300	69,300
NPV (20 years)	**175,558**	**176,160**	**176,570**

The installation of a lighting system does not represent any significant additional cost in the overall costs of the office building as the price of these systems is relatively low in comparison to the costs of construction. However, the economic benefits are huge, especially in the cases of a higher glazing surface. The higher glazing surface together with the lighting control system permit the use of daylighting during the working time and an important reduction in the electricity consumed.

4.3.4 LCC analyses considering the use of localised renewable energy sources

In this section the installation of localised renewable sources, using solar photovoltaic systems as a reference case, is assessed. There are two scenarios considered:

a) the electricity produced by the PV system is consumed by the office building and the additional electricity demand bought from the grid and;

b) the electricity produced is sold to the grid at the price reported in Table 6.

Stimulated by the Directive 2001/77/EC, all Member States implemented different support schemes for the promotion of renewable energy sources in the last years. Feed-in tariffs are the most common support instrument and there existing two options: the feed-in tariff and the feed-in premium. The feed-in tariff guarantees a fixed price per kWh electricity over a contract period. The feed-in Premium is an extra value paid on top of the market price for electricity[20]. The system of fixed feed-in tariffs allows electricity generators to sell renewable energy at a fixed tariff for a determined period of time. Alternatively, the feed-in tariff can be paid in the form of an additional premium on top of the electricity market price[21]

A large range of feed-in tariff levels for PV electricity can be observed at EU-27 level. For example, in Estonia the tariff amounts to 7.4 €cts/kWh, while in Germany accounts for 43.01 €cts/kWh. Moreover, some Member States apply different tariff levels depending on the plant capacity where the PV electricity is produced. In 2009 the average feed-in tariff of different MS (Slovenia, Spain and UK) was 34 €cts/kWh, as reported by International Feed-In Cooperation[22].This is the price considered in this study.

Table 10 summarized the results of the economic assessment when the PV electricity is completely consumed by the office building and extra electricity is bought from the grid for the different scenarios and for the generic buildings located in the three different climatic zones.

Table 10. Cost analysis of improvement measures for inclusion of PV systems and PV electricity is consumed in new buildings located in London, Madrid and Tallinn

20 m^2 PV panels	London	Madrid	Tallinn
Electricity use (€/year)	51,323.49	56,842.84	49,915.81
Investment Cost (€)	8,546.25	8,546.25	8,546.25
NPV (20 years)	**-3,423**	**-68**	**-3,234**
40 m^2 PV panels	London	Madrid	Tallinn
Electricity use (€/year)	51,051.06	56,392.22	49,633.46
Investment Cost (€)	14,862.63	14,862.63	14,862.63
NPV (20 years)	**-4,613**	**2,094**	**-4,238**
60 m^2 PV panels	London	Madrid	Tallinn
Electricity use (€/year)	50,778.76	55,941.48	49,351.12
Investment Cost (€)	21,179.00	21,179.00	21,179.00
NPV (20 years)	**-5,806**	**4,259**	**-5,242**

Generally speaking, the investment costs needed to install the PV facilities are not enough to bring an economic benefit in the period considered regardless the surface area of the panels. Only in the case of large panels in the location of the climatic zone C2, the investment costs are recovered. This fact points out the importance of the climatic conditions in considering the best kind of renewable or low CO_2 energy source depending on the location and design of office building under consideration.

[20] Ragwitz, Held, Stricker, Krechting, Resch, Christian November 2010
www.feed-in-cooperation.org/.../8th-workshop/IFIC_feed-in_evaluation_Nov_2010.pdf .
[21] Klein, A.; Pfluger, B.; Held, A.; Ragwitz, M.; Resch, G.; Faber, T. (2008).
Accessed at http://www.feed-in-cooperation.org/images/files/best_practice_paper_2nd_edition_final.pdf
[22] by A. Klein, A. Held, M. Ragwitz, G. Resch, T. Faber 2006
Evaluation of different feed-in tariff design options - Best practice paper for the International Feed-in Cooperation

Table 11 summarized the results of the economic assessment when the PV electricity is completely sold to the grid for the different scenarios and for the generic buildings located in the three different climatic zones.

Table 11. Cost analysis of improvement measures for inclusion of PV systems and PV electricity is sold to the grid in new buildings located in London, Madrid and Tallinn

20 m² PV panels	London	Madrid	Tallinn
Energy production (kWh/year)[23]	2,196	3,634	2,227
Investment Cost (€)	8,546.25	8,546.25	8,546.25
Income (€/year)[24]	724.68	1,199.22	757.18
Amortization period (years)	11.8	7.1	11.3
40 m² PV panels	London	Madrid	Tallinn
Energy production (kWh/year)	4,393	7,268	4,554
Investment Cost (€)	14,862.63	14,862.63	14,862.63
Income (€/year)	1,449.69	2,398.44	1,548.36
Amortization period (years)	10.3	6.2	9.6
60 m² PV panels	London	Madrid	Tallinn
Energy production (kWh/year)	6,589	10,903	6,831
Investment Cost (€)	21,179.00	21,179.00	21,179.00
Income (€/year)	2,174.37	3,597.99	2,322.54
Amortization period (years)	9.7	5.9	9.1

If the PV electricity is sold to the grid the economic analysis provides better results. Once again the location in a climatic zone C2 results in a faster recovery of the investment costs needed for the installation of PV panels (shorter amortization periods) that other locations in colder climatic zones.

Comparing both options, it is clear that the governmental subsides to produce electricity by renewable energy sources, and in this case by PV panels, are still needed. However, the differences in the amortization periods depending on the locations of the office buildings suggest that for each location a renewable energy source should be considered as the most convenience one. Therefore, it is expected that case by case the designer considers what the best option for the renewable energy sources to be installed is.

The installation of renewable energies can also be carried out by installing thermal solar panels. In this case, the energy provided by the panels is used for heating the domestic hot water and reduces the consumption of natural gas. Table 12 summarized the economic assessment when 20, 40 or 60m^2 of thermal solar panels are installed for each of the generic building in each of the locations.

Table 12. Cost analysis of improvement measures for inclusion of thermal solar panels (20, 40 or 60m^2) in new buildings located in London, Madrid and Tallinn

20 m² thermal solar panels	London	Madrid	Tallinn
Gas use (€/year)	4,780.17	3,529.73	13,921.04
Investment Cost (€)	6,144.78	6,144.78	6,144.78
NPV (20 years)	**4,672**	**8063**	**4,386**
40 m² thermal solar panels	London	Madrid	Tallinn
Gas use (€/year)	4,695.25	3,494.86	13,853.39
Investment Cost (€)	12,289.57	12,289.57	12,289.57
NPV (20 years)	**125**	**2574**	**-486**
60 m² thermal solar panels	London	Madrid	Tallinn
Gas use (€/year)	4,661.09	3,493.87	13,821.10
Investment Cost (€)	18,434.35	18,434.35	18,434.35
NPV (20 years)	**-5,377**	**-3552**	**-6,023**

[23] This datum comes from Table 19 in the Technical analysis [IPTS 2011C].

[24] This datum comes from multiplying the energy produced per surface of PV by the price of the renewable energy sold to the grid or "feed in tariff".

Regarding the installation of the localised renewable energy sources in these generic models the following conclusions can be drawn:

- The consumption of the PV electricity in-situ is only beneficial in locations of the climatic zone C2 (the warmest one) and only if a minimum surface of 40m^2 is provided. This fact points out that the consumption of the own produced PV electricity is not appropriate for most of the locations across Europe.

- However, when the PV electricity is sold to the grid and as long as the PV electricity is subsided in a certain extend, the installation of PV panels become a profitable option with periods of amortization below 12 years in all the cases. Considering a life expectancy of these installations of 30 years[25], the economic benefits of this option are very strong in locations in the climatic zone C2 (the warmest one).

- The installation of localised renewable energy sources in the form of solar thermal panels requires an optimal installed area. Installations of thermal solar panels smaller than this optimum are not profitable. According to this study, the optimal area for the location of Tallinn is 40m^2 while for Madrid and London is 60m^2. However, these figures should be only used as reference values and the optimal surface area is expected to be calculated case by case for each location and office building characteristics.

- Regarding the installation of localized renewable energy sources, generally speaking, the renewable energy source shall be carefully chosen in order to obtain the highest economic benefits. The selection strongly depends on the location (climatic conditions) and design of the office building.

4.3.4 LCC analyses considering water saving products

Water consumption is responsible for 38% of LCCs for the base case office building. Different strategies can be applied in order to reduce water use in buildings for different equipments such as taps (air devices, thermostats, infrared sensors, limiter to the flow length), toilets (double-command, waterless or vacuum) and even devices to be installed in old equipment (mixers of water and air, interruption of toilet flush, limiters to shower flow)[26]. Moreover, other strategies such as the use of rainwater harvesting and water reuse can help to reduce water consumption, too.

Some of these strategies may have a very low or even zero cost, as nowadays water saving devices are commonly used in the construction of new buildings with similar costs in comparison to the standards ones[27]. Therefore, investment costs will depend on the chosen water reduction strategy, and may not represent an extra cost.

Applying any or all of these strategies, it will be reasonable to reduce the initial consumption of 55.5 l/p/day of the generic office building to 20.0 l/p/day as proposed by the ecolabel criterion. This 64% reduction in water consumption will result into the same range of reduction to the annual water cost. In

[25] years [IEA-PVPS, 2009] http://iea-pvps.org/fileadmin/dam/public/report/statistics/tr_2009_neu.pdf
[26] [ECOLOGIC 2007] http://ecologic.eu/2175
[27] [BEDEC 2011]. https://www.itec.cat/nouBotiga2.e/Bedec.aspx

the case of the generic office building, considering a water price of 2.64€/m^3 [28] and a reduction from the initial consumption of 3.67 10^3 m^3 /year, 12,383€ could be annually saved.

4.4 Life Cycle Cost Assessment – Summary

The life cycle cost assessment using the base-case as an example has 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.

The assessment shows that just by changing energy consumption in lighting, and keeping all other aspects equal, savings ranging from 17800 to 13000 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, 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 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.

By reducing energy consumption in heating and cooling (increasing the U-value of external walls and windows) the greatest financial savings can be made through the improvement of windows. This aspect is of especial importance in the 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. The higher isolation of the external walls can provide further savings but it strongly depends on the location and design of the office building.

The water consumption cost accounts for around 38% of the overall cost distribution of the base-case. This share of the total costs depends on the location and the cost of the water. Due to the importance of this cost, a sensitivity analysis was carried out. Due to the extremely low additional investment costs needed to install ecological water using products the economic savings all over the life of the office building are outstanding. The installation of water saving products is estimated to save around 12300 euros yearly without significant additional investment costs.

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

[28] [DG ENER 2011]

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.

5 Public Procurement Needs

5.1. Procurement considerations

In terms of procurement the building sector is extremely complex both in procedural terms, as there is usually competitive tendering for the architectural design, construction work, and the building services (heating, cooling, ventilation, hot water supply, electricity) and in terms of the variety of materials and services procured.

This section outlines a typical process for building construction in a European public authority; however, the following scheme may vary depending on the project in the number of steps to go through. This is significant as the level of technical detail about the final structure, and hence the accuracy of any calculation of energy performance or use of sustainable building materials, increases from stage to stage. The number of different services tendered can also vary) architect, construction company, building services) and thus the opportunities for inserting demand into tendering procedures will also differ from case to case

5.1.1.- Project development

Probably this stage is one of the most important phases in the building process. All project stages are based on specifications made in this phase, so here the highest potential for sustainable building design can be found. The public authority has to develop specifications for:

- Choice of the site and orientation. It has to fit in the masterplan for the area, the requirements from local authorities, accessibility, etc
- Costs
- Standards for the energy performance of the building if possible (e.g. benchmarks for heating and cooling, renewable energy sources for the building services) and other requirements such image, architecture (landmark), health conditions, sustainability level, safety level or security. These ambitions are worked out in a feasible program of requirements based on the cost calculations.

5.1.2 Preliminary design / architects competition

This step consists of two parts:

- The architects competitively tender to carry out the work. This aspect may not always be carried out as it depends on the size of the project (total budget)
- Revised preliminary design, including preliminary selection of superstructure, building materials, constructions

5.1.3 Submission of the planning

The final design for submission to building authority for planning permission (determination of superstructure, building materials, construction form, external appearance)

5.1.4. Implementation planning

Final selection of superstructure, building materials, constructions, systems for building services as the base for tendering for the construction work

5.1.5. Construction work and implementation of building services

This step consists of:

- Selection of construction firm through competitive tendering to carry out the construction work according to the implementation plan
- This should include clear quality assurance measures for monitoring energy and ecological performance

Competitive tendering has a substantial influence on how environmental performance standards can be applied in building projects, and in particular how competitive tendering can be used to achieve the best possible offer.

At the stage of the invitation to tender for the construction or major renovation of the building some major decisions, which are relevant for the environmental performance of the building (e.g. choice of superstructure and construction) may have already been taken and, depending on the nature of the contract, specifications can change once a contract has been awarded. This implies that in contrast to other procurement files, major decisions may and often are taken outside the direct competitive procurement process itself. For this reason, it is important to ensure the environmental considerations and performance parameters are included in the specifications for the design. These specifications can be used either as the basis for architect competitions or if no competition is being held, as direct targets for the design which have to be fulfilled by the architect. While in some countries this is already a common practice, in other countries it is still a hurdle to set ecological targets for the architect, as it is difficult in the preliminary design phase to calculate environmental performance with any degree of accuracy.

5.2.- Purchasing demands

An important share of office buildings procurement is carried out by public authorities although most is carried out by private companies. Sometimes a developer of may construct an office building which is then adopted by the public authority. In these cases the public authority will generally issue a specification and approve the layout and construction of the building.

Office building procurement can vary substantially, from construction of a large office building to the renovation of a small one. Accordingly, each particular tender for office buildings developed following this set of GPP criteria needs to be adapted. Important is the form and the amount of proof required in different stages to assess if the design is going into the desired direction. The administrative load should also be minimised as much as possible, but minimizing at the same time the risk of failure.

5.3.- Purchasing phases

5.3.1.- Preliminary design / architects competition

In this stage mainly design-related issues can be addressed such as a definition of heated /cooled areas, shape/volume ratio, area and disposition of windows, building position and orientation. The most appropriate approach to take will depend largely on the existence of national/regional calculation methods and standards for the energy demand, U-values and /or shape volume ratio, on the access the contracting authority has to expert advice.

There are significant opportunities for using less polluting energy sources, such the localised Renewable Energy Sources (RES) (i.e. included in the building itself, such as solar panels, biomass boilers, etc).

For the most effective use of solar power in the building it is advisable to set minimum requirements at the architect's competition stage, as the panels need to be integrated into the building shell, however this will require a good estimation of the net energy demand for the building and also selecting appropriate solar panels which the architect must use.

No matter how efficient a building is in design, the actual energy consumption is of course highly dependent on the behaviour of the building users Furthermore, if energy consumption is effectively monitored it is much easier to identify areas for improvement.

5.3.2.- Tendering for the building construction

In this stage of the project the exact definition of the thermal building shell or other components of the building can be addressed. Based on the preliminary design, at this stage the quality of the thermal building components has the most significant impact on energy performance.

In almost all the cases better isolation will mean higher construction costs – so this is difficult to handle, and can best be addressed through using the award phase of tendering. Extra points can be offered based on the overall energetic performance of building envelope presented by the competing bids.

Following the initial dosing phase, at the building construction stage decision will be taken about the actual materials to be used (and purchased) for the construction work. For all construction work it is possible to exclude the use of certain substances however it should be accompanied by a requirement

or preference to use more sustainably produced materials. In this case a sustainable building material is taken to mean one that complies with the criteria underlying any type I ecolabel meeting ISO standard 14024 or type II meeting ISO standard 14021.

5.3.3.- Tendering for the building services

This stage will define the final provision of the building services – heating, cooling, ventilation, lighting, etc – including issues such as generation, storage and distribution. The efficiency of the systems put in place, together with the energy/fuel type used to run them (electricity, oil, gas, localised RES) have a key impact on the overall energy consumption of the building whether in terms of primary energy consumption or CO_2 emissions. As buildings consume less and less energy it becomes important to stimulate an integral approach based on an integral energy concept. Sources, installation and buildings characteristics should work together to realise a low and balanced energy consumption.

These issues can be addressed in the building services stage, either by setting specific standards for the final energy consumption, or by using this as basis of competition between competing bidders (or both)

If final energy consumption is used as the indicator it will principally be decided according to what is demanded in the national/regional regulations and the basis for the calculation must be the energy consumption calculated during the design stage. Expert input will be needed to determine which approach is used.

Further improvements related to the localised RES can be made at the stage of the tendering of the building services. Here it is possible to either set a minimum percentage of final energy consumption which will require some expertise and knowledge of the local climatic and market potential of localised RES options in selecting the minimum standard.

Alternatively there can be competition around the percentage of energy consumption provided by localised RES in the building services tender, which would reduce the level of expertise needed.

5.3.4.- Experience of the construction contractor and/or property developers

Whatever criteria are used to ensure the sustainability of the building, using a construction contractor and/or property developers with experience in sustainable construction is arguably as important. Moreover, feedback from market in the design phase is desirable.

Furthermore a number of tools using LCA methods for evaluating and ensuring the sustainability of the materials used for which expertise are required. The availability, scope and applicability of these tools vary from country; however this is a good opportunity to encourage their use.

Type of criteria such as: selection based on experience with sustainable building design, compulsory use of LCA tools during design phase, testing at commissioning and hand over by e.g. air tightness, IR camera, etc, can be considered

5.5 Other aspects to be considered

As already noted, there are an enormous number of environmental impacts throughout the life-cycle of a building, from the choice of site right through the disposal of materials. The most significant of these impacts as are addressed with the criteria summarized below. However many other aspects can be taken into consideration to further improve environmental performance. Some of them are highlighted in this section

5.5.1 Sustainable site and building design

The first question that needs to be addressed is whether a new building is really needed in order to meet the space requirements or if existing buildings could be used. If existing buildings can be used, the authority needs to decide which renovation measures are necessary. Given the large amount of energy used in the preparation and transport of construction materials and in the construction process itself, it is usually a more environmental friendlier option to refurbish, reuse or redesign existing buildings rather than to construct a new one. However, not in all the cases it is so obvious. The renovation costs are substantial while the energy consumption reduction and the optimal fitted to the user functional requirement is not always easy to achieve.

Regardless this first question to be considered (construction of a new building or renovation), basic building design decisions have a fundamental effect on the lifetime performance and environmental impacts of buildings as well as on the energy performance and the range of applicable building materials, it is important therefore that proper consideration is given to the durability, form and structure of the new building.

Among these aspects, the size of the building is one of the aspects that causes a higher environmental impact. Energy consumption is highly dependant on the area of the room independently of its use. For example, rooms must be conditioned (by heating and cooling), ventilated and/or lighted, having a similar energy consumption regardless use. Therefore, a strategy (in design and by organization measures) is to reduce the amount of square meters should be awarded.

Taking this aspect into account, the floor area unit (m^2) is not appropriate but it is recommended to be used but it should be considered another expression related to a functional parameter like, for example, the number of full time employees.

A simple but extremely efficient measure for reduction of the environmental damage is to build less area for the same function. This aim can be achieved by stimulating lean and mean buildings, flex working, multifunctional workplaces, etc.

5.5.1.1 Indoor air quality

Thermal comfort, daylight or good lighting systems, humidity and noise control are fundamental requirements for occupant comfort

5.5.1.2 Behavioural aspects

The consumption of heat, water, electricity, etc are of course not only determined by the design and construction of the building, but also by the behaviour of those using the building. No matter how efficient the office building is energy consumption will considerably increase if it is not properly managed. Measures can be taken to address this issue, one of which is the training of building users in energy and water saving behaviour, the establishment of an energy accounting system or Environmental Management System are possible methods for ensuring systematic and continuous monitoring and improvement of such aspects. A complementary approach can be the installation of monitoring equipment which indicate very precisely how much energy is being consumed, when and where in the building, allowing a very accurate analysis of where potential savings lie.

5.5.1.3 Promotion of renovation work

The highest savings in energy efficiency can be achieved through the renovation of the existing building stock (reuse of buildings rather than new construction should be encouraged). Therefore renovation should be actively promoted.

6 Proposal for Core and Comprehensive Criteria

The key environmental impacts from office buildings are strongly associated with the consumption of energy in the use phase. Further, significant environmental impacts are associated with: a) energy consumption in the production and construction phase, b) use of hazardous constituents and materials that coming from no sustainable sources, c) consumption of water and generation of waste (along all the phases of the office building).

Other impacts are related to the indoor air quality and the well-being/comfort of the employees.

Key Environmental Areas and Impacts	GPP Approach
<u>Key environmental areas</u> - Energy consumption - CO_2 emissions in the use phase - Depletion of natural resources, high amount of building materials - Use of hazardous substances and materials during the production of the building materials - Release of hazardous substances during the disposal phase - Use of hazardous substances that release indoor air pollutants affecting the health of the end users - Fresh water consumption - Construction and demolition waste production - MSU waste production during the use phase <u>Key environmental impacts:</u> - The following key environmental impact categories along the product life cycle are covered: global warming, acidification, ecotoxicity, human toxicity, eutrophication, resource depletion, and water and energy consumption.	- Purchase of office buildings with high energy performance - Purchase office buildings with low CO_2 emissions - Purchase buildings with a limited amount of hazardous constituents - Purchase products with high recycled and reuse content in the building materials - Purchase buildings which facility the recovering of building materials - Purchase buildings which use sustainably harvested and produced resources - Purchase buildings with water saving technologies - Purchase buildings which minimise waste production and ensure proper waste management of C&D and MSU waste

Note: The order of impacts does not necessarily reflect their importance.

For each product/service group two sets of criteria are presented:

- 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.

EU GPP Criteria for Office Building

The following sets of EU GPP criteria are proposed:

a) Criteria for purchasing of new and major renovated high environmental performing designed office buildings

b) Criteria for contracting high environmental experience architects, constructors and property developers

3.1 EU GPP criteria for the design phase of the office buildings	
Core criteria	**Comprehensive criteria**
SUBJECT MATTER	**SUBJECT MATTER**
Construction and/or major renovation of high energy efficient office buildings	
TECHNICAL SPECIFICATIONS	**TECHNICAL SPECIFICATIONS**
Energy consumption during the use phase The overall energy consumption of the office building shall be amongst the best energy performing new and major renovated office buildings in the member state where it is located. a) If the Member State where the office building is located has developed an energy performance certificate rating A-G, the building shall meet the energy performance rated with class X (*one of the highest one*s) on the respective national calculation methods b) If no energy ratings were developed, the energy performance of the office building shall fall within the *x%* best energy performing new and major renovated office buildings of the Member State where it is located. **Verification:** In the design phase, the designers must provide information about: - the overall energy performance of the building according to the national method where the building is going to be built up - comparison of the energy performance of the building and the national ratings ensuring that the office building to be awarded will have a top energy performance (*XX% of the best energy* performing office buildings in the country).	**Energy consumption during the use phase** The overall energy consumption of the office building shall be amongst the best energy performing new and major renovated office buildings in the member state where it is located. a) If the Member State where the office building is located has developed an energy performance certificate rating A-G, the building shall meet x% better than the energy performance rated with class A on the respective national calculation methods b) If no energy ratings were developed, the energy performance of the office building shall fall within the *x% best* energy performing new and major renovated office buildings of the Member State where it is located. **Verification:** In the design phase, the designers must provide information about: - the overall energy performance of the building according to the national method where the building is going to be built up - comparison of the energy performance of the building and the national ratings ensuring that the office building to be awarded will have a top energy performance (*XX% of the best energy performing* office buildings in the country).
Energy monitoring and efficiency training The office building shall be provided with an energy monitoring system that is able to report the overall energy consumption of the building. This system shall allow the identification of the possible mismatches and improvement potential during the use phase of the office building. A user's information system shall be established ensuring that the information regarded to energy consumption is distributed to at least the maintenance staff. A training session must be given to the building manager on the energy efficient use of the building following the completion of construction/renovation works. The bidder must outline the content of the training. **Verification:** Bidders must provide specifications and graphical documents confirming	**Energy monitoring and efficiency training** The office building shall be provided with an energy monitoring system that is able to report the overall energy consumption of the building. An energy monitoring system able to report separately the energy consumption of at least heating, cooling, lighting and domestic hot water shall be installed. This system shall allow the identification of the possible mismatches and improvement potential during the use phase of the office building. A user's information system shall be established ensuring that the information regarded to energy consumption is distributed to at least the maintenance staff. A training session must be given to the building manager on the energy efficient use of the building following the completion of construction/renovation works. The bidder must outline the content of the training. **Verification:** Bidders must provide specifications and graphical documents confirming

that the energy monitoring system and the user's information system are installed. Bidders must demonstrate that the information will be displayed, reported and ideally imparted to at least the maintenance staff of the office building.	that the energy monitoring system and the user's information system are installed. Bidders must demonstrate that the information will be displayed, reported and ideally imparted to at least the maintenance staff of the office building.
	Localized Renewable energy sources A minimum of *x*% of the (*net, final or primary)* energy demand must be provided/generated by localized renewable energy sources. Localized renewable sources means renewable energy source generating capacity within the building site itself (e.g. solar panels, biomass boiler, wind turbines, etc) **Verification:** In the design phase, bidders must provide information on the renewable energy systems installed in the building and how the energy generated will be used in the building or sold to the grid.
	AWARD CRITERIA
	Innovative energy efficient building services Bidders must submit specific proposals for achieving energy efficient lighting, heating, cooling and ventilation in the building. It is recommended the energy savings and the use of passive components (e.g. insulation, daylight use, triple glazing in the windows, shadings when necessary, etc)

Explanatory notes
General note: it is recommended to evaluate which would be the best phase for including each of the proposed environmental criteria (architect's design competition, tendering procedure for constructions works, etc)
- **Localized renewable sources percentage:** the contracting authority will need to determine the appropriate minimum % of localized renewable energy source. This will largely depend on the climatic conditions and the design of the building. Typically this should be between 5-20%
- **Energy consumption standards:** the choice of net, final or primary energy will depend on the indicators used for defining energy performance provided in national legislation.
- **Energy consumption standards, defining percentage levels:** the percentage level (ambition level) to insert highly depends on the ambition level of the maximum energy performance defined in national legislation. It is recommended to aim for at least 20% lower than the most usual required energy level for new and major renovated office buildings
- **Training information:** construction works also includes the installation of heating, ventilation, air conditioning and refrigeration (HVAC) as well as energy supply, lighting and water system. A specialist company may be contracted to design and install (and sometimes maintain) these services for the building
- **Energy monitoring**: The monitoring of all energy flows that exceed 5% of the total (excepted) energy consumption is recommended in the comprehensive criteria

SUBJECT MATTER	SUBJECT MATTER
Construction and/or major renovation of high energy efficient office buildings using environmental friendly construction materials and products	
TECHNICAL SPECIFICATIONS	**TECHNICAL SPECIFICATIONS**
Use of construction materials complying with certain environmental criteria At least xx% in cost of the major building elements[29] shall be building products that comply with at least one of the following criteria: 1) Ecolabelled products (labels Type I or Type III in accordance to ISO 14024 or ISO 14025 respectively) shall be selected 2) If point 1 is not possible, materials that provide a clear and transparent information on the product environmental performance based on LCA information in accordance with ISO 14024 should be selected **Verification:** Bidders must provide a list of all: a) the Ecolabelled products used in the building, including their name, the name of their manufacturer and the Ecolabel they have been awarded with, as well as a description of their common function at building level (i.e. description of the product category). Moreover, the applicant shall provide copies of certificates corresponding to the Ecolabels awarded for all of these products. b) The LCA assessment of the materials along with the name of the manufacturer and the description of the function shall be provided.	**Use of construction materials complying with certain environmental criteria** At least xx% in cost of the major building elements shall be building products that comply with at least one of the following criteria: 1) Ecolabelled products (labels Type I or Type III in accordance to ISO 14024 or ISO 14025 respectively) shall be selected 2) If point 1 is not possible, materials that provide a clear and transparent information on the product environmental performance based on LCA information in accordance with ISO 14024 should be selected **Verification:** Bidders must provide a list of all: a) the Ecolabelled products used in the building, including their name, the name of their manufacturer and the Ecolabel they have been awarded with, as well as a description of their common function at building level (i.e. description of the product category). Moreover, the applicant shall provide copies of certificates corresponding to the Ecolabels awarded for all of these products. b) The LCA assessment of the materials along with the name of the manufacturer and the description of the function shall be provided.
	Use of construction recycled and reused materials The preparation for re-use, recycling and other material recovery, including backfilling operations using waste to substitute other materials, of non-hazardous construction and demolition waste excluding naturally occurring material defined in category 17 05 04 in the list of waste of the Directive 2008/98/EC on waste shall be increased to a minimum of > 80% by weight. **Verification:** Bidders must provide a detailed description of the methodology to calculate the estimated material recovery potential of the demolition waste, once the building completes its service life. Material recovery potentials should not be hypothetical but based on existing technologies, economic viability and applicable industry standards. In the description bidders must: - identify the potentially recyclable or reusable materials, - explain how these materials could be identified and collected during the demolition processes, and - foresee which will be the most probable and appropriate recycling process.

[29] Building elements are considered as those which in their totality constitute the office building. These are: external and internal walls, slabs, windows and doors and floors (including coverings, etc)

	Finally, bidders must calculate the percentage in weight that the recovered materials represent in relation to the total amount of materials and products used in the building.
	Use of building materials with recycled and reused content At least *xx%* in cost of the building components installed in the building, will be formed by products containing at least *xx%* recycled or reused materials. **Verification:** Bidders must provide a list of all the products used in the building which contain recycled materials, including their name, the name of their manufacturer and the percentage and origins of the recycled content, as well as a description of their common function at building level (i.e. description of the product category). Moreover, bidders must provide copies of the certificates or declarations corresponding to the recycled content of products
Responsible sourcing of wood and wood-based materials At least xx% of the wood and wood-based materials shall be responsibly sourced materials. **Verification:** Certification schemes that can certify this requirement such as FSC[30], PEFC[31], or any equivalent means of proof (accepted by the respective competent body).	**Responsible sourcing of wood and wood-based materials** At least xx% of the wood and wood-based materials shall be responsibly sourced materials. **Verification:** Certification schemes that can certify this requirement such as FSC, PEFC or any equivalent means of proof (accepted by the respective competent body).

Explanatory notes:

General note: it is recommended to evaluate which would be the best phase for including each of the proposed environmental criteria (architect's design competition, tendering procedure for construction works, etc)

- Construction materials that comply with certain environmental criteria: a minimum requirement of 60-80% in cost of all the materials to be used could be proposed
- Recycled/reused content: a minimum requirement of 30 and 50% in cost of materials with at least 20% in weight of recovered content can be used. If award criterion (LCA comparison of building materials) is used, a relatively low percentage should be set
- Use of environmental construction materials and products: this criterion can be in the award phase as the contracting authority will likely not have sufficient knowledge of the market availability and price of such products. If the contracting authority has a good market knowledge, minimum percentages for certain products types or a global one could be included in the specifications.
- Responsible sourcing of wood and wood-based materials: a minimum requirement of 60-80% in weight of the wood and wood-based certified materials can be used.
- LCA comparison of construction materials: the availability of LCA data on building materials varies considerably across Europe. The contracting authority will need to consider whether sufficient data exists to apply this criterion as award one. The contracting authority will need to determine which LCA tools are most appropriate for the region/type of construction work. Where LCA tools are available, it may replace the most specific requirements on building materials (as they are covered by the LCA tool).
The use of LCA tool during the design phase is also recommended.

30 **http://www.fsc.org/** Forest Stewardship Council
31 http://www.pefc.org/ Programme for the Endorsement of Forestry Certification

SUBJECT MATTER	SUBJECT MATTER
Construction and/or major renovation of high energy efficient office buildings with high indoor air quality and well-being for the employees	
TECHNICAL SPECIFICATIONS	**TECHNICAL SPECIFICATIONS**
Exclusion of certain materials The following materials/substances will not be used in the building: 1. Products which contains 'Substances of very high concern (SVHC)' 2. Products that release indoor air pollutants (e.g VOC, CO_2, CO, PM, etc): the emissions from the building products used must not exceed the respective values outlined in the European standard for the determination of emissions from building products EN ISO 16000-9 to -11 or equivalent **Verification:** 1. Bidders must declare that these products/substances will not be used in the building 2. Test report based on the outlined methods or equivalent	**Exclusion of certain materials** The following materials/substances will not be used in the building: 1. Products which contains 'Substances of very high concern (SVHC)' 2. Products that release indoor air pollutants (e.g VOC, CO_2, CO, PM, etc): the emissions from the building products used must not exceed the respective values outlined in the European standard for the determination of emissions from building products EN ISO 16000-9 to -11 or equivalent **Verification:** 1. Bidders must declare that these products/substances will not be used in the building 2. Test report based on the outlined methods or equivalent
	A separate room printers and office equipment The building shall have separate service rooms for placing imaging and office equipment generating dust and/or noise (such as printers, copy machines, plotters). **Verification:** In the design phase, bidders must provide graphical documentation showing compliance with the criterion
Minimum Ventilation rate A minimum ventilation rate must be above the respective values outlined in the national standards that ensures the IA pollutants are not concentrated inside the building **Verification:** In the design phase, bidders must provide information on the compliance within the national standards.	**Minimum Ventilation rate** A minimum ventilation rate must be above the respective values outlined in the national standards that ensures the IA pollutants are not concentrated inside the building **Verification:** In the design phase, bidders must provide information on the compliance within the national standards.
Visual comfort 1. Visual comfort based on balanced illumination without appreciable interferences and sufficient illumination levels shall be guaranteed in the permanent workplaces following the respective national best practice. 2. Purchase of the indoor lighting and lighting systems shall be done following GPP criteria **Verification:** Bidders must provide information on the compliance within the national standards	**Visual comfort** 1. Visual comfort based on balanced illumination without appreciable interferences and sufficient illumination levels shall be guaranteed in the permanent workplaces following the respective national best practice. 2. Purchase of the indoor lighting and lighting systems shall be done following GPP criteria **Verification:** Bidders must provide information on the compliance within the national standards

Explanatory notes
General note: It is recommended to evaluate which would be the best phase for including each of the proposed environmental criteria (architect's design competition, tendering procedure for construction works).

SUBJECT MATTER	**SUBJECT MATTER**
Construction and/or major renovation of high energy efficient office buildings with lower waste generation and well waste management	
TECHNICAL SPECIFICATIONS	**TECHNICAL SPECIFICATIONS**

Recycling facilities Dedicated storage space to cater for recyclable materials generated during the use phase shall be constructed. The waste collection area or areas to be provided with sufficient different containers that shall be clearly labelled to facilitate the segregation of materials for recycling and adequately dimensioned according to the building operation and likely level of occupation. **Verification:** Bidders must provide graphical documents proving that a common space has been set aside for waste sorting and collection in all building's floors and evidencing the assumptions made in order to estimate the space provision.	**Recycling facilities and waste management plan** Dedicated storage space to cater for recyclable materials generated during the use phase shall be constructed. The waste collection area or areas to be provided with sufficient different containers that shall be clearly labelled to facilitate the segregation of materials for recycling and adequately dimensioned according to the building operation and likely level of occupation. **Verification:** Bidders must provide graphical documents proving that a common space has been set aside for waste sorting and collection in all building's floors and evidencing the assumptions made in order to estimate the space provision.
	Management plan A waste management plan shall be developed containing information on how to collect the waste generated, provision for the monitoring of the waste streams and giving instructions on the separated waste streams should be sorted and collected. **Verification:** After delivery of the building, the criteria will be evaluated by visual check by the competent body or delegate onsite.
Construction and demolition Waste management The contractor must put appropriate measures in place to reduce and recover (reuse and recycle) waste that is produced during the demolition and construction process. It is required to have a recovery rate of at least 60% related to weight percentage segregation **Verification:** proof of compliance can be provided by an Environmental Management System (EMS) such as EMAS or other evidence of equivalent environmental management measures	**Construction and demolition Waste management** The contractor must put appropriate measures in place to reduce and recover (reuse and recycle) waste that is produced during the demolition and construction process. It is required to have a recovery rate of at least 60% related to weight percentage segregation **Verification:** proof of compliance can be provided by an Environmental Management System (EMS) such as EMAS or other evidence of equivalent environmental management measures
Explanatory notes: Waste reduction and management: the contracting authority must set up a proper monitoring and evaluation system during the construction process that, besides general quality control issues, also focuses on the monitoring of the waste management system	
SUBJECT MATTER	**SUBJECT MATTER**
Construction and/or major renovation of high energy efficient office buildings with lower water consumption	
TECHNICAL SPECIFICATIONS	**TECHNICAL SPECIFICATIONS**

Maximum water consumption The estimated maximum water consumption shall be equal or less than 25 liter/person/day, where person refers to the equivalent of a full-time employee in the office building **Verification:** Bidders must provide documentation with the calculated estimate of the daily water consumption per employee and day. This estimate will be based on the functional characteristics of the bathroom fittings (WC and basin taps), assuming a minimum daily consumption of 1.5l of drinking water, and three uses of the WC (calculated as average flush) and the basin per employee and day. When carrying out these calculations, only potable water will be taken into account, leaving out rainwater or grey water used within the building. Showers are excluded from the estimation. Average flush is defined as: - female average WC flush = (2*reduced WC flush + 1*full WC flush)/3 - male average WC flush = (2*urinal flush + 1*full WC flush)/3	**Maximum water consumption** The estimated maximum water consumption shall be equal or less than 20 liter/person/day, where person refers to the equivalent of a full-time employee in the office building. **Verification:** Bidders must provide documentation with the calculated estimate of the daily water consumption per employee and day. This estimate will be based on the functional characteristics of the bathroom fittings (WC and basin taps), assuming a minimum daily consumption of 1.5l of drinking water, and three uses of the WC (calculated as average flush) and the basin per employee and day. When carrying out these calculations, only potable water will be taken into account, leaving out rainwater or grey water used within the building. Showers are excluded from the estimation. Average flush is defined as: - female average WC flush = (2*reduced WC flush + 1*full WC flush)/3 - male average WC flush = (2*urinal flush + 1*full WC flush)/3
	Water saving installations All sanitary and kitchen water facilities must be equipped with the latest water-saving technologies available on the market: - Dual flush WC with 6l/flush for the full flush and urinals with 3liters/full flush - Water saving devices fitted into cisterns must demonstrate a water saving of at least 30% for toilet flushing - Taps inserts should save at least 50% of water compared to normal tap use **Verification:** Bidders must provide technical data-sheets for the products to be installed that verify compliance with the specifications
	Water saving management system A water saving management system shall be developed consisting of: - A water saving management plan which stipulates the recommended schedule, methods and assessments for the inspection of the water facilities - A water monitoring system able to report the overall water consumption of the building and separately the water consumption of at least toilets, basins, showers, kitchen taps, white appliances, water for irrigation and cooling towers (if existing). The monitoring system shall allow for the identification of possible mismatches between the estimated and actual water consumption and the possible improvement potential during the use phase of the office building - A user's information system shall be established ensuring that the information regarding water consumption is distributed to and ideally imparted to at least the maintenance staff Verification After delivery of the building, the water saving management system as well

	as the information/communication system will be evaluated by the competent body or delegate.
	AWARD CRITERIA
	Rainwater and grey-water use Bidders must provide a proposal on how to maximise the use of rainwater and grey-water supply and return system of the building. The proposal will be rated according to the following criteria: - Design and quality of the technology including adaptability to the building design - Estimate percentage of overall water supply from rainwater and grey-water sources - Maintenance costs and durability of the product (installation and maintenance costs)

Explanatory notes
General note: It is recommended to evaluate which would be the best phase for including each of the proposed environmental criteria (architect's design competition, tendering procedure for construction works).
- Water saving installations – verification: in order to set the specifications and very compliance, the contracting authority should have an overview of the available technologies such as tap attachments and water flow restrictions on the market. The criteria can be adapted as necessary to fit the market availability
- Water saving installations – defining percentages: the level of ambition (x%) strongly depends on the market availability of the demanded technologies in the specific European region. Where the contracting authority is unfamiliar with the market situation, it is recommended to use this criterion in the award phase in order to set a realistic demand
- Rainwater and grey water use – specifications on the award phase: it is also possible to set minimum percentages of overall water supply for rainwater and grey-water sources, however the potential will vary considerably according to climatic conditions. Therefore local expertise would be needed to set appropriate levels

SUBJCT MATTER	**SUBJECT MATTER**
Construction and/or major renovation of high energy efficient office buildings with low environmental impact commuting facilities	
TECHNICAL SPECIFICATIONS	**TECHNICAL SPECIFICATIONS**
	Promotion of bicycles Dry bicycle storage space with slots shall made be available for at least 15% of the building users. The cycle storage shall be safe, secure and accessible. Showers, changing rooms and lockers shall be set up in sufficient quantify according to the number of bicycle storage space. **Verification:** Bidders must provide a description and graphical documents proving that a number of bicycles could be safely stored within the building or suitable adjacent structure. Moreover, the applicant shall provide an estimate of the number of people working in the office building, ensuring that at least 15% of them will be supported to commute by bicycle. Bidders must provide graphical documents proving that facilities, showers, changing rooms and storage cabinets are available in sufficient quantify.

3.2 EU GPP criteria for the contract performance clauses of office buildings	
Core criteria	**Comprehensive criteria**
SUBJECT MATTER	**SUBJECT MATTER**
Construction and/or major renovation of high energy efficient office buildings	
SELECTION CRITERION	**SELECTION CRITERION**
Exclusion of certain constructors Construction companies, which have repeatedly acted against environmental legislation and have been found guilty of grave professional misconduct as outlined in Articles 53 and 54 of Directive 2004/17/EC and Article 45 of Directive 2004/18/EC, will be excluded from the tendering procedure	**Exclusion of certain constructors** Construction companies, which have repeatedly acted against environmental legislation and have been found guilty of grave professional misconduct as outlined in Articles 53 and 54 of Directive 2004/17/EC and Article 45 of Directive 2004/18/EC, will be excluded from the tendering procedure
The construction contractor and/or property developers shall have sufficient past experience with sustainable building design. **Verification:** The contractor shall supply a list of the persons responsible for the project, indicating educational and professional qualifications and relevant experience. This should include persons employed by subcontractors where the work is to be sub-contracted. The contractor shall also supply a list of the projects the contractor has carried out over the last two years.	**The construction contractor and/or property developers shall have sufficient past experience with sustainable building design.** **Verification:** The contractor shall supply a list of the persons responsible for the project, indicating educational and professional qualifications and relevant experience. This should include persons employed by subcontractors where the work is to be sub-contracted. The contractor shall also supply a list of the projects the contractor has carried out over the last two years.
The contractor shall ensure that has relevant experience in - Optimal designing for the reduction of floor area needed for the same function - Energy efficient construction design, including if available specific energy demand per m^2 including heating, cooling, lighting, hot water and auxiliary equipment for previous construction - Water efficient construction design, including if available specific water demand per employee. - The use of less polluting energy sources - Installation of monitoring systems and the communication of mismatches to the end users. - Bioclimatic architecture, to achieve energy efficiency, thermal and optical comfort, etc - Use of LCA tools in the design - Use of low environmental impact construction materials - Achievement of good indoor air quality standards **Verification**: Statement by the contractor that the relevant adjustments and calibrations will be carried out.	**The contractor shall ensure that has relevant experience in** - Optimal designing for the reduction of floor area needed for the same function - Energy efficient construction design, including if available specific energy demand per m^2 including heating, cooling, lighting, hot water and auxiliary equipment for previous construction - Water efficient construction design, including if available specific water demand per employee. - The use of less polluting energy sources - Installation of monitoring systems and the communication of mismatches to the end users. - Bioclimatic architecture, to achieve energy efficiency, thermal and optical comfort, etc - Use of LCA tools in the design - Use of low environmental impact construction materials - Achievement of good indoor air quality standards **Verification:** Statement by the contractor that the relevant adjustments and calibrations will be carried out.

Technical capacity to take the necessary environmental management measures in order to ensure that the construction works are executed in an environmental friendly way Bidders must demonstrate their technical capacity (either having the expertise within the company or by co-operation with experts) to put in place certain environmental management measures that meet the following requirements: - Ensuring effective protection of fauna and flora in the building area and its surroundings (where construction takes place in an environmentally sensitive area) - Measures to prevent any harmful waste and hazardous substance flows that may adversely impact the areas - Environmental management measures aimed at minimising waste production on the site, respecting noise regulations and avoiding traffic congestions - Measures to ensure energy and water efficiency **Verification:** Possible proof include EMAS and ISO 14001 certificates or equivalent certificates issued by bodies conforming to Community law or the relevant European international standards concerning certification based on environmental management standards. Other means of evidence provided by the company that can prove the required technical capacity will also be accepted.	**Technical capacity to take the necessary environmental management measures in order to ensure that the construction works are executed in an environmental friendly way** Bidders must demonstrate their technical capacity (either having the expertise within the company or by co-operation with experts) to put in place certain environmental management measures that meet the following requirements: - Ensuring effective protection of fauna and flora in the building area and its surroundings (where construction takes place in an environmentally sensitive area) - Measures to prevent any harmful waste and hazardous substance flows that may adversely impact the areas - Environmental management measures aimed at minimising waste production on the site, respecting noise regulations and avoiding traffic congestions - Measures to ensure energy and water efficiency **Verification:** Possible proof include EMAS and ISO 14001 certificates or equivalent certificates issued by bodies conforming to Community law or the relevant European international standards concerning certification based on environmental management standards. Other means of evidence provided by the company that can prove the required technical capacity will also be accepted.
Explanatory notes **- Experience of the architect in environmental construction:** judging the experience of the architect requires experience from the contracting authority. It may be appropriate to bring in external expertise and set up a jury that combines common knowledge to judge the experience statements of competing architects This list is indicative and can be expanded/reduced to fit the situation. It will be necessary for the authority to determine what appropriate past experience means **- Exclusion of grave professional misconduct.** Contracting companies can only be excluded if the national laws of a Member State include provisions on environmental laws and where the violation of such laws (and the final decision in this sense by a court) would constitute grave professional misconduct, bidders who have been convicted in this sense could be excluded (articles 53 and 54 of Directive 2004/17/EC and Article 45 of Directive 2004/18/EC) In procuring office buildings, contracting authorities may let separate contracts (covering, for example, design, construction, % of renovation, etc) to different contractors. In such cases, different contractors may therefore be responsible for ensuring that different criteria are met	

Maintenance

Office buildings require proper maintenance to ensure the proper functioning of the system. Over time, certain elements/systems of office building may lose their efficiency and required properties, e.g. sealings and windows, will not ensure proper protection against heat losses and gains (isolation), and their replacement may be necessary. Thus, control of the state of office building and replacement of used elements/systems should be scheduled programme.

Cost Considerations

Life cycle costing

The contracting authority may optimally wish to carry out a life cycle cost assessment, or to require the bidder to carry out such an assessment. Such an assessment should include the initial cost of the installation, its estimated lifetime, replacement costs of office building and their estimated life, and energy (fuel and electricity) cost and water cost of the office building over its lifetime. The contracting authority will need to define its winery (including fuel, electricity and those coming from alternative energy sources) price and the rate at which this increases, and its interest rate on investments.

It is recommended to apply a “total cost of ownership methodology” when awarding the contract. This means that instead of considering just the purchase price of the product when assessing the one offering best value for money, the contracting authority will consider the life cycle cost (LCC) over the estimated period of ownership of the building. This would cover the purchase price, the cost of maintenance and other services, the cost of energy and water consumption and other services (such as waste management) for the building, and any disposal costs. This will allow the authority to take into account environmental aspects in both the quality assessment (through environmental technical specifications and/or award criteria) and the price/investment (through inclusion of the Life cycle cost).

7 Verification Issues

Verification of the GPP core and comprehensive criteria can be conducted using respective documentation from owner/developer or constructors.

Recently more and more owner/developers have given higher attention to environmental impacts, which their construction process and buildings cause and they have tried to reduce respective negative effects. Growing environmental consciousness among both owners/developers and end-users and the increasing importance of sustainability in policy development at various levels has contributed towards a growing importance to establish in the construction sector environmental management systems and/or to certify with labels indicating preferable environmental performance.

The certification process for awarding a building with an Ecobuilding label will consist of fulfilling for the building a set of criteria developed especially for it. In this respect issues of assessment and verification methods used to check the compliance with these criteria are of high importance. Applicants usually have to submit to the awarding authority documents in form of declarations of compliance by the producer or by the supplier, technical and/or product safety sheets;

If GPP criteria are based on other policy tools such Member States ecolabels, the compliance with these criteria may be proved through demonstration of owning the relevant label, provided that this label fulfils the given requirements. In this case public procurers shall ask for copies of relevant documents. If this is not the case, contracting authorities shall ask bidders to submit additional documents confirming compliance with the criteria. Verification procedures are indicated in the verification section of criteria document for a given product for each criterion separately.

8 Conclusions and Summary

Office buildings represent an important share of the overall public building sector, although most of them belong to the private sector. Both private and public office buildings are covered by the scope of this product group. This work provides a guideline for the green procurement of office buildings in Europe. Because of each office building is unique the selection of the most appropriate criteria and benchmarks depend on not only the location and design of the building but also on the experience and knowledge of the contracting body. As a result, the GPP criteria for office building presented in this study should not be regarded as a set of criteria to be complied with but a set of proposal for achieving a green purchase of an office building.

The main environmental impacts caused by the use of office buildings are associated clearly with the consumption of energy needed for lighting, heating and cooling and auxiliary equipment including ventilation. To a lower extent the consumption of fresh water and the generation of waste during the construction, use and demolition phases cause environmental damages as well. Therefore, the key requirements for green public procurement of office buildings shall refer to the following aspects influencing energy efficiency, energy sources, water use and waste generation reduction:

- **Construction or major renovation of high energy efficient office buildings** with

- high overall energy performance during the use phase. The energy performance should correspond at least to the highest energy performance rated in the Member State where it is located

- energy monitoring system that allows the identification of mismatches between the energy performance designed and the real one. Information obtained thanks to this system should be reported to the building manager

- on-site renewable energy sources is recommended

- construction materials that comply with certain environmental criteria, if possible labelled with a Type I or Type III label according to TC/CEN 350 standards or ISO EN 14024 and 14025

- construction materials with a high potential recovery

- construction materials with a high recycled or reused content, but without decreasing its quality

- responsible sourcing wood and wood based materials

- lower water consumption. The reduction of the water consumption can be achieved by using water saving products (taps, showers and toilets) as well as water saving devices fitted into cisterns and taps

- water saving management system that allows the identification of leakages and mismatches between the designed and real values of consumption

- waste management plan for C&D waste and recyclable materials generated during the use phase. Dedicated storage space and appropriated measures to reduce and recover waste that is

produced during these phases is recommended to be included during the design phase of the new office building or the major renovation

As the LCC analyses showed, most of the measures proposed in this work, even if the purchase costs /investment costs for these buildings are higher, provide savings in the overall life cycle of the building (due to the short return time needed). Among these measures the installation of water saving products, the reduction of the energy consumption, the monitoring and control systems to avoid unnecessary consumption and the installation of on-site renewable energy sources provide economical savings in a very short time.

Other measures, such as the use of construction materials that comply with certain environmental criteria, have a high potential for recovery or have high recovered content cause significant environmental benefits without having a significant impact on the economical life of the building. Thus, though they are not significant from an economical point of view, they are recommended to be followed from an environmental point of view.

Further, due to the issues of comfort for end-users, construction materials with hazardous substances or materials classified as substances of very high concern and those that release indoor air pollutants over the values outlined in the European standards EN ISO 16000-9 to -11 should be excluded. In addition, a ventilation rate above the minimum ventilation rate according to the national standards should be ensured to avoid the concentration of indoor air pollutants in the rooms. Finally, a balanced illumination without appreciable interferences and sufficient illumination levels is proposed to be guaranteed in the permanent workplaces. These last measures ensure a better well-being of the employees what can reinvest in a higher productivity of the workers/employees and the associated environmental benefits.

Because of the high level of difficulty in designing a sustainable building, a proof of the experience of the construction contractor and/or property developers in these tasks can be required, although it is not recommendable to use it as an exclusion criterion. Experience on energy efficient construction design, water efficient construction design, use/design of on-site renewable energy sources, installation of monitoring systems and communication of mismatches to the end users, bioclimatic architecture to achieve high energy efficiency by using passive elements, use of LCA tools or use of construction materials that comply with certain environmental criteria is desirable.

Eventually, the authority can require the compulsory proofs of the high energy performance of the office buildings by several tests such as blower door test, IR camera, etc

9 Existing Standards & Ecolabels and Other Information Sources

9.1 Directives at European level

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

The objective of the recast of EPBD 2002 on the energy performance of buildings, EPBD recast 2010, is to clarify and simplify certain provisions, extend the scope of the Directive, strengthen some of its provisions so that their impact is more effective, and to provide for the leading role of the public sector. In doing so, the transposition and implementation of the EPBD recast 2010 is to be facilitated and a significant portion of the remaining cost-efficient potential in the buildings sector will be reaped. At the same time, the objectives and principles of the current Directive are retained and it is again left to Member States to determine the concrete requirements and ways to implement it as before. The EPBD recast 2010 was motivated by the EU expectation to lower the energy consumption by 5-6% across EU member states, slashing CO_2 emissions by 5% by 2020 and to harmonize and strengthen EU legislation and methodologies across all member states.

This Directive is aimed at the reduction of buildings energy consumption by proposing guiding principles for Member States with regard to the energy performance. Office buildings are only mentioned as a type of buildings to be taken into account (single family houses, sports facilities, etc…) with regard to the specific energy consumption levels calculation. No further definition or requirements for office building are provided.

The total energy demands of the buildings, and therefore of office buildings, consists of several inputs such as heating, cooling, ventilation and lighting. With the EPBD recast 2010 the European Commission has provided a guideline for the EU MSs to evaluate buildings in these inputs. This guideline shall be implemented by each MS regarding their national requirements and standards for construction and refurbishment of buildings. The implementation of this directive in most of the EU-MS is still in progress[32]. As a result, the comparison of benchmarking for buildings is a complex issue across Europe.

The key points of EPBD recast 2010 are:

- Member States should set their requirements using their own calculation methodology with a view to achieve the cost-optimal levels determined by them. The MS should adopt, either at national or regional level, a methodology for calculating the energy efficiency of buildings, and take into account different elements like: thermal characteristics, heating insulation, air-conditioning and built-in installation, indoor climatic conditions and hot water supply. Also, the positive influence of other aspects such local solar exposure, natural lighting, electricity produced by cogeneration and district or block heating or cooling systems should be taken into account.

[32] Schlenger 2009, http://re.jrc.ec.europa.eu/energyefficiency/greenbuilding/

- All MSs should set in place minimum requirements for energy performance with cost-optimal levels. The level of these requirements should be reviewed every 5 years. MS should differentiate between new and existing buildings and between different categories. According to this point and although the methodology to calculate the energy performance of an office building might be the same than that of a residential building, the minimum performance should be different.

Prior to the EPBD recast 2010, some MS developed their own methodology to calculate the energy performance of the buildings. In some cases, the methodology only includes some minor changes on the calculation of residential and office buildings energy performance, as for example in Spain. The Spanish methodology considered lighting when calculating the energy performance of an office building, but not of a residential building. Due to the heterogeneity in the methodologies used by each MS, its direct applicability to the EU Ecolabel is not recommended.

- There is no longer a threshold of 1000m2 of refurbishment to fulfil the minimum energy performance. This measure excludes 72% of the buildings stock which disposes of an outstanding, cost-effective energy saving potential. Clearly, the best moment for the introduction of energy efficiency measures is when the building undergoes major renovations (approx. every 25-40 years for residential buildings but approx. every 10 years for office buildings). In this way the additional investment needs are not high and due to energy savings they are repaid within the lifetime of the measures.

- For existing buildings, their energy performance should be upgraded so that they also satisfy the minimum requirements. No specific targets are set for the refurbishment of existing private buildings, which account for 99% of the current building stock. However, public authorities could be required to refurbish at least 3% of their buildings by floor area every year. The European Commission proposed this in its long-awaited European energy efficiency plan, presented on March 2011 in Strasbourg.

- Some buildings may be exempt from the application of the minimum requirements: officially protected, places of worship, temporary, residential for limited seasonal use or small[33] stand-alone buildings.

- The Directive strongly encourages the introduction of intelligent energy consumption metering systems, whether the building is newly constructed or undergoes renovation.

- The goal of nearly zero-energy consumption for new buildings by 31 December 2020 is set. For public owned or occupied buildings this deadline is set by 31 December 2018. Furthermore, the Directive encourages the creation of national plans to put in practice the definition of nearly zero-energy buildings, the definition of intermediate targets for improving the energy performance of new buildings by 2015. It also encourages the provision of information on the policies and financial measures adopted to encourage improving the buildings energy performance. Some steps forward have been done, MEPs in the European Parliament define zero-energy buildings as buildings "where, as a result of the very high level of energy efficiency of the building, the overall annual primary energy consumption is equal to or less than the energy production from renewable energy sources on site".

[33] < 50 m^2 of total useful floor area.

The Directive does not clearly define what a “nearly zero energy building” is, either for new build or refurbishment of existing buildings. Article 2(1a) gives a purely qualitative definition: A “nearly zero energy building” is a building that has a very high energy performance. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby[34]

- A system of energy performance certificates for buildings should be implemented. When the building unit is offered for sale or for rent, the corresponding energy performance indicator should be included in the advertisements in commercial media. For the case of new buildings, the certificate should be shown to the prospective buyer. It should be handed over to the new tenant. For buildings occupied by a public authority or buildings of public use with a total floor area of over 500 m^2, the energy performance certificate shall be displayed in a prominent place and be clearly visible35.

9.1.2. Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on energy end-use efficiency and energy services

The purpose of this Directive is to increase the energy end-use efficiency products and services. The goal is to achieve a minimum annual volume of the 1% in energy savings, and an overall 9% in the period from 2008 to 2016.

There is not explicit mention of office buildings, but the energy saving measures for end users include guidelines about the insulation of buildings, the addition of passive solar elements to the outside buildings constructions, the installation of solar thermal systems, etc.

9.1.3. Directive 2005/32/EC of the European Parliament and of the Council of 6 July 2005 establishing a framework for the setting of ecodesign requirements for energy-using products

This Directive establishes a framework for setting ecodesign requirements (such as energy efficiency) for all energy using products in the residential, tertiary and industrial sectors. The directive does not introduce directly binding requirements for specific products, but does define conditions and criteria for setting requirements regarding environmentally relevant product characteristics (such as energy consumption). This Directive applies in principle to all energy using products and covers all energy sources.

In respect with office buildings, heating and water heating equipment, domestic lighting, domestic appliances, office equipment and HVAC systems are considered as a priority in the working plan regarding buildings. These elements are connected with the energy performance of buildings but they are out of the scope of this study.

[34] www.ren21.net/Portals/97/documents/GSR/REN21_GSR2011.pdf
[35] This threshold shall be lowered to 250 m^2 on 9 July 2015.

9.1.4. Directive 89/106/EEC of 21 December 1988 on the approximation of laws, regulations and administrative provisions of the Member States relating to construction products

This “Construction Products Directive” regulates the products for building works. Products may only be placed in the market if they are fit for their intended use. They should provide for an economically reasonable working life, the essential requirements with regard to mechanical strength, stability, security in case of fire, hygiene, health and safety of use. Furthermore, they should provide protection against noise and help to save energy and provide thermal insulation.

Environmental issues are addressed at the article 3 of the annex I. The construction work must be designed and built in such a way that it will not be a threat to the hygiene or health of the occupants or neighbours, especially with the giving-off of toxic gas, the presence of dangerous particles or gases in the air, the emission of dangerous radiation, pollution or poisoning of the water soil, faulty elimination of waste water, smoke, solid or liquid wastes, the presence of damp in parts of the works or on surfaces within the works.

9.1.5. Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives

This Waste Directive repeals directives 75/439/EEC, 91/689/EEC and 2006/12/EC and establishes a legal framework for the treatment of waste. It sets the basic concepts and definitions related to waste management and lays down waste management principles such as the "polluter pays principle" or the "waste hierarchy": 1) prevention, 2) preparing for reuse, 3) recycling, 4) other recovery (notably energy recovery) and 5) disposal. It aims at protecting the environment and human health through the prevention of the harmful effects of waste generation and waste management.

MS can implement legislative measures with a view to reinforcing this waste treatment hierarchy and take steps to ensure that, by 2020, 70% of weight of waste non-hazardous construction and demolition waste will be intended for reuse, recycling and other materials recovery operations, including filler operations using waste instead of other materials.

Concerning hazardous waste, it must be stored and treated in conditions that ensure the protection of health and the environment. It must not, in any case, be mixed with other hazardous waste and must be packaged or labelled in line with international or Community regulations. Any establishment or undertaking intending to carry out waste treatment must obtain a permit from the competent authorities who determine notably the quantity and type of treated waste, the method used as well as monitoring and control operations.

Any incineration or co-incineration method aimed at energy recovery must only be carried out if this recovery takes place with a high level of energy efficiency.

9.1.6. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy

The Water Framework Directive objectives are to ensure the good quality of running water across Europe by 2015. The construction sector has a high indirect impact on running water schemes across Europe. Reduced water consumption and waste relating to construction works and products contribute significantly to the fulfilment of the aims and objectives of the WFD.
The installation of intelligent water-saving technologies in buildings as well as measures to re-use water combined with rainwater usage systems are measures to enhance the quality of European water resources by reducing the pressure on springs and surface waters, and reducing wastewater streams.

9.2 EU Regulations and Communications

9.2.1. Regulation (EC) 66/2010 of the European Parliament and of the council of 25 November 2009 on the EU Ecolabel

The aim of Regulation is to establish a voluntary ecolabel award scheme intended to promote products with a reduced environmental impact during their entire life cycle and to provide consumers with accurate, non-deceptive, science-based information on the environmental impact of products.

9.2.2. COD 2008/0098 Regulation of the European Parliament and of the Council laying down harmonized conditions for the marketing of the construction products

A product level, the European Commission is developing a new Construction Products Regulation which will replace the Directive 89/106/EEC. The new CPR proposal involves the obligation to declare (using the “CE” marking), the performance of building products. The proposal includes a new prerequisite for the sustainable use of natural resources during the whole life cycle (design, construction and demolition).

Where applicable, provisions for an intended use or uses of a construction product in a Member State, aimed at fulfilling basic requirements for construction works, determine the essential characteristics the performance of which should be declared. In order to avoid an empty declaration of performance, at least one of the essential characteristics of a construction product which are relevant for the declared use or uses should be declared. Besides, when assessing the performance of a construction product, account should also be taken of the health and safety aspects related to its use during its entire life cycle.

In addition, where applicable, the declaration of performance should be accompanied by information on the content of hazardous substances in the construction product in order to improve the possibilities for sustainable construction and to facilitate the development of environmentally friendlier

products. All the hazardous substances will comply and be treated as it is specified in articles 6.6 and 6.7 of the Ecolabel Regulation

9.2.3. Communication from the Commission of 11 February 2004. Towards a thematic strategy on the urban environment

The main objectives covered by this Communication are to revitalize and mainstream the environmental management of Europe's largest towns and cities and to overcome isolated policies (buildings, infrastructure, transport, energy, waste, etc.) with a general focus on sustainable urban management, sustainable urban transport, sustainable construction and sustainable urban design. Within these main objectives the development of a common methodology for evaluating the overall sustainability of buildings and the built environment is the main target of this thematic strategy. Aspects such as the life cycle assessment of buildings and the development of indicators for life-cycle costs are part of this strategy.
The Thematic Strategy on the Urban Environment was adopted on 11 January 2006. It strongly encourages Member States, regional and local authorities to develop programmes to promote sustainable construction. The document focuses not only on energy related aspects, such as increasing the renovation rate, but also on the labelling of building products and strategies for the prevention and recycling of waste.

9.3 Green Public Procurement

This is a set of criteria that should be applied to all public tendering processes for public authorities. Since the annual expenditure in new and renovation of existing buildings represents up to 50% for most governments, these criteria are especially important for offices, which play a major role.

GPP construction takes into account environmental criteria related to energy consumption, the use of renewable energy sources, the construction materials and products, waste and water management, and other aspects of the environmental impact: the architect’s design and the monitoring and user perspective aspects.

Generally speaking GPP criteria are developed with the aim to be simple and universally applicable. However, due to the complexity of the product group, the differing climatic conditions and the differing national legislative frameworks, this goal is hardly achieved. One key point of these criteria is the attention paid to the fact that the energy performance strongly depends on the architect’s choices during design. Therefore, it pays attention to the integration of the environmental requirements into the architect’s work during the competition procedure for construction work.

Other environmental requirements regarding the percentage of sustainable building materials, the recycling of materials, the reduction of dangerous substances and the energy demand for the construction plot are demanded.

In this case, GPP for construction gives recommendations for the procurement of construction works, including the supply of related services such as cooling, heating and ventilation services and the provision of electricity. It addresses the design, construction, use and disposal phase of buildings such as public services buildings and office buildings. For each of these phases environmental criteria are proposed.

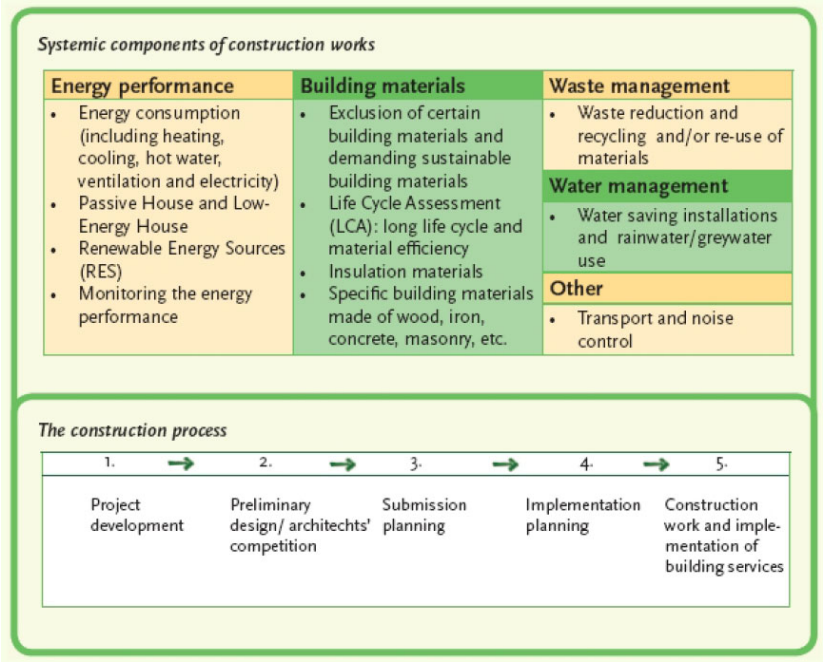

Figure 5: GPP proposed areas for developing criteria regarding construction works

Table 13 shows the impacts and the areas considered by GPP in order to develop the criteria and Table 14 provides the background technical assessment why these areas are considered to be the most important ones.

Table 13: Key environmental impacts

IMPACT	GPP Approach
The consumption of energy for heating, cooling, ventilation, hot water, and electricity, and resulting CO2 emissions	- Maximize the energy performance of buildings - Ensure high energy efficiency standards for heating, cooling, ventilation and hot water systems, and electronic devices - Encourage the use of localised5 renewable energy sources (l-RES)
The consumption of natural resources	- Include a systematic Life Cycle Approach (LCA) for building materials - Encourage the use of sustainably harvested and produced resources
Over-consumption of fresh water resources both during construction and during the use phase	- Encourage the installation of high-end water saving technologies and reduce the use of freshwater during the construction process.
Emission of substances harmful to human health and the environment during the production or disposal of building materials leading to air and water pollution Negative health impacts on building users due to building materials containing dangerous substances	- Encourage the use of non-toxic building materials - Encourage the use of substitute substances/materials for dangerous building materials
Transportation of construction materials and products generates CO2 emissions that have an influence on climate change	- Use energy efficient vehicles for transportation and on the building site - Apply effective supply chain management systems

Table 14: Background study and environmental aspects

Aspect	Background reason
Production of materials	Raw materials are extracted from renewable and non-renewable resources for the production of building materials. When processing the raw materials into building products, energy and environmentally-hazardous chemicals are needed and harmful emissions to air, water and soil can arise.

	When planning and constructing a building, the production phase can be influenced by favouring environmentally-sound materials. Possibilities are to use building materials that fulfil the criteria of an eco-labelling scheme and recycled materials and to avoid, where possible, materials containing environmentally-hazardous substances.
Construction	During the construction phase, there can be harmful emissions of substances and materials to air and water. In the surrounding area of the construction site, there might be disturbance from noise and transport of material by heavy vehicles, influencing people and local eco-systems. Environmentally-responsible collection and disposal/recycling of construction waste are important. It is also important to consider the effects of construction processes on the indoor environment during the use of the building, e.g. material and quality controls to prohibit built-in damp damage. Quality management in construction can also be important for ensuring a long life, for proper insulation, and for the correct functioning of the ventilation and heating/cooling systems and other appliances.
Use	The use of energy for space, water heating and ventilation, electrical equipment and lighting cause the largest environmental impacts of a building during its lifetime. Water consumption and the production of waste water are other important impacts of buildings. In the planning and construction phases of a building, it is important to consider the ultimate use of the building and possible reduction of environmental impacts through: - energy efficiency (ventilation, heating and cooling, insulation, lighting, various appliances, etc.) - water efficiency - promotion of good condition and long-life of the building, by, for example, a service and maintenance plan for the house - improving the indoor environment, considering constituent materials/ good ventilation / material and quality control during the construction phase, for example, to prohibit built-in damp damage - including the possibility to alter and modify the inner space (i.e. distribution of rooms and functions like bathrooms and kitchens). The service and maintenance plan ('House care book') should describe the functioning and properties of all the technical equipment, material content as well as appropriate advice for maintenance and repair of all the relevant structures and covering materials, including a timeTable for repairs and renovations, etc.
Waste	At the end of a building's life, there are several kinds of waste to be taken care of. Waste amounts can be reduced by ensuring a longer life for the building: a service and maintenance plan for the house can contribute here. Problems during renovations and at the end of life can be reduced/avoided by preventing environmentally hazardous substances in the construction materials.

9.4. Legislation at Member State level

The assess of the environmental impact of buildings in most of the MS is considered, as a general rule, by national programs (some of them of voluntary application) where the building is considered as a whole and the energy performance is the main environmental impact considered. The improvements in the energy savings depends on the earlier implementation of the EPBD 2002 by the Member States. For example, Denmark, Germany, the Netherlands or the United Kingdom, which went beyond the requirements of the Directive and are now thus in a better position to take on the tasks of the EPBD recast 2010. Regarding this situation, a report called "Towards an Energy Efficient European Buildings Stock"[36] was done within the project BUILD UP. In annex II of this document it is summarized part of the information provided.

9.5. Labels at Member State level

Because of the large amount of data collected, all the Tables regarding criteria areas and benchmarks are available in the annex III of this document.

[36] RICS 2009 http://www.rics.org/site/scripts/download_info.aspx?downloadID=4413&fileID=5311

9.5.1 France

The voluntary initiative “Haute Qualite Environmentalle” the also voluntary but mandatory for all public sector residential buildings37 Qualitel and an organization responsible for the label (Qualitel) are the main elements of the French green building design. Its objectives are to reduce the environmental impact with both eco-design and eco-management.

HQE bases on a global approach, but with increasingly focus in energy and water management and a greater demand for certification. It is a multi-criteria approach divided into three main components:

- An environmental management system of the operation (SME) where the client sets his objectives and defines the role of different actors;
- 14 targets to structure the technical, architectural and economic answers for those objectives and
- Performance indicators.

Moreover, there are two standards that closely approach office buildings

- NF tertiary sector buildings: Construction and renovation that was designed specifically for offices buildings
- NF Tertiary Buildings in Operation

Qualitel standard has the dual aim of meeting technical and environmental challenges and coming into action on users’ needs, on community’s expectations and on assessment for building sector professionals.

The scheme aims at pointing out the targets the building should comply with. Moreover, this scheme developed a document called “model for evaluation of environmental quality of buildings”[38] that although it does not replace the certification standard HQE it describes the benchmarks and calculation methods that should be used.

9.5.2 Germany

The German Sustainable Building Certificate [DGNB] is one of the codes that was developed firstly for offices and covers all relevant topics of sustainable construction (ecology, economy, socio-cultural topics as well as functional ones). The evaluation is not based in a single measure (as happens with the French and the English systems) but is based in a list of 51 different criteria. Each criterion is weighted differently, according to "New construction office and administration buildings" code. In this code, 6 topics considered the relevant sectors of sustainable construction evaluate the building's quality and the quality of the location.

To shut up, the DGNB system is a framework with detailed specifications and characteristics for conducting a building LCA. On this basis, benchmarks with two elements (construction and operation)

[37] Mandatory for buildings larger than 25 units

[38] Evaluation of the environmental impact of buildings, including quality and financial cost., K. Allacker, F. Troyer http://www.mech.kuleuven.be/lce2006/028.pdf

have been derived and can be used to define the life cycle based environmental performance of buildings. Specific data, criteria and benchmarks are listed on annex III of this document.

9.5.3 Spain

GBC Spain, Green Building Council, has established an evaluation system based in the application or the VERDE tool. GBC Spain applies the evaluation methodology for environmental impact of buildings known as VERDE that establishes a total of six Certification levels. It is only possible to certify residential and office buildings. In addition, design stage and construction finished stage would be certified. VERDE methodology makes and approach to LCA of the building. Reduction levels are calculated regarding the impacts associated with environmental and design issues, such as indoor environmental quality and socioeconomic matters. The evaluation procedure is focus only on the building, thus excluding the area outside the building footprint.

In Catalonia, Spain, the "Distintiu de Garantía de Qualitat Ambiental" [DISTINTIU] has established other methodology for the building certification. It is a system to identify products and services that satisfy certain properties or features involving environmental care. The environmental criteria for the offices building category are divided in ten sections, each of which contains basic specific criteria required as well as optional criteria. All of them rated from 1 to 9, mainly regarding lighting, climatization, energy efficiency in installations and offices machinery, maintenance, waste management, CO_2 emissions, etc. To get the "Distintiu de Garantía de Qualitat Ambiental", the building must meet each basic criteria and obtains a minimum of 80 points in the computation for at least three of the optional ones.

9.5.4 Switzerland

The voluntary "Minergie" has been in effect since 1997. Buildings with such Ecolabel achieve an energy consumption reduction of the 300% (with respect to conventional buildings) with only a 2-4% increase in the construction costs.

This label is divided in four different categories as shown in Table 15.

Table 25: Swiss Minergie Categories

Minergie-standard	- general energy consumption is lower than 75% of that of the average buildings - fossil fuel consumption is lower than 50% of the energy consumption of this building - increase of the costs should be only 10% in comparison to a standard building
Minergie-P	- very low energy consumption, it is specially demanding in regard to heating. This standard corresponds to the passive house
Minergie-Eco	- ecological requirements such as recyclability, indoor air quality, noise protection, etc to the regular requirements
Minergie-Modules	- building components and building equipment elements which are certified as being exceptionally well performing with regard to energy efficiency

9.5.5 United Kingdom

There are two main procedures:

- the mandatory Code for Sustainable Homes, for residential buildings [CSH],
- the voluntary Building Research Establishment Environmental Assessment Method [BREEAM]. It has a specific scheme for office buildings. See annex III for more detailed information about criteria and benchmarks of this label.

The "Code for Sustainable Homes" measures the sustainability of new buildings in nine different dimensions as shown in Table 16: energy, water, materials, surface water run-off, waste, pollution, health and well being, management and ecology. Each of them has a different grade of flexibility. The result is a single rating for the whole building. These criteria are evaluated at two different stages: design and post-construction being much more demanding that the minimum standards needed to satisfy Building Regulations.

Table 16: The mandatory Code for sustainable homes.

Category	Flexibility
Energy/CO2 Water	Minimum standards at each level of the Code
Materials Surface water run-off Waste	Minimum standards at Code entry level
Pollution Health and well-being Management Ecology	No minimum standards

The BREEAM single rating of the building aims at assessing the environmental impact of the building using a range of indicators by providing a set of predefined criteria. Many of the criteria set specific performance targets while others are more subjective and harder to quantify and does not cover every possible design solution. The BREEAM code can be applied to new buildings, design stage and post-construction stages and buildings undergoing major refurbishment.

BREEAM Offices is the world's most widely used means of reviewing and improving the environmental performance of office buildings. It can be carried out as three different categories: new built, major refurbishment or fit out. BREEAM Offices scheme covers ten categories of sustainability including: management, health and wellbeing, energy, transport, water, materials, waste, land use and ecology, pollution and innovation. Each category consists of a number of issues. When a performance target has been achieved the number of available BREEAM credits can be awarded. It has two main stages, one for the design (interim certificate) and the last one for the Post-construction stage (final certificate).

Apart from the BREEAM scheme for Office Building, some programs have been developed by the Department of Energy, Climate Change and Energy Saving in the UK aiming to reduce CO2 emissions from buildings. Among these programs, "Low Carbon Buildings Programme" [LCBP], supports the installation of combined energy efficiency technologies (such as geothermal heat pumps), renewable energies (solar, biomass, wind or mini hydro stations) and micro-cogeneration in residential buildings, schools and other public buildings and the “Definition of Zero Carbon Homes and

Non-domestic Buildings: Consultation" [ZCH 2008], sets out the parameters of what is known in UK as "Zero Carbon Homes". A Zero Carbon Home must offer a zero annual CO_2 emissions balance, considering the emissions associated with energy consumption for heating, ventilation, hot sanitary water, lighting, appliances and other devices, as well as the avoided emissions by the energy exported from the grid to the building.

9.5.6 Nordic Swam, Nordic countries

The Nordic Swan Ecolabel for buildings is a combination of requirements for the building process, materials and energy consumption and point score system. Among the developed schemes, the closest one to the scope of this study is the "Small houses, apartment buildings and pre-school buildings" scheme [Nordic Swan v2.1], since there is a lack of schemes for offices or non residential buildings. This criteria scheme comprises a combination of obligatory requirements and point score requirements. Reviewed Table in annex III of this document, regarding area, criteria and benchmarks proposed by this label.

9.6 Overview over mandatory and voluntary legislation in EU Member States

To shut up, the differences and common points between the EU MS labels are as follows:

- Common points:

1. the existence of mandatory and optional criteria. These two kinds of criteria help make difference among the importance of the environmental impacts of buildings. The criteria indicate the potential improvements in the near future and can be considered as the new lines for building development and evolution.

2. Similar general criteria areas such as:

-Energy (total energy consumed, pollution associated with building, ACV of the building, energy embedded in materials and processes or on-site generation);

-Materials used in the building (or banned hazardous substances, quality and provenance of materials, ability to be recycled or nature thereof);

-Waste generated around the same (different stages of life of the building, reusing or recycling them);

-Indoor environment (conditions of comfort, day light, illumination, noise, outside views, ventilation or air quality);

-Water (greywater and rainwater use, waste water and total water consumption) and finally

-Management of all processes (from design, construction, use or dismantling of building).

- Differences:

1. Some criteria areas e.g. transport, relations with external conditions, green spaces and services for office building or even, land use. 2. Benchmarks