

JRC TECHNICAL REPORT

EU Green Public Procurement (GPP)
criteria for the design, construction,
renovation, demolition and management
of buildings.

*DRAFT TECHNICAL REPORT
(v1.0)*

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Working draft

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Working draft

Abstract

This report presents Green Public Procurement (GPP) criteria proposals that can be used in the procurement of services and works for the design, construction, renovation, demolition and management of buildings across the EU. This report effectively replaces the previous EU GPP criteria published by the Commission in 2016 for office buildings.

The criteria are presented in the general order of a building life cycle, regardless of whether the project starts with an existing building, a derelict site or a greenfield site. At the beginning of each criterion there is a note stating which type of project(s) that criterion is suitable for.

Criteria are grouped into a number of themes considered as being relevant to GPP. Procuring authorities can therefore decide if they want to focus on one theme in particular or have a broader and more holistic approach. The GPP-relevant themes for buildings are, in no particular order of importance, as follows :

1. Energy consumption and greenhouse gas emissions
2. Material circularity
3. Efficient use of water resources
4. Occupant comfort and wellbeing
5. Vulnerability and resilience to climate change
6. Life cycle costing
7. Biodiversity

These new proposals apply not only to office buildings, but also to schools and social housing. In principle, the same criteria could also be used in other types of public buildings or in the private sector. By highlighting those criteria that are relevant to leasing and management of existing buildings, the potential impact of these proposed criteria is maximised – since any building owner or prospective tenant could potentially apply them.

The criteria are generally aligned with the Level(s) framework of indicators for assessing the sustainability and benchmarks have been set by taking into account relevant Green Building Certification schemes, EU policy such as the sustainable finance taxonomy as well as good practice established within Europe in the building sector. A short rationale appears after each criterion and any links to more detailed information are included therein.

1 Introduction

Public authorities' expenditures in the purchase of goods, services and works (excluding utilities and defence) constitute approximately 14% of the overall Gross Domestic Product (GDP) in Europe, accounting for roughly EUR 1.8 trillion annually (EC, 2016)

Thus, public procurement has the potential to provide significant leverage in seeking to influence the market and to achieve environmental improvements in the public sector. This effect can be particularly significant for goods, services and works (referred to collectively as products) that account for a high share of public purchasing combined with the substantial improvement potential for environmental performance. The European Commission has identified **Buildings** as one such "product group".

Green Public Procurement (GPP) is defined in the Commission's Communication *COM (2008) 400 – "Public procurement for a better environment"* as "...a process whereby public authorities seek to procure goods, services and works with a reduced environmental impact throughout their life cycle when compared to goods, services and works with the same primary function that would otherwise be procured".

Life cycle impacts of European buildings are generally considered to account for half of all extracted materials, half of all energy consumed, a third of all water consumed and around a third of all waste generated in Europe. Building stock in the EU is dominated by residential buildings (ca. 75%). Public buildings (e.g. social housing) accounts for anywhere between 0 and 29% of total residential buildings in European countries. With non-residential buildings, the share covered by public offices and educational buildings can account for anywhere between one fifth and one half of total non-residential buildings, depending on the European country in question. Consequently, setting green public procurement criteria for the design, construction, renovation, demolition and management of buildings can potentially deliver major environmental benefits.

By choosing to invest in buildings and the technical systems therein that have lower environmental impacts, public authorities can make an important contribution to reduce the direct environmental impact resulting from their activities. Moreover, by promoting and using GPP for buildings, public authorities can provide industry with real incentives for developing green technologies and products. In some sectors, public purchasers command a large share of the market (e.g. public transport and construction, health services and education) and so their decisions have considerable impact. In fact, in the above-mentioned Commission's communication the capability that public procurement has to shape production and consumption trends, increase demand for "greener" products and services and provide incentives for companies to develop environmental friendly technologies is clearly emphasised.

The development of voluntary EU GPP criteria aims to help public authorities ensure that the goods, services and works they require are procured and executed in a way that reduces their associated environmental impacts. The criteria are thus formulated in such a way that they can be integrated, if deemed appropriate by the individual authority, into its tender documents with minimal editing.

GPP criteria are to be understood as being part of the procurement process and must conform to its standard format and rules as laid out by Public Procurement Directive 2014/24/EU (public works, supply and service contracts). Hence, EU GPP criteria must comply with the guiding principles of:

- Free movement of goods and services and freedom of establishment;
- Non-discrimination and equal treatment;
- Transparency;
- Proportionality and Mutual recognition.

GPP criteria must be verifiable and it should be formulated either as Selection criteria (SC), Technical specifications (TS), Award criteria (AC) or Contract performance clauses (CPCs), which can be understood as follows:

Selection Criteria (SC): Selection criteria refer to the tenderer, *i.e.*, the company tendering for the contract, and not to the product being procured. It may relate to suitability to pursue the professional activity, economic and financial standing and technical and professional ability and may- for services and works contracts - ask specifically about their ability to apply environmental management measures when carrying out the contract.

Technical Specifications (TSs): Technical specifications constitute minimum compliance requirements that must be met by all tenders. It must be linked to the contract's subject matter (the 'subject matter' of a

contract is about what good, service or work is intended to be procured. It can consist in a description of the product, but can also take the form of a functional or performance based definition) and must not concern general corporate practices but only characteristics specific to the product being procured. Link to the subject matter can concern any stage of the product's life-cycle, including its supply-chain, even if not obvious in the final product, *i.e.*, not part of the material substance of the product. Offers not complying with the technical specifications must be rejected. Technical specifications are not scored for award purposes; they are strictly pass/fail requirements.

Award Criteria (AC): At the award stage, the contracting authority evaluates the quality of the tenders and compares costs. Contracts are awarded on the basis of most economically advantageous tender (MEAT). MEAT includes a cost element and a wide range of other factors that may influence the value of a tender from the point of view of the contracting authority including environmental aspects (EC, 2016). Everything that is evaluated and scored for award purposes is an award criterion. These may refer to characteristics of goods or to the way in which services or works will be performed (in this case they cannot be verified at the award stage since they refer to future events. Therefore, in this case, the criteria are to be understood as commitments to carry out services or works in a specific way and should be monitored/verified during the execution of the contract via a contract performance clause). As technical specifications, also award criteria must be linked to the contract's subject matter and must not concern general corporate practices but only characteristics specific to the product being procured. Link to the subject matter can concern any stage of the product's life-cycle, including its supply-chain, even if not obvious in the final product, *i.e.*, not part of the material substance of the product. Award criteria can be used to stimulate additional environmental performance without being mandatory and, therefore, without foreclosing the market for products not reaching the proposed level of performance.

Contract Performance Clauses (CPCs): Contract performance clauses are used to specify how a contract must be carried out. As with TSs and ACs, also CPCs must be linked to the contract's subject matter and must not concern general corporate practices but only those specific to the product being procured. Link to the subject matter can concern any stage of the product's life-cycle, including its supply-chain, even if not obvious in the final product, *i.e.*, not part of the material substance of the product. The economic operator may not be requested to prove compliance with the CPCs during the procurement procedure. Contract performance clauses are not scored for award purposes. Compliance with CPCs should be monitored during the execution of the contract, therefore after it has been awarded. It may be linked to penalties or bonuses under the contract in order to ensure compliance.

For each criterion there is a choice between two levels of environmental ambition, which the contracting authority can choose from according to its particular goals and/or constraints:

The **Core criteria** are designed to allow easy application of GPP, focussing on the key areas of environmental performance of a product and aimed at keeping administrative costs for companies to a minimum.

The **Comprehensive criteria** take into account more aspects or higher levels of environmental performance, for use by authorities that want to go further in supporting environmental and innovation goals.

In this first version of the report, most of the criteria proposals are set as technical specifications as the initial discussions should be on the criteria content and relevance, then in the next proposals, it can be more carefully considered if some criteria should be ACs and which types of CPCs may be needed.

As said before, the development of EU GPP criteria aims to help public authorities ensure that the goods, services and works they require are procured and executed in a way that reduces their associated environmental impacts and is focused on the products' most significant improvement areas, resulting from the cross-check between the key environmental hot-spots and market analysis. This development also requires an understanding of commonly used procurement practices and processes and the taking on board of learnings from the actors involved in successfully fulfilling contracts.

For this reason, the European Commission has developed a research and consultation process aimed at bringing together both technical and procurement experts to collate a broad body of evidence and to develop, in a consensus oriented manner, a proposal for precise and verifiable criteria that can be used to procure products with a reduced environmental impact.

A detailed environmental and market analysis, as well as an assessment of relevant EU policy, legislation and technical standards, was conducted within the framework of this project and has been presented in the Background Report on EU Green Public Procurement Criteria for the design, construction, renovation, demolition and management of buildings. This report can be publicly accessed at the JRC website for

Buildings (<https://susproc.jrc.ec.europa.eu/product-bureau//product-groups/408/documents>). The main findings presented in the Background Report are summarised in the next chapter.

Working draft

2 Summary of background report

The EU GPP criteria presented in this JRC Technical Report are broadly supported and framed by background research that is presented in a larger JRC Background Report. The background report consists of research carried out into the following tasks:

- Task 1: Scope and definition.
- Task 2: Market analysis.
- Task 3: Environmental impacts associated with buildings.
- Task 4: Technical analysis and improvement potential

Policy and scope: Buildings are a major source of environmental impacts and are targeted in a number of cross-cutting policies (e.g. the European Green Deal, Circular Economy Action Plan and the EU Taxonomy) and building-specific policies (e.g. the Energy Performance of Buildings Directive, the Renovation Wave and the Level(s) framework).

Taking all of these policies into consideration, EU GPP criteria for buildings will be centred on the following seven themes listed below.

- Theme 1: energy consumption and greenhouse gas emissions
- Theme 2: Material efficiency and circularity
- Theme 3: Efficient use of water resources
- Theme 4: Occupant comfort and wellbeing
- Theme 5: Vulnerability and resilience to climate change
- Theme 6: Life cycle costing
- Theme 7: Biodiversity

In order to increase the potential impact of EU GPP criteria for buildings, the scope is proposed to be increased from just office buildings to also include social housing and educational buildings. However, it should be borne in mind that individual criteria can potentially be applied to most buildings.

The initial proposal for the scope is as follows:

“The procurement of any works or services for the design, site-preparation, construction, completion, renovation or management of social housing, office buildings and buildings relating to educational and any multi-functional buildings where one of the aforementioned functions accounts for at least 50% of the gross internal floor area.”

The initial proposals for related definitions apply:

- **“Buildings related to educational services”** means buildings whose primary function is the teaching of students and includes kindergartens, primary schools, secondary schools, special needs schools, vocational colleges, technical colleges and university buildings.
- **“Completion”**, in the context of a building project, means works or services relating to the installation of electrical infrastructure, lifts, escalators, telecommunications equipment, illumination equipment, thermal insulation, sound insulation, plumbing, sanitary works, heating, ventilation, air-conditioning, drains, gas fittings, railings, fencing, fire-prevention features, doors, windows and related components, suspended ceilings, partition walls, fitted kitchens, internal floor and wall coverings, outdoor cladding and paving as well as any other works relating to plastering, joinery & carpentry, painting, surface protection or façade.
- **“Construction”**, in the context of a building project, means works or services relating to building foundations, structure, structural shell, parking lot (if within the building plot area), roof works, scaffolding, concrete work, structural steel erection work and masonry and bricklaying work.
- **“Design”**, in the context of a building project, covers architectural, feasibility study, engineering, planning, specifications drafting, surveying, working drawings, approval planning and cost estimation services relating to conceptual and detailed designs for a new or renovated building.

- **“Management”**, in the context of a currently occupied building, means the routine maintenance of building facilities, including sanitary fittings, security features and technical systems, as well as the operation and optimisation of energy systems, reporting on building performance to occupants about factors such as specific energy consumption, CO₂ emissions, specific water consumption or indoor air quality and periodically evaluating occupant satisfaction with the building performance.
- **“Office buildings”**, means buildings whose primary function is to provide space for administrative financial, professional or customer services. The office area must make up a significant majority of the total building’s gross area. The building may also comprise other type of spaces, like meeting rooms, training classrooms, staff facilities, or technical rooms.
- **“Renovation”**, in the context of a building project, means construction and/or demolition works to improve aspects of a building. Renovation activities can vary in terms of their depth (% of e.g. floor area affected by the renovation activity) and their primary focus (e.g. replacement/upgrading of building energy systems, façade replacement, new windows, floor and wall coverings etc.).
- **“Residential buildings”** means buildings whose primary function is to provide private living spaces for people and includes multi-dwelling buildings, individual houses or sheltered housing.
- **“Site preparation”**, in the context of a building project, means works or services relating to demolition, excavation, earthmoving and land-reclamation.

Market analysis: Europe’s building stock is dominated by residential buildings (around 75% of total) of which only a small fraction is social housing. However, the share of social housing varies significantly from Member State to Member State (e.g. for virtually 0% of rented accommodation in Greece to around 29% in the Netherlands). In terms of non-residential buildings, public offices and educational buildings typically accounted for 20 to 40% of total non-residential buildings at Member State level.

Environmental impacts: A review of literature on the Life Cycle Assessment (LCA) of buildings shows a general focus on Global Warming Potential (GWP) more than other impact categories and highlighted the importance of operational energy consumption on overall impacts. As the energy efficiency of buildings improves, the share of impacts embodied in construction materials becomes more important to overall results and policies are shifting towards whole life carbon. However, concerns have been raised about the lack of data available to accurately quantify embodied impacts, the potential impacts of different applications of cut-off rules and certain methodological differences between the Product Environmental Footprint (PEF) and EN 15978.

Impacts that are not so well captured by LCA methods relate to biodiversity, and human health. The latter aspect extends to different features of building design, such as indoor air quality, thermal comfort, daylighting, noise levels and potential contribution to flood risk.

Technical analysis: The analysis of the main technical systems used in buildings that relate to energy and water efficiency should be reviewed, with a view to explaining how they work, different approaches that can be taken and the scope for further improvement. In the first draft of this background report, only an analysis of taps and showers has been carried out. The analysis revealed a high range of specific consumption rates and different designs that can deliver potentially large improvement potentials (factor of 2 or 3 ranges in performance are not uncommon). Since taps and showers are CE marked with performance classes, this could be used in GPP specifications. Another interesting option for specifying would be to refer to voluntary water labels, which have thousands of examples of tap and shower products on the EU market.

Targeted questions to stakeholders about background research:

Q1: Opinions on the scope? Should buildings providing social services also be included (e.g. retirement homes, nursing homes, daycare centres etc.)?

Q2: Opinions on the definitions provided? How to define “major renovation”?

Q3: What building systems should be assessed in more detail in the technical analysis of the background report to identify improvement potentials? (Need to focus only on the most relevant building technical systems and products).

3 Overview of EU GPP criteria for buildings

3.1 Cross-check of EU GPP criteria with key policy and other initiatives

The main selection criteria, technical specifications and award criteria are listed below, grouped by “theme” and cross-checked against the Level(s) framework, the sustainable finance taxonomy and relevant green building certification schemes.

Table 1. EU GPP criteria for the design, construction, renovation, demolition and management of buildings.

EU GPP criteria	Link to Level(s)?	Link to taxonomy?
Selection criteria (SC): for project team, contractors and building managers.	Only general references in the sections titled “who should be involved and when?”	*still to be checked
1.1. Use stage energy consumption	1.1. Use stage energy consumption	Technical screening criteria and do no significant harm requirements for substantial contributions for “ <u>climate change mitigation</u> ” in construction and real estate.
1.2. Whole Life Carbon (WLC)	1.2. Life cycle Global Warming Potential (GWP)	
2.1. Inventory of building elements, technical systems, construction products and materials purchased.	2.1. Bill of quantities, materials and lifespans	Do no significant harm requirements for “ <u>Transition to a circular economy</u> ” construction and real estate. <i>In development: Technical screening criteria for “<u>Transition to a circular economy</u>” in construction and real estate.</i>
2.2. Construction, Demolition and Excavation Waste (CDEW) management.	2.2. Construction and Demolition Waste	
2.3. Design for adaptability	2.3. Design for adaptability	
2.4. Design for deconstruction	2.4. Design for deconstruction	
2.5. Operational waste management	n/a	
3.1.1. Water efficient devices and appliances	3.1. Use stage water consumption.	Do no significant harm requirements for “ <u>sustainable use and protection of water and marine resources</u> ” construction and real estate.
3.1.2. Rainwater harvesting systems		
3.1.3. Greywater reuse systems		
3.1.4. Per capita potable water use		
4.1. Indoor air quality	4.1. Indoor air quality	Do no significant harm requirements for “ <u>pollution prevention and control</u> ” in construction and real estate.
4.2. Thermal comfort	4.2. Time outside of thermal comfort range	n/a
4.3. Lighting	4.3. Lighting and visual comfort	n/a
4.4. Acoustics	4.4. Acoustics and protection against noise	n/a
4.5. Electropollution	n/a	n/a
5.1. Future thermal comfort time out of range	5.1. Protection of occupier health and thermal comfort.	Technical screening criteria and do no significant harm requirements for substantial contributions for “ <u>climate</u> ”
5.2. Resilience to flooding	5.2. Increased risk of adverse weather events.	

EU GPP criteria	Link to Level(s)?	Link to taxonomy?
5.3. Sustainable drainage	5.3. Sustainable drainage.	change adaptation” in construction and real estate
5.4. Resilience to mains energy and water supply failures.	n/a	
6.1. Life cycle cost assessment	6.1. Life cycle costing	n/a
7.1. Green roofs	n/a	Do no significant harm requirements for construction and real estate. <i>In development: Technical screening criteria for “Protection and restoration of biodiversity and ecosystems” in construction and real estate.</i>
7.2. Green walls	n/a	
7.3. Landscaping and habitat creation	n/a	
7.4. Artificial light at night (ALAN)	n/a	

*A more thorough screening of the EU Taxonomy may be needed to check if other activities (not construction and real estate) may also set related requirements, for example with relation to professional skills for the services mentioned in the selection criteria.

3.2 How EU GPP criteria should apply to different types of building project

Different criteria will apply depending on the nature of the building procurement activity in question. The matrix below shows how the building project stages already defined in the 2016 EU GPP for office buildings (A to G) align with Common Procurement Vocabulary codes, and the main types of activities involved.

Table 2. Comparison of building project stages with Common Procurement Vocabulary codes

Project stage for defined GPP criteria	Common Procurement Vocabulary code	Activities involved
A: Selection of the design team and contractors	71221xxx-x 7123xxx-x	Architectural design services Architectural design contest
B: Detailed design and performance requirements	71241xxx-x 71242xxx-x 71243xxx-x 71244xxx-x 71245xxx-x 71246xxx-x 71248xxx-x 7132xxx-x 715xxxx-x	Feasibility study, advisory service, analysis Project and design preparation, estimation of costs Draft plans (systems and integration) Calculation of costs, monitoring of costs Approval plans, working drawings and specifications Determining and listing of quantities in construction Supervision of project and documentation Engineering design services Construction-related services
C: Strip-out, demolition and site preparation works	451xxxx-x	Site preparation work (building demolition and wrecking work and earthmoving work, incl. landscaping)
D: Construction of the building or major renovation works	71247xxx-x 4521xxx-x	Supervision of building work For residential buildings; buildings relating to leisure, sports, culture, lodging and restaurants; commercial buildings, warehouses, industrial buildings & buildings relating to transport; buildings relating to education and research; buildings relating to health and social services; buildings relating to law and order or emergency services and for military buildings.
	45223xxx-x 4526xxx-x	Structures construction works Roof works and other special trade construction works
E: Installation of energy systems or the supply of energy services	453xxxx-x 4531xxx-x 4532xxx-x 4533xxx-x 4534xxx-x 4535xxx-x	Building installation work Electrical installation work Insulation installation work Plumbing and sanitary installation works Fencing, railing and safety equipment installation Mechanical installations.
F: Completion and handover	454xxxx-x 4541xxx-x 4542xxx-x 4543xxx-x 4544xxx-x 4545xxx-x	Building completion work Plastering work Joinery and carpentry installation work Floor and wall covering work Electrical installation work Other completion work
G: Facilities Management	71314xxx-x 71315xxx-x	Energy and related services Building services

Depending on how budgets are set and managed by the contracting authority, and the needs for the project in question, the actual procurement exercise may cover only some or all of these parts of the building project. For example:

- **Design only:** focuses purely on the design stages (A+B), and relies on services provided by architects, engineers and building surveyors. One scenario for a design only approach that may become increasingly relevant would be for when cost and carbon comparison is requested to inform whether it would be best to demolish and build new or to renovate and existing public building.
- **Site preparation only:** a separate contract like this may apply in cases where an old derelict building needs to be demolished and there is no immediate need (or budget available) to construct a new building on the same site, or where the site will not have any new building on it in the future for reasons of urban planning strategy.
- **Design and build/renovate:** requires the design services (A+B) and site preparation works (C) plus those that are necessary to construct/renovate the building (D), including the installation and commissioning of any building technical systems (E) and the completion works and handover (F). The advantage of this type of contract is that the designer and main contractor are on the same team and have to find an optimum solution between them. The design services and construction works contractor may be from the same company or be represented within a one-off or strategic consortium of companies. Due to the wide variety and specialisation of construction activities, many of them may be sub-contracted by the contractor.
- **Design, build/renovate and manage:** such an arrangement is much more common in calls for tender for highly technical investments, such as a water or wastewater treatment plants, or a public transport building. This management aspect could refer simply to the routine and periodic maintenance of the building elements and systems (G). As systems become more complicate (e.g. building energy management systems with onsite renewables), the linking of system providers and management services is becoming more attractive in buildings. Services that go beyond this and have some influence on occupant experience (e.g. security or tenancy administration) or that actively manage the actual building activity itself (e.g. healthcare in public private partnerships) are not within the scope of these GPP criteria.

The GPP criteria provided in this document may be applicable only to one type of building project and/or to more than one stage of a given building project. In order to better focus reader attention on the different themes, the criteria in this version of the Technical Report are presented theme by theme instead of project stage by project stage. However, with each criterion, the relevant project stage(s) are indicated as shown below. This approach also ensures that the GPP criteria to numbered in line with the Level(s) framework as much as possible.

Indicator example				Meaning
Design	Site prep.	Construction	Management	Criterion is applied and verified in the design stage
Design	Site prep.	Construction	Management	Criterion is applied and verified in design, site preparation and construction stages
Design	Site prep.	Construction	Management	Criterion is applied and verified in the design stage and compliance with design checked during construction
Design	Site prep.	Construction	Management	Criterion is only applicable to management stage

In the final version of the technical report, it is proposed that the criteria will be rearranged by the project stage structure (i.e. the A to G) that was used in the 2016 version of EU GPP criteria, so that the final document is more useful for public procurers and professionals working in real-life building projects.

4 Selection criteria

Core criteria				Comprehensive criteria			
SELECTION CRITERIA (SC)							
<p><i>Note: Which SCs are relevant will depend on the nature of the procurement exercise, the type of building project and the criteria where technical specifications have been set by the contracting authority. Consequently, requirements have only been stated in a general manner.</i></p>							
Design	Site prep.	Construction	Management	Design	Site prep.	Construction	Management
<p>SC1: Competencies of the project manager</p> <p>The project manager shall have relevant competencies and experience in each of the following areas for which they would be responsible under the contract (select as relevant to the specific contract):</p> <ul style="list-style-type: none"> - The project management of building contracts that have met or exceeded the environmental performance requirements set by clients; - The successful identification and management of the delivery of a range of environmental technologies and design innovations required to deliver improved environmental performance and quality; - Involvement in the financial appraisal of environmental technologies and design innovations as part of the delivery of projects. <p>Verification:</p> <p>Evidence in the form of information and references related to relevant contracts in the previous 5 years in which the above elements have been carried out. This shall be supported by CVs for personnel who will work on the project.</p>				<p>SC1: Competencies of the project manager</p> <p>The project manager shall have relevant competencies and experience in each of the following areas for which they would be responsible under the contract (select as relevant to the specific contract):</p> <ul style="list-style-type: none"> - The project management of building contracts that have met or exceeded the environmental performance requirements set by clients; - The successful identification and management of the delivery of a range of environmental technologies and design innovations required to deliver improved environmental performance and quality; - Involvement in the financial appraisal of environmental technologies and design innovations as part of the delivery of projects; - Projects that included the assessment of building environmental performance using multi-criteria building assessment, reporting and certification schemes; - The use of holistic assessment tools in the design, appraisal and specification of environmentally improved buildings, including LCC and LCA. <p>Verification:</p> <p>Evidence in the form of information and references related to relevant contracts in the previous 5 years in which the above elements have been carried out. This shall be supported by CVs for personnel who will work on the project.</p>			
Design	Site prep.	Construction	Management	Design	Site prep.	Construction	Management
<p>SC2: Competencies of the design team</p> <p>The architect, consultant and/or design team consortium shall have relevant competencies and experience in each of the following areas for which they would be responsible under the contract (select as relevant to the specific contract):</p> <ul style="list-style-type: none"> - The management of building contracts that have delivered improved environmental performance that goes beyond minimum building-code requirements (specify if national, regional, local or other) regarding the following aspects (to be completed with elements deemed important by the contracting authority and not covered below); - Energy efficient building fabric and services design for new-build or renovation projects (select as 				<p>SC2: Competencies of the design team</p> <p>The architect, consultant and/or design team consortium shall have relevant competencies and experience in each of the following areas for which they would be responsible under the contract (select as relevant to the specific contract):</p> <ul style="list-style-type: none"> - The management of building contracts that have delivered improved environmental performance that goes beyond minimum building-code requirements (specify if national, regional, local or other) regarding the following aspects (to be completed with elements deemed important by the contracting authority and not covered below); - Energy efficient building fabric and services design for new-build and/or renovation projects (select as 			

Core criteria				Comprehensive criteria			
SELECTION CRITERIA (SC)							
<p><i>Note: Which SCs are relevant will depend on the nature of the procurement exercise, the type of building project and the criteria where technical specifications have been set by the contracting authority. Consequently, requirements have only been stated in a general manner.</i></p>							
<p>appropriate), including if available measured energy performance data per m² from completed projects including heating, cooling, lighting, hot water and auxiliary equipment;</p> <ul style="list-style-type: none"> - Installation of Building Energy Monitoring Systems (BEMS), communication of how they work to building managers and their use to diagnose energy use patterns in buildings; - Water efficient services design, including measured water demand per employee from completed projects; - The specification, procurement and installation of low environmental impact construction materials. To include reference to EPDs in compliance with ISO 14025 or EN 15804; - The development and implementation of staff travel plans, including infrastructure for low emission vehicles and bicycles. <p>Project experience and Continuous Professional Development (CPD) of relevance to these areas shall be highlighted.</p> <p><i>The contracting authority may require a minimum number of contracts according to the nature of the project.</i></p> <p>Verification:</p> <p>Evidence in the form of information and references related to relevant contracts in the previous 5 years in which the above elements have been carried out. This shall be supported by CVs of personnel who will work on the project.</p>				<p>appropriate), including if available measured energy performance data per m² from completed projects including heating, cooling, lighting, hot water and auxiliary equipment;</p> <ul style="list-style-type: none"> - The specification and design of renewable and/or high efficiency energy generation equipment; - Installation of Building Energy Monitoring Systems (BEMS), communication of how they can be used to building occupiers and their use to diagnose energy use patterns in buildings; - Water efficient services design, including measured water demand per employee from completed projects; - Bioclimatic architecture and passive design to good thermal and optical comfort, natural air purification etc; - Assessment of building environmental performance using multi-criteria building assessment and certification schemes, - The specification, procurement and installation of low environmental impact construction materials. To include reference to EPDs in compliance with ISO 14025 or EN 15804. - The use of holistic assessment tools in the design and specification of environmentally improved buildings including LCC and LCA. Comparative studies in compliance with ISO 14040/14044 or EN 15978. - Design, specification and monitoring to address daylighting and glare, thermal comfort and indoor air quality - The development and implementation of staff travel plans, including infrastructure for low emission vehicles and bicycles. <p>Project experience and Continuous Professional Development (CPD) of relevance to these areas shall be highlighted.</p> <p><i>The contracting authority may require a minimum number of contracts according to the nature of the project.</i></p> <p>Verification:</p> <p>Evidence in the form of information and references related to relevant contracts in the previous 5 years in which the above elements have been carried out. This shall be supported by CVs of personnel who will work on the project.</p>			
Design	Site prep.	Construction	Management	Design	Site prep.	Construction	Management
SC3. Competencies of the main construction contractor and specialist contractors.				SC3. Competencies of the main construction contractor and specialist contractors.			

Core criteria	Comprehensive criteria
SELECTION CRITERIA (SC)	
<p><i>Note: Which SCs are relevant will depend on the nature of the procurement exercise, the type of building project and the criteria where technical specifications have been set by the contracting authority. Consequently, requirements have only been stated in a general manner.</i></p>	
<p><i>Note: These criteria may form part of a pre-selection procedure for the main contractor or where specialist contractors are to be procured e.g. demolition, ESCOs.</i></p> <p>The construction contractor shall have relevant competencies and experience in the completion of building contracts that have been shown to have delivered improved environmental performance.</p> <p>In the case of design and build contracts, criterion A1 will also be relevant to the design team employed.</p> <p>Relevant areas of experience shall include (as appropriate to the project and the selected GPP criteria):</p> <ul style="list-style-type: none"> - Energy efficient building fabric and services design for new-build or renovation projects (<i>select as appropriate</i>), including if available measured energy demand per m2 from completed projects including heating, cooling, lighting, hot water and auxiliary equipment. This will have been applied in the context of new-build and/or renovation projects (select as appropriate); - The installation of Building Energy Monitoring Systems (BEMS) and communication of how they work to building managers; - The installation of water efficient services, including if available measured water demand per employee from completed projects; - The procurement, installation and verification of low environmental impact construction materials. - The successful implementation of demolition and site waste management plans in order to minimise waste arisings. Selection and knowledge of off-site treatment options. <p>Verification:</p> <p>Evidence in the form of information and references related to relevant contracts in the last 5 years in which the above elements have been carried out. This shall also be supported by CVs for personnel who will work on the project and their relevant project experience</p>	<p><i>Note: These criteria may form part of a pre-selection procedure for the main contractor or where specialist contractors are to be procured e.g. demolition, ESCOs.</i></p> <p>The construction contractor shall have relevant competencies and experience in the completion of building contracts that have been shown to have delivered improved environmental performance.</p> <p>In the case of design and build contracts criteria A1 will also be relevant to the design team employed.</p> <p>Relevant areas of experience shall include (as appropriate to the project and the selected GPP criteria):</p> <ul style="list-style-type: none"> - Energy efficient building fabric and services design, including if available measured energy demand per m2 from completed projects including heating, cooling, lighting, hot water and auxiliary equipment. This will have been applied in the context of new-build and/or renovation projects (select as appropriate); - The installation, commissioning and (as relevant) ongoing operation/maintenance of renewable and/or high efficiency energy generation equipment; - The installation of Building Energy Monitoring Systems (BEMS) and communication of how they work to building managers; - The installation of water efficient services, including if available measured water demand per employee from completed projects; - Functioning passive design features to achieve low energy use and good thermal and optical comfort, etc; as evidenced by post-occupancy studies; - The procurement, installation and verification of low environmental impact construction materials. Supply chain management to ensure compliance with building assessment and certification systems and in order to support modelled resource efficiency strategies; - The successful implementation of demolition site waste management plans in order to minimise waste arisings. Selection and knowledge of off-site treatment options. - The installation of features to address daylighting and glare, thermal comfort and indoor air quality <p>Verification:</p> <p>Evidence in the form of information and references related to previous contracts in the last 5 years in which the above elements have been carried out. This shall be supported by evidence and data from:</p> <ul style="list-style-type: none"> - Third party auditing,

Core criteria				Comprehensive criteria			
SELECTION CRITERIA (SC)							
<p><i>Note: Which SCs are relevant will depend on the nature of the procurement exercise, the type of building project and the criteria where technical specifications have been set by the contracting authority. Consequently, requirements have only been stated in a general manner.</i></p>							
				<ul style="list-style-type: none"> - Post-occupancy auditing, - LCA/LCC analysis and/or - Data collection from monitoring <p>This shall also be supported by CVs for personnel who will work on the project and their relevant project experience.</p>			
Design	Site prep.	Construction	Management	Design	Site prep.	Construction	Management
<p>SC4. Competencies of Design-Build-Operate (DBO) contractors and property developers</p> <p><i>Note: These criteria may form part of a pre-selection procedure for the DBO contractor or property developer that will operate the building.</i></p> <p>The contractor shall have relevant competencies and experience in managing the construction and operation of office buildings that have been shown to have delivered improved environmental performance. Criterion SC1 will also be relevant to the design team employed</p> <p>Relevant areas of experience shall include (as appropriate to the project and the selected GPP criteria):</p> <ul style="list-style-type: none"> - The management of design teams to achieve the permitting and construction of office buildings that met client performance requirements, including under DBO arrangements; - The management of main contractors for the construction of office buildings that have environmentally improved performance, including under DBO arrangements; - Ongoing facilities management in order to optimise the performance of office buildings, including the use of systems such as BEMS, the contracting of energy managers and the ongoing monitoring/reporting on performance; <p>Verification:</p> <p>Evidence in the form of information and references related to previous projects and contracts in the last 5 years in which the above elements have been carried out. This shall also be supported by CVs for personnel who will work on the project and their relevant project experience.</p>				<p>SC4. Competencies of Design-Build-Operate (DBO) contractors and property developers</p> <p><i>Note: These criteria may form part of a pre-selection procedure for the DBO contractor or property developer that will operate the building.</i></p> <p>The contractor shall have relevant competencies and experience in managing the construction and operation of office buildings that have been shown to have delivered improved environmental performance. Criterion SC1 will also be relevant to the design team employed</p> <p>Relevant areas of experience shall include (as appropriate to the project and the selected GPP criteria):</p> <ul style="list-style-type: none"> - The management of design teams to achieve the permitting and construction of office buildings that met client performance requirements, including under DBO arrangements; - The management of main contractors for the construction of office buildings that have environmentally improved performance, including under DBO arrangements;. - The management of design teams and/or main contractors to obtain ratings according to multi-criteria building assessment and certification schemes; - Ongoing facilities management in order to optimise the performance of office buildings, including the use of systems such as BEMS, the contracting of energy managers and the ongoing monitoring/reporting on performance; <p>Verification:</p> <p>Evidence in the form of information and references related to previous projects and contracts in the last 5 years in which the above elements have been carried out. This shall also be supported by CVs for personnel who will work on the project and their relevant project experience.</p>			
		Design	Site prep.	Construction			
<p>SC5. Energy Management System</p> <p><i>Note: These criteria may form part of a pre-selection procedure for a developer/operator of the office building.</i></p>							

Core criteria	Comprehensive criteria
SELECTION CRITERIA (SC)	
<p><i>Note: Which SCs are relevant will depend on the nature of the procurement exercise, the type of building project and the criteria where technical specifications have been set by the contracting authority. Consequently, requirements have only been stated in a general manner.</i></p>	
<p>The DBO contractor or property developer who will operate the building shall be able to demonstrate experience in implementing energy management systems for sites, such as ISO 50001 or equivalent, as part of facilities management arrangements.</p> <p>Verification:</p> <p>The DBO contractor or property developer shall provide management system certifications for sites they operate or have operated over the last three years.</p>	

Supporting notes:

- The evaluation of consultants, design teams and contractors requires an experienced evaluation panel. It may be appropriate to bring in external expertise, which may include appointment of a project manager, and the setting up of a panel with the knowledge and experience to judge the experience of competing contractors. The lists included in SC1 and SC2 are indicative and should be adapted to the project and the procurement stage.

- In the Public Procurement Directives (2014/24/EU and 2014/25/EU), it is explicitly stated (Art. 66 of Directive 2014/24/EU) that the organisation, qualification and experience of staff assigned to performing the contract (where the quality of the staff assigned can have a significant impact on the level of performance of the contract) can be a criterion for awarding a contract. For complex contracts such as building contracts it can usually be expected that the quality of the project managers, design team, specialist consultants and contractors can have a significant impact on the performance of the project. Please note that the educational and professional qualifications of the service provider or contractor or those of the undertaking's managerial staff may only be evaluated once in a tender procedure, either at selection stage or as an award criterion (Annex XII, Part 2 f of Directive 2014/24/EU).

5 Technical specifications and award criteria

Theme 1: Energy consumption and greenhouse gas emissions

1.1. Use-stage energy consumption

Core criteria				Comprehensive criteria			
TECHNICAL SPECIFICATIONS (TSs) AND AWARD CRITERIA (ACs)							
<i>Note: Energy consumption (and associated operational greenhouse gas emissions) are relevant for all types of building project.</i>							
Design	Site prep.	Construction	Management	Design	Site prep.	Construction	Management
<p>TS1.1.1: Use stage energy consumption</p> <p><i>Note: The final results should be reported in the format presented in the explanatory note for the sake of transparency and consistency. It is up to the contracting authority to define the scope of the assessment clearly in the call for tender.</i></p> <p><u>For new construction projects:</u> The primary energy demand of the building shall be at least 10% lower than the threshold set for nearly zero-energy building (NZEB) requirements in national measures implementing Directive 2010/31/EU.</p> <p><u>For renovation projects:</u> The building renovation leads to a reduction of at least 30% of the primary energy demand of the building.</p> <p>Verification:</p> <p><u>For new construction projects:</u> In addition to an Energy Performance Certificate, the design calculations for estimating primary energy demand shall be presented in accordance with the EN ISO 52000 series of standards and any related national standards.</p> <p>Underlying data shall also be presented to the contracting authority in the reporting format defined for Level(s) indicator 1.1, level 2 (see explanatory note for more information).</p> <p><u>For renovation projects:</u> The initial (i.e. before renovation) primary energy demand and the estimated improvement after renovation shall be based on a detailed building survey, an energy audit conducted by an accredited independent expert or any other transparent and proportionate method, and validated through an Energy Performance Certificate.</p> <p>The 30% improvement results from an actual reduction in primary energy demand (where the reductions in net primary energy demand through the export of energy from onsite renewable energy systems are not taken into account), and can be achieved through a succession of measures within a maximum of three years.</p> <p>Underlying data for both the initial and planned performance shall also be presented to the contracting authority in the reporting format defined for Level(s) indicator 1.1, level 2 (see explanatory note for more information).</p>				<p>TS1.1.1: Use stage energy consumption</p> <p><i>Note: The final results should be reported in the format presented in the explanatory note for the sake of transparency and consistency. It is up to the contracting authority to define the scope of the assessment clearly in the call for tender.</i></p> <p><u>For new construction projects:</u> The primary energy demand of the building shall be at least 20% lower than the threshold set for nearly zero-energy building (NZEB) requirements in national measures implementing Directive 2010/31/EU.</p> <p><u>For renovation projects:</u> The building renovation leads to a reduction of at least 60% of the primary energy demand of the building.</p> <p>Verification:</p> <p><u>For new construction projects:</u> In addition to an Energy Performance Certificate, the design calculations for estimating primary energy demand shall be presented in accordance with the EN ISO 52000 series of standards and any related national standards.</p> <p>Underlying data shall also be presented to the contracting authority in the reporting format defined for Level(s) indicator 1.1, level 2 (see explanatory note for more information).</p> <p><u>For renovation projects:</u> The initial (i.e. before renovation) primary energy demand and the estimated improvement after renovation shall be based on a detailed building survey, an energy audit conducted by an accredited independent expert or any other transparent and proportionate method, and validated through an Energy Performance Certificate.</p> <p>The 60% improvement results from an actual reduction in primary energy demand (where the reductions in net primary energy demand through the export of energy from onsite renewable energy systems are not taken into account), and can be achieved through a succession of measures within a maximum of three years.</p> <p>Underlying data for both the initial and planned performance shall also be presented to the contracting authority in the reporting format defined for Level(s) indicator 1.1, level 2 (see explanatory note for more information).</p>			

Core criteria	Comprehensive criteria
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TECHNICAL SPECIFICATIONS (TSs) AND AWARD CRITERIA (ACs)

Note: Energy consumption (and associated operational greenhouse gas emissions) are relevant for all types of building project

Explanatory note for TS1.1.1:

The common reporting format for use stage energy consumption should be as follows:

Type of assessment		<i>e.g. Building permit, as-built EPC or a tailored assessment</i>								
Calculation method		<i>Specify the method and any software tools used</i>								
		<i>Specify the time step for data used by the method e.g. monthly, daily, hourly</i>								
Building service	Energy need	System efficiency ¹	Energy carrier ²	Delivered energy per energy carrier	Non renewable primary energy factor ³		Renewable primary energy factor ³		Total primary energy factor ³	
	kWh/yr	Decimal	Free text	kWh/yr	Decimal factor	kWh/yr	Decimal factor	kWh/yr	Decimal factor	kWh/yr
Heating										
Cooling										
Ventilation										
Hot water										
Lighting										
Other (please specify) ⁴										
Exported renewable energy ⁵	n/a	n/a								
Total										

- The efficiency with which delivered energy is converted into needed energy. For example, if a boiler converts 85% of the calorific value of a fuel into heat in water coming out of the tap or shower, the system efficiency would be 0.85. Dividing the energy need by the system efficiency will produce the delivered energy result (delivered energy can never be lower than the energy needed).
- For example, energy carriers from distant sources: solid, liquid or gaseous fossil fuels; solid, liquid or gaseous biofuels or grid electricity. From nearby sources: district heating or district cooling. From onsite sources: electricity from PV panels, electricity from wind turbines, heat from solar thermal, geothermal or aerothermal. In cases where more than one energy carrier is used for the same building system (e.g. hot water from a gas boiler and from onsite solar thermal) two rows should be made for hot water, one for each energy carrier.
- Any given energy carrier may have a non-renewable factor and a renewable factor, or just one of the two. These factors may be greater or less than 1, although the combined total of non-renewable and renewable primary energy factors for a given energy carrier cannot be less than 1.
- If the methodology requires other energy needs to be accounted for, or the user simply wants to do this, then one row should be used for each "other" energy service.
- When making the entry for delivered energy for any exported renewable energy from the building, a negative number should be used.

The data from the above primary energy demand estimates should then be converted into final primary energy demand, which should be expressed by all of the indicators below unless otherwise specified by the contracting authority.

Primary Energy Demand indicator	kWh/m ² /yr
L2.1 EPBD services ¹ non-renewable primary energy self-used ² (mandatory)	
L2.2 EPBD services ¹ renewable primary energy self-used ² (mandatory)	
L2.3 EPBD services ¹ total primary energy self-used ² (mandatory)	L2.1 + L2.2
L2.4 Exported renewable primary energy (mandatory)	
L2.5 EPBD services ¹ total primary energy balance ³ (mandatory)	L2.3 – L2.4
L2.6 Non-EPBD services non-renewable primary energy self-used ² (optional)	
L2.7 Non-EPBD services renewable primary energy self-used ² (optional)	
L2.8 Non-EPBD services ¹ total primary energy self-used ² (optional)	L2.6 + L2.7

Core criteria				Comprehensive criteria			
TECHNICAL SPECIFICATIONS (TSs) AND AWARD CRITERIA (ACs)							
Note: Energy consumption (and associated operational greenhouse gas emissions) are relevant for all types of building project							
L2.9 Total primary energy self-used ² (optional)				L2.3 + L2.8			
L2.10 Total primary energy balance ³ (optional)				L2.9 – L2.4			
<p>1. For the purposes of comparability, EPBD services in Level(s) reporting should be considered as: heating, cooling, ventilation (including any humidification and dehumidification), hot water and lighting.</p> <p>2. Self-used means energy delivered to the building as part of the building operation. This includes all energy delivered from all sources, including onsite sources for EPBD services, such as PV panels and solar thermal installations and ignores any excess of renewable energy from onsite sources that is exported.</p> <p>3. Primary energy "balance" means the subtracting any exported renewable primary energy from the total "self-used" energy.</p>							
Design	Site prep.	Construction	Management	Design	Site prep.	Construction	Management
<p>TS1.1.2: Passive HVAC features</p> <p>Note: the contracting authority should select the requirements they wish to meet from the list below:</p> <p>The building design solutions for heating, ventilation and air conditioning systems shall incorporate the following passive features to minimise the consumption of fuel or electricity by these systems:</p> <ul style="list-style-type: none"> • Potential for solar gain or solar shading via adjustable devices to passively increase or decrease heat and daylight gains. • The installation of solar water heating systems. • The installation of heat exchangers to recover heat from drained shower water. • The installation of openings and the distribution of building spaces that maximise the potential for cross-ventilation via temperature and/or pressure gradients and allow for secure passive night-time cooling during hot periods. • Air tightness: $\leq 2 \text{ m}^3/\text{h.m}^2$ at 50Pa • Thermal bridging: ≤ 0.10 (y value) <p>The project manager shall ensure that the passive features are installed as per design specifications during the construction and installation stages.</p> <p>Verification:</p> <p>The design team shall provide a brief description of the HVAC system design with the passive aspects clearly highlighted. Where relevant, the U value claims shall be supported by manufacturer declarations and test results.</p> <p>Upon completion, the contractor shall test the building form for thermal defects via thermal imaging in line with EN 13187 or relevant national building standards. The air permeability test shall be conducted in accordance with EN ISO 9972, EN 13829 or relevant national building standards</p>				<p>TS1.1.2: Passive HVAC features</p> <p>Note: the contracting authority should select the requirements they wish to meet from the list below: A limited number of requirements or less ambitious limits may apply for renovation projects, where there is limited opportunity for improvement.</p> <p>The building design solutions for heating, ventilation and air conditioning systems shall incorporate the following passive features to minimise the consumption of fuel or electricity by these systems:</p> <ul style="list-style-type: none"> • Potential for solar gain or solar shading via adjustable devices to passively increase or decrease heat gains. • The installation of solar water heating systems. • The installation of heat exchangers to recover heat from drained shower water. • The installation of openings and the distribution of building spaces that maximise the potential for cross-ventilation via temperature and/or pressure gradients and allow for secure passive night-time cooling during hot periods. • Low thermal conductivity walls: $\leq 0.15 \text{ W/m}^2.\text{K}$. • Low thermal conductivity floor: $\leq 0.12 \text{ W/m}^2.\text{K}$. • Low thermal conductivity roof: $\leq 0.12 \text{ W/m}^2.\text{K}$. • Low thermal conductivity windows: $\leq 1.0 \text{ W/m}^2.\text{K}$. • Low thermal conductivity doors: $\leq 1.2 \text{ W/m}^2.\text{K}$. • Air tightness: $\leq 1 \text{ m}^3/\text{h.m}^2$ at 50Pa • Thermal bridging: ≤ 0.06 (y value) • Glass: ≤ 0.6 (g value) • MVHR* efficiency: $\geq 80\%$ (with optional summer by-pass function). <p>The project manager shall ensure that the passive features are installed as per design specifications</p>			

Core criteria				Comprehensive criteria			
TECHNICAL SPECIFICATIONS (TSs) AND AWARD CRITERIA (ACs)							
<i>Note: Energy consumption (and associated operational greenhouse gas emissions) are relevant for all types of building project.</i>							
				<p>during the construction and installation stages.</p> <p>Verification:</p> <p>The design team shall provide a brief description of the HVAC system design with the passive aspects clearly highlighted. Where relevant, the U value claims shall be supported by manufacturer declarations and test results.</p> <p>Upon completion, the contractor shall test the building form for thermal defects via thermal imaging in line with EN 13187 or relevant national building standards. The air permeability test shall be conducted in accordance with EN ISO 9972, EN 13829 or relevant national building standards</p>			
Design	Site prep.	Construction	Management	Design	Site prep.	Construction	Management
<p>TS1.1.3: Energy efficient HVAC, lighting and water heating equipment</p> <p>Where any of the HVAC, light sources or water heating equipment is covered by an EU Energy Labelling Regulation, they will have an energy class that represents the top 30% of products of the same typology.</p> <p>The project manager shall ensure that the energy labelled equipment that is installed has suitable energy class labels during the construction and installation stages.</p> <p>Verification:</p> <p>The design team shall clarify whether or not the HVAC, light source or water heating equipment is covered by EU Energy Labelling Regulations.</p> <p>If so, the energy classes representing the top 30% of relevant products shall be justified by search and filter functions of the European Product Registry for Energy Labelling (EPREL) database.</p> <p>In cases where there are multiple typologies of product within the same product category, the search should be specific to the typology in question, if EPREL database filters allow for this.</p>				<p>TS1.1.3: Energy efficient HVAC, lighting and water heating equipment</p> <p>Where any of the HVAC, light sources or water heating equipment is covered by an EU Energy Labelling Regulation, they will have an energy class that represents the top 20% of products of the same typology.</p> <p>The project manager shall ensure that the energy labelled equipment that is installed has suitable energy class labels during the construction and installation stages.</p> <p>Verification:</p> <p>The design team shall clarify whether or not the HVAC, light source or water heating equipment is covered by EU Energy Labelling Regulations.</p> <p>If so, the energy classes representing the top 20% of relevant products shall be justified by search and filter functions of the European Product Registry for Energy Labelling (EPREL) database.</p> <p>In cases where there are multiple typologies of product within the same product category, the search should be specific to the typology in question, if EPREL database filters allow for this.</p>			
		Design	Site prep.	Construction	Management		
<p>AC1.1.3: Energy efficient HVAC, lighting and water heating equipment</p> <p>A maximum of X points shall be awarded for tenders that provide design solutions where any HVAC, light sources or water heating equipment covered by an EU Energy Labelling Regulation has an energy class that is the highest class available on the market at the date of submitting the tender.</p> <p>Verification:</p> <p>The design team shall clarify whether or not the HVAC, light source or water heating equipment is covered by EU Energy Labelling Regulations.</p> <p>If so, the energy classes representing the highest populated energy class for relevant products shall be justified by search and filter functions of the European Product Registry for Energy Labelling (EPREL) database.</p> <p>In cases where there are multiple typologies of product within the same product category, the search</p>							

Core criteria	Comprehensive criteria			
TECHNICAL SPECIFICATIONS (TSs) AND AWARD CRITERIA (ACs)				
<i>Note: Energy consumption (and associated operational greenhouse gas emissions) are relevant for all types of building project</i>				
should be specific to the typology in question, if EPREL database filters allow for this.				
	Design	Site prep.	Construction	Management
TS1.1.4: Installation of a building energy storage, building energy management and onsite or nearby renewable energy systems				
<i>Note: The contracting authority may choose to fix a total value of renewables, in kWh/yr, as this might be simpler than setting a % of an as yet unknown value, because each design will vary in total energy needs.</i>				
Onsite or nearby renewable energy systems shall be installed that can meet at least 10% of the estimated building energy consumption (X kWh/yr), on an annual basis.				
The building shall have an energy storage system that is capable of storing at least 2 days of normal expected energy demand.				
A building energy management system shall also be installed to:				
<ul style="list-style-type: none"> • Monitor real time energy consumption on a second by second basis and make this data available to building management via a live interface. • Automatically generate and log uneditable energy data files for building management. • Apply demand response logic in order to optimise imports from and exports to the electrical grid (e.g. export to grid during peak demand hours when electricity is more expensive and higher carbon, and import from grid during off-peak demand hours when electricity is cheaper and lower carbon). 				
Verification:				
The design team shall provide a description of the onsite renewable energy system(s), energy storage system, building energy management system and control philosophy. The capacities of the onsite renewable energy system and energy storage system shall be clearly stated.				
The contractor shall provide the following documentation of the installed systems:				
<ul style="list-style-type: none"> • installation instructions, • an explanation of how the controls and sensors can be installed, programmed and adjusted • an operation manual and maintenance instructions. • details of suppliers or manufacturers shall be provided for any future procurement of spare parts or repairs. 				
The correct construction and installation of the ventilation system(s) and of building elements especially relevant to predicted ventilation performance shall be ensured by the project manager during the construction and installation stages.				
The building manager shall provide periodic (e.g. once per year) reports about the specific energy production and consumption trends that highlight the performance of the onsite renewable energy system, in terms of kWh generated, used in the building or exported. The report should also highlight the effect of these systems on operational costs and carbon emissions compared to a business as usual scenario where all energy would have come from the electrical grid or gas mains.				
	Design	Site prep.	Construction	Management
AC1.1.4: Installation of onsite or nearby renewable energy systems				
<i>Note: the possibilities for applying this criterion will depend on the space available and planning permissions. The contracting authority may choose to fix a total value of renewables, in kWh/yr, as this might be simpler than setting a % of an as yet unknown value, because each design will vary in total energy needs.</i>				
A maximum of X points shall be awarded to offers that are able to meet 100% of the estimated building energy consumption (Y kWh/yr), on an annual basis via onsite or nearby renewable energy systems.				
Points shall be awarded proportionately in response to where the % coverage by renewables lies between the minimum 10% and the maximum 100%.				
Onsite or nearby renewable energy systems shall be installed that can meet at least 10% of the estimated building energy consumption (Y kWh/yr), on an annual basis.				
The correct construction and installation of any onsite or nearby renewable energy systems shall be ensured by the project manager during the construction and installation stages.				

Core criteria	Comprehensive criteria
TECHNICAL SPECIFICATIONS (TSs) AND AWARD CRITERIA (ACs)	
<i>Note: Energy consumption (and associated operational greenhouse gas emissions) are relevant for all types of building project.</i>	
<p>Verification:</p> <p>The design team shall provide a description of the onsite renewable energy system(s), energy storage system, building energy management system and control philosophy. The capacity of the onsite renewable energy system shall be clearly stated.</p> <p>The contractor shall provide the following documentation of the installed systems:</p> <ul style="list-style-type: none"> • installation instructions, • an explanation of how the controls and sensors can be installed, programmed and adjusted • an operation manual and maintenance instructions. • details of suppliers or manufacturers shall be provided for any future procurement of spare parts or repairs. <p>The correct construction and installation of the ventilation system(s) and of building elements especially relevant to predicted ventilation performance shall be ensured by the project manager during the construction and installation stages.</p> <p>The building manager shall provide periodic (e.g. once per year) reports about the specific energy production and consumption trends that highlight the performance of the onsite renewable energy system, in terms of kWh generated, used in the building or exported. The report should also highlight the effect of these systems on operational costs and carbon emissions compared to a business as usual scenario where all energy would have come from the electrical grid or gas mains.</p>	

Supporting rationale for criteria 1.1.1 to 1.1.4 on use stage energy consumption:

Environmental relevance:

Impacts associated with use stage energy consumption (module B6 in the EN 15978 framework) have traditionally dominated the life cycle impacts of buildings for most impact categories. At the European level, use stage energy consumption in buildings accounts for around 40% of total final energy consumption in Europe.

Total use stage energy consumption tends to be dominated by heating, cooling, ventilation, hot water production and lighting systems. The predominance of one type of energy demand over another will depend on the local climate, building design features and occupant behaviour. Since design calculations and EN standards are well established for these systems already, the criterion focuses on them first and foremost. If the contracting authority wishes to have an estimate of other energy uses, these should be specified clearly in the call for tender and associated numbers should be reported separately, as indicated in the reporting format in the explanatory note for TS1.1.1.

There are lots of different ways to get to and exceed NZEB performance levels. In reality, a combination of approaches will be required and the combinations of criteria 1.1.2, 1.1.3 and 1.1.4 demonstrate this.

The need for a paradigm shift in building energy consumption and energy systems

The current reliance of EU building stock on natural gas for heating cannot continue if ambitious EU climate goals are to be realised. However, a rapid shift from natural gas to electrically powered heating systems would completely overload electrical grids. For example, see the relative scales of gas energy and electrical energy demand below. These scales are based on real data for the UK during cold weather in the heating season, although similar data could apply for many European countries with well established gas mains supply networks.

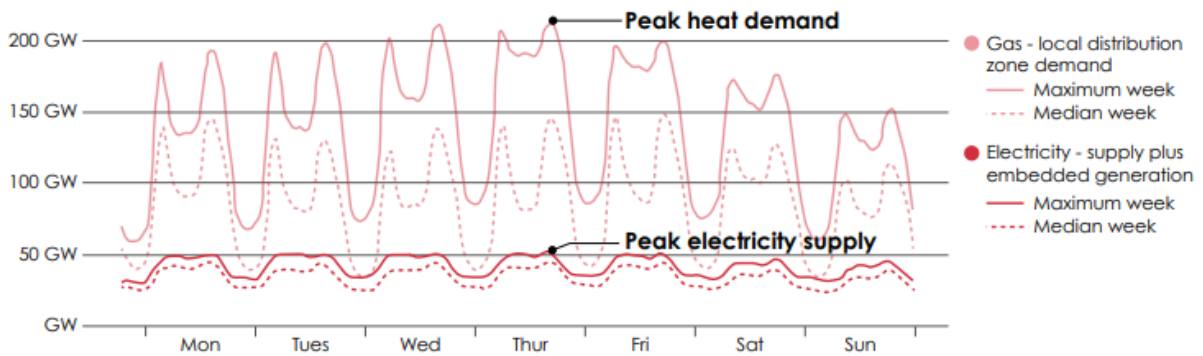


Figure 1. Comparison of gas energy demand and electrical energy supply in a UK heating season.

Source: Wilson et al., (2018), as cited in LETI, CEDG.

One of the key points shown in Figure 1 is that during cold weather, the demand for gas to meet heating needs increases by a factor of 3 between the hours of 5am and 8am. This flexibility is able to be met by the gas system due to the gas network having strategic reserve capacity, which can be increased by increasing the pressure in the gas networks to store extra energy. However, such an ability to store extra energy in the electrical network in most regions does not exist (one exception perhaps being hydropower).

At all times during the data presented above, the gas energy demand is anywhere from 2 to 4 times higher than the electricity supply.

As if making the shift from gas to electrical heating systems in buildings was not already challenging enough, at the same time, another major “new” source of demand for electricity is the shift from petrol- or diesel-powered vehicles to 100% electric or hybrid ones.

Consequently, buildings will have to play a fundamental role in this new energy paradigm. They are going to have to consume less energy, provide flexibility in energy storage to ride out their own daily peaks in demand and be able to meet part or all of their own energy demand via onsite or nearby renewables. In order to optimise the management of this complex system, a building energy management system is necessary.

The “energy efficiency first” principles are supported by specifying passive building features that reduce the electrical or fuel energy demands in the first place (TS1.1.2), and by specifying HVAC, light sources and water heaters that have good energy classes (TS1.1.3), also pushing for the best energy class possible in AC1.1.3. The use of TS1.1.4 brings another dimension to building performance by specifying building energy storage and building energy management systems, which not only provide great benefits to the grid, but also economic benefits to building occupants if the price of electricity is different between peak and off-peak times. The incorporation of onsite or nearby renewables is an important part of the overall building energy paradigm shift and is required in TS1.1.4 (at least 10% of own demand) and rewarded in AC1.1.4 for going further up towards 100% of own demand.

Policy relevance:

Use stage energy consumption of buildings is strongly rooted in EU policy, especially with the Renovation Wave, the Level(s) framework and with the EU Taxonomy. Legal obligations under the Energy Performance of Buildings Directive (EPBD) for Member States to develop and implement methodologies for assessing building energy performance (Article 3 of EPBD), to set minimum energy performance requirements (Article 4 of EPBD) and to develop long-term renovation strategies (Article 2a of EPBD) that, amongst other things, must target public buildings.

The Energy Efficiency Directive (EED) provides impetus to public authorities to increase renovation rates of poorly performing central government buildings in order to lead by example (Article 5 of EED). Proposals to recast the EED would expand the exemplary role in energy renovation to all public bodies, not just central government. The application of comprehensive level TS1.1.3 alone (or in tandem with AC1.1.3) could be considered as practically applying the text from Article 6(1) and Annex III to the EED, especially where it says: “insofar as that is consistent with cost-effectiveness, economical feasibility, wider sustainability, technical suitability, as well as sufficient competition”. It is clear that TS1.1.3 should be a cornerstone of all public procurement for the construction of new buildings or major renovation of existing ones.

Since Annex III to the EED also referred to Energy Star labelling, and that system recognised the top 25% performing products, the core and comprehensive requirements have been set at top 20% and top 30%. Unfortunately, Energy Star products are no longer marketed as such on the EU market following the expiry of the EU-US agreement in 2018. The opportunity to reward the top energy class is provided in AC1.1.3, and it is up to contracting authorities to decide how many points they would be willing to award here to compensate for higher purchasing costs of the most efficient equipment.

Why 5 indicators for TS1.1.1?

The reporting system in the explanatory note requires a total of five different numbers, and is in line with the reporting format for Level(s) indicator 1.1. The main reason for this is that it is the only way to get the full picture of the design energy performance. The most important value is arguably L2.3, total self-used primary energy. This particular indicator can be considered as most important because:

- It is the truest reflection of energy efficient design – in order to achieve a low number, energy efficiency first principles must be applied.
- Low numbers cannot be achieved simply by sourcing more energy from renewable sources and/or by over-sizing onsite renewable energy systems to have large exports of renewable energy.

The other indicators should be of interest to the contracting authority as well for other reasons. For example, the split of renewable and non-renewable primary energy shows how well the design is embracing renewable energy sources, and the relative size of energy export is important to know for the purposes of life cycle costing. National reporting methodologies will almost certainly require at least one of these numbers (e.g. L2.1, L2.2 or L2.5) or the preferred “total self-used primary energy” (L2.3).

Why no absolute number or energy class specified in TS1.1.1?

Although the 2016 criteria for office buildings did set quantitative energy requirements (in terms of kWh/m² and/or energy performance certificate class) since then the EU Taxonomy has decided to define significant contributions to climate change mitigation in buildings as a certain % below NZEB definitions for new buildings and a certain % below previous primary energy consumption for building renovation. In order to send a consistent message to the industry, the EU GPP criteria take a similar approach.

Another major reason for not setting an absolute number (in terms of kWh/m²/yr) for the total primary energy use for the building in the criteria was because the building energy performance assessment methodologies still differ significantly from one Member State to another, in terms of scope, in terms of reporting unit (e.g. total or non-renewable primary energy, self-used or net primary energy) and possibly also in the definition of floor area of the building.

A simple reference to the rating of the Energy Performance Certificate in the EU GPP criteria was not made either for similar reasons, namely that an “A” rating in one Member State will not mean the same as in another Member State.

Unfortunately, the definition of NZEB in each Member State will probably suffer from similar differences, but this point of comparison was chosen because it was the solution promoted by the EU Taxonomy for environmentally sustainable economic activities. Further research into exactly how methodologies and definitions differ between different Member States is ongoing and will be presented in the next versions of the background report, and referred to in the next draft of this technical report.

One potential quick solution that would allow specific energy consumption values to be required by contracting authorities across Europe would be to link benchmarks to the voluntary energy performance assessment methodology defined by the ALDREN project. This is proposed to be discussed further with stakeholders.

Requirements relating to passive design aspects:

As stated earlier, passive design aspects reduce energy demand in the first place, reducing pressure on other aspects of building energy performance. The building envelope thermal performance requirements are broad in scope. The ambition level is similar to passive house standards, which are notably more ambitious than the equivalent limits set in the 2016 criteria, especially for air tightness.

While often going hand in hand, air tightness and insulation are not necessarily the same thing. For example, air can easily pass through mineral wool, despite this material being an excellent insulator. Likewise, aluminium foil can provide excellent air tightness, but does not insulate heat very well. For this reason, it is necessary to consider requirements on both air tightness and thermal conductivity of the building envelope.

The improvement of air tightness brings important advantages for reducing heat loss via but extra care needs to be taken with regard to water tightness of the envelope and the ventilation system. With high performance air tightness, the need for mechanical ventilation becomes more important to guarantee secure ventilation at all times to prevent the build-up of moisture and indoor air pollutants.

Market considerations:

Since the energy performance assessment is supposed to be carried out for all new buildings and all existing buildings whenever they are subject to major renovation or whenever technical building systems are installed, replaced or upgraded (Article 1(2a-c) of EPBD), there should be plenty of economic operators and specialists available to carry out such an assessment.

Contracting authorities may wish to further specify minimum energy class requirements for certain energy-related products that are covered by the Energy Labelling Regulation (EU) 2017/1369. In such cases, the distribution of energy classes on the market for relevant energy labelled products should be checked on the European Product Registry for Energy Labelling (EPREL) before deciding on what ambition level would be appropriate. However, at the time of writing, the EPREL database is still not functional. If the EPREL database is launched before the background report for EU GPP criteria for buildings is finalised, an analysis of ranges of energy class labels for some of the most relevant products will be included.

What do Green Building Rating Systems or other initiatives say?

(To be completed).

Targeted questions to stakeholders about TS1.1:

Q4: Should EU GPP criteria make reference to energy classes in Energy Performance Certificates (EPCs) in addition to performances relative to national NZEB definitions? Or can it be assumed that better than NZEB will always be Energy Rating A on an EPC?

Q5: Given the still significant differences in EPB methodology at Member State level, should the comprehensive criterion offer an approach that follows a voluntary harmonised methodology (i.e. the ALDREN methodology) via an optional award criterion?

Q6: If yes to question 5, what kind of ALDREN-based requirements could be presented for social housing, office buildings and educational buildings?

Q7: Any suggestions about the passive requirements set in TS1.1.2 to reduce energy demand? Should less ambitious building envelope performance values be defined for renovation and/or the core level? Should different levels be specified for social housing, office or educational buildings? If so, which values?

Q8: Can you share building envelope thermal performance and air permeability requirements that are defined in the latest versions of national building codes?

Q9: Should the installation of onsite or nearby renewable energy systems that supply energy to the building be treated as separate procurement exercises? If so, what conditions would justify this separation (e.g. physical distance from the building, scope of energy supply beyond the building etc.).

1.2. Whole life carbon

Core criteria				Comprehensive criteria			
TECHNICAL SPECIFICATIONS (TSs)							
<p><i>Note: Energy consumption (and associated greenhouse gas emissions) are relevant for all types of building project. Greenhouse gas emissions embodied in materials are mainly applicable to new construction projects or, in certain cases, to major renovation projects if a "carbon payback" type analysis is of interest.</i></p>							
Design	Site prep.	Construction	Management	Design	Site prep.	Construction	Management
<p>TS1.2: Whole life carbon assessment</p> <p><i>Note: The final results should be reported in the format presented in the explanatory note for the sake of transparency and consistency. It is up to the contracting authority to define the scope of the assessment clearly in the call for tender, as well as what LCA software and databases to use and any more specific national or regional methodology to be followed that is in line with EN 15978.</i></p> <p>At the design stage, the whole life carbon assessment of the building shall be estimated based on modules A through D of the building life cycle in accordance with the EN 15978 standard.</p> <p>Verification:</p> <p>The tenderer will provide a written report that provides a summary and breakdown of all carbon emissions associated with the building life cycle at least into the following modules:</p> <ul style="list-style-type: none"> - A1-A3 (products). - A4-A5 (construction). - B1-B5 (use stage – materials). - B6-B7 (use stage – energy and water). - C1-C4 (End of life stage). - D (Benefits and loads beyond the system boundary). <p>For modules A1-A3 and B1-B5, carbon emissions for all the relevant ingoing construction materials and products shall be supported by relevant Environmental Product Declarations or generic data from identified life cycle inventories.</p> <p>For modules A4-A5, any assumptions about wastage rates shall be clearly stated.</p> <p>For module B6, the scope of building services covered shall be clearly stated (e.g. heating, cooling, ventilation, hot water, lighting etc.) and what assumptions are made about projected trends in grid electricity carbon factors.</p>				<p>TS1.2: Whole life carbon assessment</p> <p><i>Note: The final results should be reported in the format presented in the explanatory note for the sake of transparency and consistency. It is up to the contracting authority to define the scope of the assessment clearly in the call for tender, as well as what LCA software and databases to use and any more specific national or regional methodology to be followed that is in line with EN 15978.</i></p> <p>A total of three whole life carbon assessments shall be carried out: (i) at the design stage; (ii) after the building has been completed, and (iii) after X years occupation.</p> <p>The whole life carbon emissions of the building shall be estimated based on modules A through D of the building life cycle in accordance with the EN 15978 standard and compared to the design stage results.</p> <p>Verification:</p> <p>The tenderer will provide a written report that provides a summary and breakdown of all carbon emissions associated with the building life cycle at least into the following modules:</p> <ul style="list-style-type: none"> - A1-A3 (products). - A4-A5 (construction). - B1-B5 (use stage – materials). - B6-B7 (use stage – energy and water). - C1-C4 (End of life stage). - D (Benefits and loads beyond the system boundary). <p>For modules A1-A3 and B1-B5, carbon emissions for all the relevant ingoing construction materials and products shall be supported by relevant Environmental Product Declarations or generic data from identified life cycle inventories.</p> <p>For modules A4-A5, assumptions about wastage rates for the design stage assessment shall be clearly stated. For the second and third assessments, assumptions shall be based on waste management data during the construction phase and any maintenance activities.</p> <p>For modules B6 and B7, the scope of building services covered shall be clearly stated for the design assessment (e.g. heating, cooling, ventilation, hot water, lighting, irrigation etc.) and what assumptions are made about projected trends in grid electricity carbon factors. For the second and third assessments, assumptions shall be based on real meter readings for electricity, fuel and mains</p>			

Core criteria	Comprehensive criteria
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TECHNICAL SPECIFICATIONS (TSs)

Note: Energy consumption (and associated greenhouse gas emissions) are relevant for all types of building project. Greenhouse gas emissions embodied in materials are mainly applicable to new construction projects or, in certain cases, to major renovation projects if a "carbon payback" type analysis is of interest.

water consumed.

Explanatory note for TS1.2:

When calculating embodied carbon, entries should be made for the following minimum scope of building elements shown in the table below. To estimate replacement rates, some default lifespans have been provided as well. If other default lifespans are to be assumed, these should be clearly specified by the contracting authority in the call for tender.

Building element hierarchy			Default service life	
Tier 1	Tier 2	Tier 3		
Shell	Foundations (substructure)	Piles or shallow foundations	60 years	
		Basements		
		Retaining walls		
	Loadbearing structural frame	Frame (beams, columns and slabs)		
		Upper floors		
		External walls		
	Non-load bearing elements	Balconies		30 years
		Ground floor slab		
		Internal walls, partitions and doors		
	Stairs and ramps			30 years (35 years if glazed)
		External wall systems, cladding and shading devices		
		Façade openings (including windows and external doors)		
	Facades	External paints, coatings and renders		10 years (paint) 30 years (render)
		Structure		30 years
Weatherproofing				
Roof		30 years		
Parking facilities	Above ground and underground (within the curtilage of the building and servicing the building occupiers)	60 years		
Core	Fittings and furnishings	Sanitary fittings	20 years	
		Cupboards, wardrobes and worktops (where provided in residential property)	10 years	
		False ceilings	20 years	
		Wall and ceiling finishes	20 years (finishes) 10 years (coatings)	
		Skirting and trimming	30 years	
		Sockets and switches	30 years	
		Floor coverings and finishes	30 years (finishes) 10 years (coatings)	
	In-built lighting system	Light fittings	15 years	
		Control systems and sensors		
	Energy system	Heating plant and distribution	20 years	
		Cooling plant and distribution	15 years	
		Electricity generation	15 years	
		Electricity distribution	30 years	
	Ventilation system	Air handling units	20 years	
		Ductwork and distribution	30 years	
	Sanitary systems	Cold water distribution	25 years	
		Hot water distribution		
		Water treatment systems		
		Drainage system		
	Other systems	Lifts and escalators	20 years	
Firefighting installations		30 years		
Communication and security installations		15 years		
Telecoms and data installations		15 years		
External works	Utilities	Connections and diversions	30 years	
		Substations and equipment		
	Landscaping	Paving and other hard surfacing	25 years	

Core criteria		Comprehensive criteria					
TECHNICAL SPECIFICATIONS (TSs)							
<p>Note: Energy consumption (and associated greenhouse gas emissions) are relevant for all types of building project. Greenhouse gas emissions embodied in materials are mainly applicable to new construction projects or, in certain cases, to major renovation projects if a "carbon payback" type analysis is of interest.</p>							
		Fencing, railings and walls	20 years				
		Drainage system	30 years				
<p>Results of the assessment should be reported in the format below, together with a combined result that covers stages A1 to C4, and is normalised into kgCO₂eq./m²/yr.</p>							
Indicator	Unit	Product	Construction process	Use stage materials	Use stage energy and water	End of life	Benefits and loads beyond the system boundary
		(A1-A3)	(A4-A5)	(B1-B5)	(B6-B7)	(C1-C4)	(D)
(1) GWP – fossil	kg CO ₂ eq						
(2) GWP – biogenic							
GWP-GHG _s (1+2)							
(3) GWP – LULUC *							
GWP-overall (1+2+3)							
<p>Notes:</p> <p>*LULUC stands for Land Use and Land Use Change</p> <p>Results should be expressed in normalised units of per m²/yr over the projected building life cycle. Unless otherwise specified by the contracting authority, the projected lifetime of the building shall be assumed to be 50 years.</p>							

Supporting rationale for TS1.2 Whole Life Carbon:

Environmental relevance:

Carbon emissions, based on the Global Warming Potential midpoint indicator of LCA methodologies, is arguably the best known metric for environmental impact amongst members of the public. The Communication on Europe's 2030 climate ambition estimates that around 36% of greenhouse gas emissions come from the building sector. Depending on the characteristics of the building and the behaviour of its occupants, the dominant source of carbon emissions over its life cycle will be embodied carbon in the building materials or operational carbon due to energy use.

There is a large potential to reduce carbon emissions from operational energy use by making buildings more passive, by improving the energy efficiency of building technical systems and by switching to renewable sources of energy wherever possible. The literature indicates that there are larger uncertainties with regards to accurately estimating embodied carbon in buildings but, because embodied carbon will become more relevant in energy efficient buildings and because trade-offs can exist (e.g. reducing operational carbon with insulation will increase embodied carbon) then it is important that embodied carbon is reported in as much detail as possible.

This criterion can be used to optimise new building projects, be used to estimate the "carbon payback" of investments in renovation to improve energy efficiency or investments in onsite installation of renewable energy systems. Whole life carbon assessment could even be used, possibly as part of a stand-alone design feasibility study, to aid decision-making when there is the option to undergo a major renovation or to demolish and build a new building instead. For this latter option, the contracting authority would need to very clearly define the scope and boundary to ensure a fair comparison.

Policy relevance:

This indicator is also firmly rooted in high profile EU policy such as the European Green Deal and the 2030 Climate ambition for Europe. The LCA methodology is based on the EN 15978 framework standard and more specific details of the scope for embodied carbon (provided in explanatory note next to the criterion) are in line with indicator 1.2 of the Level(s) framework and the EU Taxonomy approach for new buildings >5000m² (see section 7.1 of Annex I to Regulation (EU) 2020/852). Proposals for the recast EPBD published in December 2021 state that whole life carbon should be mandatory for all new buildings >2000m² by 2027 and all new buildings by 2030.

Market considerations:

There are a number of different LCA software and LCA databases available on the market. The EN 15978 standard is not overly prescriptive, so more detailed guidance about cut-off rules, the use of generic data, service element lifetime, trends in carbon factors for grid electricity, occupation patterns and the scope and boundary will need to be clearly stated by the contracting authority. Depending on the expertise within the contracting authority, they may need to contract an LCA specialist to prepare the project specific requirements on Whole Life Carbon, to review this part of the tenders received and to confirm that the final contractor meets the requirements.

No specific benchmark is set for Whole Life Carbon in EU GPP criteria since final results will be very sensitive to the scope of building elements included in embodied carbon, the assumed lifespan of those building elements, the assumed lifetime of the building and the scope of building services included in estimates for carbon emissions due to operational energy use. Furthermore, in cases where tenders might be competing against each other on the basis of whole life carbon (e.g. if award criteria are used for offers below a certain benchmark) then great attention needs to be attached to claims and it will need to be investigated if the winning tender actually meets its design claims.

In order to better understand how design claims can vary from as-built buildings and occupied buildings, the comprehensive level EU GPP criterion on whole life carbon actually commits to repeating the life cycle carbon analysis three times for the building at different stages of its life cycle, as illustrated below.

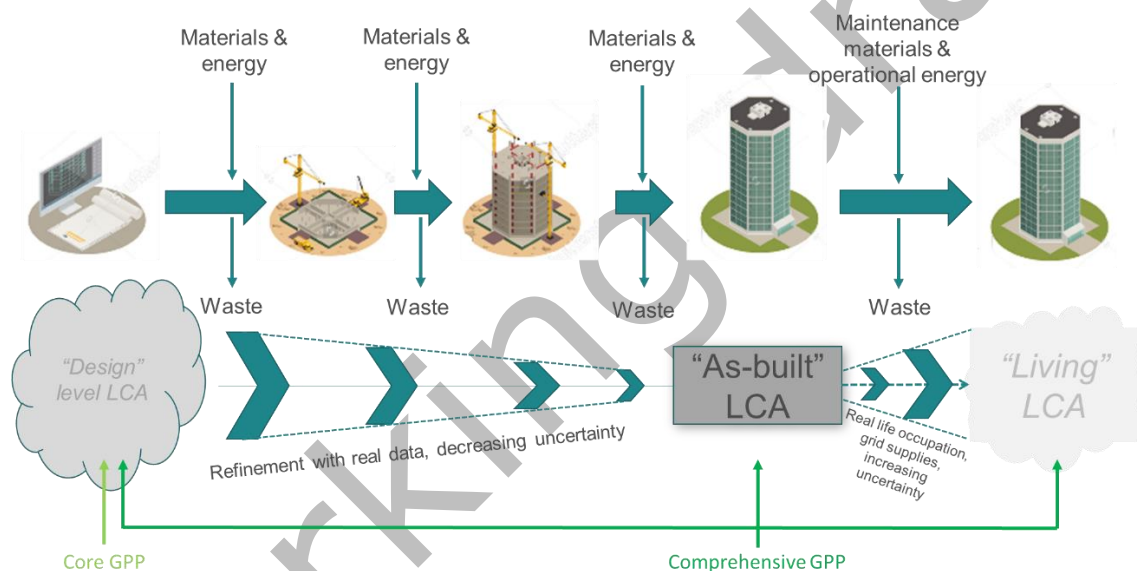


Figure 2. Illustration of LCA certainty across a building life cycle

The comprehensive approach will help inform both building owners and LCA practitioners about the performance gaps between design estimates and real life performance and, unless substituted by specific data, the same generic data and methodology should always be used, in order to avoid introducing other sources of variability. The core approach still provides useful information, but with less time or cost commitment required.

What do Green Building Rating Systems or other initiatives say?

The Royal Institute of British Architects (RIBA) set the following voluntary embodied carbon benchmarks for their 2030 climate challenge: <750 kgCO₂.eq/m² for new offices, <540 kgCO₂.eq/m² for new schools and <625 kgCO₂.eq/m² for new residential buildings.

Targeted questions to stakeholders about TS1.2:

Q10: Opinions about the suggested minimum scope of building elements to cover for embodied carbon? (note: this comes from the Level(s) framework)

Q11: Should the scope of building elements exactly mirror the hierarchy of elements set out in the

[International Cost Management Standard \(ICMS-3\)](#), which is used for costing building materials?

Q12: Any opinions on how the m² of the building floor area should be defined, in order to improve consistency of assessments? For example, gross versus net areas, what to do with external floor space like patios, balconies and underground car parks etc.?

Working draft

Theme 2: Material circularity

2.1: Inventory of building elements, technical systems, construction products and materials purchased.

Core criteria				Comprehensive criteria																														
TECHNICAL SPECIFICATIONS (TSs)																																		
Design	Site prep.	Construction	Management	Design	Site prep.	Construction	Management																											
<p>TS2.1: Inventory of building elements, technical systems, construction products and materials purchased.</p> <p>All of the building elements, technical systems, construction products and materials purchased for the construction stage shall be inventoried for both cost and carbon.</p> <p>Verification:</p> <p>If requested by the contracting authority, tenderers shall provide an outline inventory as part of their offer.</p> <p>During the new construction or renovation project, the contractor shall refine the inventory as the project proceeds.</p> <p>Unless otherwise specified by the contracting authority, the scope of the material inventory should be as per the explanatory note below.</p> <p>Final entries to the inventory shall be supported by invoices for cost elements and Environmental Product Declarations or generic Life Cycle Inventory data for embodied carbon inputs.</p>				<p>TS2.1: Inventory of building elements, technical systems, construction products and materials purchased.</p> <p>All of the building elements, technical systems, construction products and materials purchased for the construction stage shall be inventoried for both cost and carbon.</p> <p>The future replacement of building elements, technical systems, construction products and materials shall also be estimated for a reference study period of 50 years (or another period defined by the contracting authority).</p> <p>Verification:</p> <p>If requested by the contracting authority, tenderers shall provide an outline inventory as part of their offer and initial cost estimates.</p> <p>During the new construction or renovation project, the contractor shall refine the inventory as the project proceeds.</p> <p>Unless otherwise specified by the contracting authority, the scope of the material inventory should be as per the explanatory note below.</p> <p>Final entries to the inventory shall be supported by invoices for cost elements and Environmental Product Declarations or generic Life Cycle Inventory data for embodied carbon inputs.</p>																														
<p><u>Explanatory note for TS2.1:</u></p> <p>When calculating economic or carbon costs, entries should be made for the following minimum scope of building elements shown in the table below. To estimate replacement rates for the comprehensive level requirement, some default lifespans have been provided as well. If other lifespans are to be used, these should be clearly specified by the contracting authority in the call for tender or be justified by the tenderer/contractor.</p>																																		
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Core criteria		Comprehensive criteria	
TECHNICAL SPECIFICATIONS (TSs)			
	Roof	External paints, coatings and renders	10 years (paint) 30 years (render)
		Structure Weatherproofing	30 years
	Parking facilities	Above ground and underground (within the curtilage of the building and servicing the building occupiers)	60 years
Core	Fittings and furnishings	Sanitary fittings	20 years
		Cupboards, wardrobes and worktops (where provided in residential property)	10 years
		False ceilings	20 years
		Wall and ceiling finishes	20 years (finishes) 10 years (coatings)
		Skirting and trimming	30 years
		Sockets and switches	30 years
		Floor coverings and finishes	30 years (finishes) 10 years (coatings)
	In-built lighting system	Light fittings	15 years
		Control systems and sensors	
	Energy system	Heating plant and distribution	20 years
		Cooling plant and distribution	15 years
		Electricity generation	15 years
		Electricity distribution	30 years
	Ventilation system	Air handling units	20 years
		Ductwork and distribution	30 years
	Sanitary systems	Cold water distribution	25 years
		Hot water distribution	
		Water treatment systems	
		Drainage system	
Other systems	Lifts and escalators	20 years	
	Firefighting installations	30 years	
	Communication and security installations	15 years	
	Telecoms and data installations	15 years	
External works	Utilities	Connections and diversions	30 years
		Substations and equipment	
	Landscaping	Paving and other hard surfacing	25 years
		Fencing, railings and walls	20 years
		Drainage system	30 years

Supporting rationale for TS2.1: this is grouped together with the rationale for TS2.2, TS2.3 and TS2.4, presented at the end of TS2.4.

2.2. Construction, Demolition and Excavation Waste (CDEW) management

Core criteria				Comprehensive criteria			
TECHNICAL SPECIFICATIONS (TSs)							
Design	Site prep.	Construction	Management	Design	Site prep.	Construction	Management
<p>TS2.2: Construction, Demolition and Excavation Waste (CDEW) management.</p> <p>All tenderers will provide an outline site waste management plan that identifies how CDEW generated by the building project would be segregated, stored and reused, recycled, recovered or disposed of.</p> <p>The following targets shall be complied with by the contractor during the project:</p> <ul style="list-style-type: none"> - 90% reuse onsite or within a 2km radius of all non-hazardous excavation waste (soil and stones). - 90% diversion from landfill of all non-hazardous CDW. - 70% reuse, recycling or material recovery of all non-hazardous CDW. <p>Verification:</p> <p>Tenderers shall submit an outline waste management plan that illustrates what different waste streams would be generated, how they should be segregated and stored and what reuse, recycling, material recovery, energy recovery and disposal options exist for each waste stream in the regional area.</p> <p>The contractor shall maintain a log of waste generated and stored onsite or offsite. Shipments of materials for reuse or waste for recycling, material recovery, energy recovery or disposal shall be kept and be coded in accordance with the EU List of Wastes (Commission Decision 2014/955/EU)..</p> <p>Final results of the project waste log shall be reported using the Level(s) indicator 2.2 calculator or an equivalent tool that produces results in the format shown in the explanatory note below.</p>				<p>TS2.2: Construction, Demolition and Excavation Waste (CDEW) management.</p> <p>All tenderers will provide an outline site waste management plan that identifies how CDEW generated by the building project would be segregated, stored and reused, recycled, recovered or disposed of.</p> <p>The following targets shall be complied with by the contractor during the project:</p> <ul style="list-style-type: none"> - 100% reuse onsite or within a 2km radius of all non-hazardous excavation waste (soil and stones). - 100% diversion from landfill of all non-hazardous CDW. - 90% reuse, recycling or material recovery of all non-hazardous CDW. - 70% reuse or recycling of all non-hazardous CDW. <p>Verification:</p> <p>Tenderers shall submit an outline waste management plan that illustrates what different waste streams would be generated, how they should be segregated and stored and what reuse, recycling, material recovery, energy recovery and disposal options exist for each waste stream in the regional area.</p> <p>The contractor shall maintain a log of waste generated and stored onsite or offsite. Shipments of materials for reuse or waste for recycling, material recovery, energy recovery or disposal shall be kept and be coded in accordance with the EU List of Wastes (Commission Decision 2014/955/EU).</p> <p>Final results of the project waste log shall be reported using the Level(s) indicator 2.2 calculator or an equivalent tool that produces results in the format shown in the explanatory note below.</p>			

Explanatory note for TS2.2:

The format for reporting on CDW should be as follows:

Outcome for CDW	Summed streams		Split by specific waste streams for CDW									
	Mass (kg)	Fraction ¹	Concrete, brick, tile, ceramic	Wood	Glass	Plastic	Haz. Wood, glass, plastic	Bituminous mixtures	Metals	Insulation materials	Gypsum	Mixed
Prepared for reuse												

Core criteria		Comprehensive criteria									
TECHNICAL SPECIFICATIONS (TSs)											
Recycling											
Backfilling											
Other Material recovery											
Energy recovery											
Disposal											
Total inert+non-hazardous waste											
Split by type											
Inert											
Non-haz.											
Haz.											
Total											
Building GFA (m2)		1 – The total quantity of hazardous plus non-hazardous plus inert waste sums up to 100%. It is presumed that all hazardous waste is disposed of. So any targets specifically related to non-hazardous waste should be adjusted to ignore the fraction that was hazardous.									
Normalised CDW (kg/m2)											

Excavation waste (EW) must be reported separately, using the format below:

	Total mass of EW generated (kg)	Total mass of EW kept onsite or reused within 2km	Fraction (%)
Inert or non-haz. EW			
Haz. EW			

Supporting rationale for TS2.2: this is grouped together with the rationale for TS 2.1, 2.3 and 2.4, presented at the end of TS2.4.

2.3. Design for adaptability

Core criteria	Comprehensive criteria																		
TECHNICAL SPECIFICATIONS (TSs)																			
<p><i>Note: The term "adaptability" is generally defined in the Level(s) indicator 2.3 guidance as: "The ability of the object of assessment or parts thereof to be changed or modified during its useful life to make it suitable to accommodate a new or adapted use." For buildings in particular, this relates to the adaptability of indoor spaces. However, if the contracting authority also wishes to include exterior spaces (e.g. for educational buildings with significant land space).</i></p>																			
<p>TS2.3. Design for adaptability</p> <table border="1" style="width: 100%; text-align: center;"> <tr> <td style="background-color: #D3D3D3;">Design</td> <td style="background-color: #F0E68C;">Site prep.</td> <td style="background-color: #90EE90;">Construction</td> <td style="background-color: #D3D3D3;">Management</td> </tr> </table> <p><i>Note: the potential for introducing adaptability features is much greater in new building projects than in renovation projects. The adaptability concepts are general ones only, contracting authorities should be more specific about their perceived future adaptability needs and set the requirements accordingly.</i></p> <p>The building design shall obtain an adaptability score of a minimum of X/100 points by incorporating features that:</p> <ul style="list-style-type: none"> • facilitate changes to the internal space distribution • facilitate changes to the routing or type of building services (e.g. heating, ventilation and air conditioning, plumbing, electrical and telecommunications). <p>Verification:</p> <p>The building design shall be scored against a pre-prepared scoring matrix, which the designer shall have been made aware of prior to the design work.</p> <p>The precise scoring matrix should be defined by the contracting authority and the weighting can be adjusted to reflect their priorities. An example matrix is provided in the explanatory note below.</p> <p>The construction and completion of the adaptability features by the contractor must also be verified.</p>	Design	Site prep.	Construction	Management	<p>TS2.3. Design for adaptability</p> <table border="1" style="width: 100%; text-align: center;"> <tr> <td style="background-color: #D3D3D3;">Design</td> <td style="background-color: #F0E68C;">Site prep.</td> <td style="background-color: #90EE90;">Construction</td> <td style="background-color: #D3D3D3;">Management</td> </tr> </table> <p><i>Note: the potential for introducing adaptability features is much greater in new building projects than in renovation projects. The adaptability concepts are general ones only, contracting authorities should be more specific about their perceived future adaptability needs.</i></p> <p>The building design shall obtain an adaptability score of a minimum of X+10/100 points by incorporating features that:</p> <ul style="list-style-type: none"> • facilitate changes to the internal space distribution • facilitate changes to the routing or type of building services (e.g. heating, ventilation and air conditioning, plumbing, electrical and telecommunications) • facilitate changes to the building façade and structure (e.g. façade replacement, vertical or horizontal expansion of building) <p>Verification:</p> <p>The building design shall be scored against a pre-prepared scoring matrix, which the designer shall have been made aware of prior to the design work.</p> <p>The precise scoring matrix should be defined by the contracting authority and the weighting can be adjusted to reflect their priorities. An example matrix is provided in the explanatory note below.</p> <p>The construction and completion of the adaptability features by the contractor must also be verified.</p>	Design	Site prep.	Construction	Management										
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<p><u><i>Explanatory note for TS2.3:</i></u></p> <p>The following example of a scoring matrix for design for adaptability is in line with Level(s) indicator 2.3:</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="background-color: #D3D3D3;">Adaptability design concept</th> <th style="background-color: #D3D3D3;">Specific design aspect</th> <th style="background-color: #D3D3D3;">How it contributes to adaptability</th> <th style="background-color: #D3D3D3;">Scoring rules</th> <th style="background-color: #D3D3D3;">(Weighting factor) and points</th> </tr> </thead> <tbody> <tr> <td rowspan="3" style="text-align: center; vertical-align: middle;">1. Changes to internal space distribution</td> <td style="text-align: center;">1.1. Column grid spans</td> <td style="text-align: center;">Wider column spans will allow for more flexible floor layouts.</td> <td>Column spacing: - < 5400 mm - 5400 mm < 8100 mm - > 8100 mm - free span</td> <td style="text-align: center;">(x1.5) 0 points 1 point 2 points 3 points</td> </tr> <tr> <td style="text-align: center;">1.2. Façade pattern</td> <td style="text-align: center;">Narrower bays will allow for more internal space configurations</td> <td>Spacing between bays: - 1350 to >1800 mm - 1350-1800 mm - 1350-1800 mm + some 900-1350 mm - 900 - 1350 mm, some bays < 900 mm</td> <td style="text-align: center;">(x1.5) 0 points 1 point 2 points 3 points</td> </tr> <tr> <td style="text-align: center;">1.3. Internal wall system</td> <td style="text-align: center;">Non-loading bearing internal walls will allow for changes to be made more easily to floor</td> <td>- Immovable interior walls, multiple functions - Immovable interior walls, temporary structures</td> <td style="text-align: center;">(x4.5) 0 points 1 point</td> </tr> </tbody> </table>		Adaptability design concept	Specific design aspect	How it contributes to adaptability	Scoring rules	(Weighting factor) and points	1. Changes to internal space distribution	1.1. Column grid spans	Wider column spans will allow for more flexible floor layouts.	Column spacing: - < 5400 mm - 5400 mm < 8100 mm - > 8100 mm - free span	(x1.5) 0 points 1 point 2 points 3 points	1.2. Façade pattern	Narrower bays will allow for more internal space configurations	Spacing between bays: - 1350 to >1800 mm - 1350-1800 mm - 1350-1800 mm + some 900-1350 mm - 900 - 1350 mm, some bays < 900 mm	(x1.5) 0 points 1 point 2 points 3 points	1.3. Internal wall system	Non-loading bearing internal walls will allow for changes to be made more easily to floor	- Immovable interior walls, multiple functions - Immovable interior walls, temporary structures	(x4.5) 0 points 1 point
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Core criteria		Comprehensive criteria		
TECHNICAL SPECIFICATIONS (TSs)				
		layouts.	<ul style="list-style-type: none"> - Movable interior walls, requires disassembly - Easily movable interior walls, partition system 	2 points 3 points
	1.4. Unit size and access	By ensuring that access/egress is possible for sub-divisions of the spaces, this will provide more sub-letting options.	Weighted average unit/floor plate size: <ul style="list-style-type: none"> - > 600 m² - 400 - 600 m² - 200 - 400 m² - < 200 m² 	(x3.0) 0 points 1 point 2 points 3 points
2. Changes to the routing or type of building services	2.1 Ease of access to service ducts	Access will be improved if services are not embedded in the building structure.	Location of key service ducts: <ul style="list-style-type: none"> - Embedded in the floor - Between 2 building layers - Above one building layer (floor) - Below one building layer (ceiling) 	(x1.5) 0 points 1 point 2 points 3 points
	2.2 Ease of access to plant rooms	Future changes of technical equipment will be facilitated if there is ease of access to plant rooms and equipment.	<ul style="list-style-type: none"> - Embedded in a sub-basement of the building - Located in a plant room on the roof or within an accessible patio - Located in a ground floor plant room with easy external access - Located external to the building with complete access 	(x1.5) 0 points 1 point 2 points 3 points
	2.3 Longitudinal ducts for service routes	The inclusion of longitudinal ducts will provide flexibility in the location of service points.	<ul style="list-style-type: none"> - Connection grid in 1 direction - Cable duct in 1 direction - Connection grid in 2 directions - Cable duct in 2 directions 	(x1.5) 0 points 1 point 2 points 3 points
	2.4 Higher ceilings for service routes	The use of greater ceiling heights will provide more flexibility in the routing of services.	Internal height (floor surface to ceiling surface): <ul style="list-style-type: none"> - < 3000 mm - 3000-3500 mm - 3500-4000 mm - > 4000 mm 	(x4.5) 0 points 1 point 2 points 3 points
	2.5 Services to sub-divisions	By ensuring that individual servicing for sanitary facilities is possible for sub-divisions of the spaces, this will provide more sub-letting options.	Weighted average unit/floor plate sub-division size that can be serviced: <ul style="list-style-type: none"> - > 600 m² - 400 - 600 m² - 200 - 400 m² - < 200 m² 	(x3.0) 0 points 1 point 2 points 3 points
	3. Changes to the building façade and structure	3.1 Non-load bearing facades	Non-load bearing facades will allow for changes to be made more easily to both internal layouts and external elements.	<ul style="list-style-type: none"> - Bearing facade with bearing obstacles - Bearing facade, no bearing obstacles - Non-bearing facade, bearing obstacles - Non-bearing facade, no bearing obstacles <i>Note: Examples of obstacles include bearing interior walls, columns, elevator shafts or installation ducts.</i>
3.2 Future-proofing of load bearing capacity		The incorporation of redundant load bearing capacity will support potential future changes in the building's façade and uses.	Variable capacity: <ul style="list-style-type: none"> - 1,75 kN/m² - 2,50 kN/m² - 4,00 kN/m² - 5,00 kN/m² 	(x4.5) 0 points 1 point 2 points 3 points
3.3 Structural design to support future expansion		Structural designs that have the vertical strength to support additional storeys will allow for future expansion of the floor area.	Capacity to add storeys: <ul style="list-style-type: none"> - 1 storey - 2 storey - 3 storeys - 4 or more storeys 	(x1.5) 0 points 1 point 2 points 3 points

Supporting rationale for TS2.3: this is grouped together with the rationale for TS 2.1, 2.2 and 2.4, presented at the end of TS2.4.

Working draft

2.4. Design for deconstruction

Core criteria				Comprehensive criteria			
TECHNICAL SPECIFICATIONS (TSs)							
<i>Note: The term “deconstruction” is generally defined in the Level(s) indicator 2.4 guidance as: “A process of selectively and systematically dismantling buildings to reduce the amount of waste created and generate a supply of high value secondary materials that are suitable for reuse and recycling.”</i>							
Design	Site prep.	Construction	Management	Design	Site prep.	Construction	Management
<p>TS2.4: Design for deconstruction</p> <p><i>Note: It is important that the scoring format for TS2.4 should match the inventory of materials and construction products from TS2.1. This indicator is relevant to new build projects only, although in principle, it could be applied to renovation projects if the scope for scoring is reduced to only renovated elements.</i></p> <p>The building design shall be accompanied by a design for deconstruction report that includes an inventory of the different building elements, components and materials used and how they could be disassembled or stripped and prepared for reuse, be recycled or be subject to material or energy recovery at the end of life of the building or the element, component or material.</p> <p>If no explanation is provided, then the building elements will be assumed to be disposal to landfill.</p> <p>Following the methodology defined in Level(s) indicator 2.4, a minimum circularity score of 40% by mass and 40% by cost shall be demonstrated.</p> <p>Verification:</p> <p>The designer shall provide a design for deconstruction report, supported by the Level(s) indicator 2.4 excel template with an inventory of building elements and the justified best practical outcome for each entry in the inventory.</p> <p>The circularity scoring should be an automatic output of the excel spreadsheet.</p> <p>The construction and completion of the design for deconstruction features by the contractor must also be verified.</p>				<p>TS2.4: Design for deconstruction</p> <p><i>Note: It is important that the scoring format for TS2.4 should match the inventory of materials and construction products from TS2.1. This indicator is relevant to new build projects only, although in principle, it could be applied to renovation projects if the scope for scoring is reduced to only renovated elements.</i></p> <p>The building design shall be accompanied by a design for deconstruction report that includes an inventory of the different building elements, components and materials used and how they could be disassembled or stripped and prepared for reuse, be recycled or be subject to material or energy recovery at the end of life of the building or the element, component or material.</p> <p>If no explanation is provided, then the building elements will be assumed to be disposal to landfill.</p> <p>Following the methodology defined in Level(s) indicator 2.4, a minimum circularity score of 60% by mass and 60% by cost shall be demonstrated.</p> <p>Verification:</p> <p>The designer shall provide a design for deconstruction report, supported by the Level(s) indicator 2.4 excel template with an inventory of building elements and the justified best practical outcome for each entry in the inventory.</p> <p>The circularity scoring should be an automatic output of the excel spreadsheet.</p> <p>The construction and completion of the design for deconstruction features by the contractor must also be verified.</p>			
<p><u>Explanatory note for TS2.4:</u></p> <p>The default scope for scoring for deconstruction should match the reporting format for TS2.1 mentioned earlier in this section.</p>							

Supporting rationale for TS2.1 to TS2.4:

Since TS2.1, 2.2, 2.3 and 2.4 essentially work together to reduce the embodied impacts of buildings along their life cycles, a common rationale is provided.

Environmental relevance: It is generally agreed that the construction sector accounts for highly significant quantities of waste generated in Europe (e.g. the new Circular Economy Action Plan cites a figure of around 35% of total European waste). Construction and Demolition Waste (CDW) is coming from the demolition of old buildings, the renovation of existing buildings and the construction of new buildings. Ranges of waste generation can also vary greatly depending on specifics of the site and project.

Technical specifications 2.1 to 2.4 can work together at the individual building project level to better understand how the life cycle embodied impacts of materials can be optimised. These criteria work together as follows:

- TS2.1 provides a standard data format and basis for the material quantities (mainly modules A1-A3 of the EN 15978 framework) involved for the initial construction and also for any planned replacement cycles during the projected building lifetime. This data can then inform embodied carbon, circularity scores and life cycle cost calculations.
- TS2.2 focuses on appropriate planning and execution of CDEW management during site preparation, construction and completion stages of the building project (modules A4-A5 of the EN 15978 framework). Waste inventories and outcomes are logged on a per shipment basis and automatically generate data for reuse, recycling, material recovery, energy recovery and disposal rates – both combined and split by material fraction. This latter aspect is especially important for informing future EU targets for recycling rates for specific material fractions.
- TS2.3 aims to lock in design features from the very beginning that will minimise or avoid altogether the need for disruptive future refurbishment works (module B5 of the EN 15978 framework) to adapt the building to future needs. It can also deliver important economic benefits for the building owner if parts of the unoccupied building can be converted into spaces for celebrating one-off events or for letting of spaces to other economic operators, individuals or families. Such flexibility can be factored into life cycle scenarios for the building and can have an important influence on life cycle costing.
- TS2.4 aims to lock in design features that maximise the recovery of building elements and materials at the end of the building life cycle. Elements that can be prepared for reuse can deliver substantial benefits in modules B2-B5, modules C1-C4 and D. This is especially the case when ensuring the reuse or recycling of high embodied energy materials like aluminium, steel and copper.

Policy relevance: The requirements covered by these specifications are in line with efforts to promote the whole life carbon assessment of buildings (e.g. Europe’s 2030 climate ambition, the Level(s) indicator 1.2 and both the climate change mitigation objective of the EU Taxonomy for the construction sector and real estate).

Of more direct relevance, these technical specifications support the CEAP goal to improve material efficiency in the building sector, go beyond existing requirements of the Waste Framework Directive (potentially helping to inform future waste targets) and are directly in line with Level(s) indicators 2.1 to 2.4. The circular economy objective of the EU Taxonomy for new construction of buildings could potentially cover some or all of these aspects although at the date of writing, screening criteria have not been published. Research under EU-funded projects into the Buildings As Material Banks (BAMB) concept is of direct relevance to TS2.4.

Market considerations: The contracting authority may prefer (or be obliged) to use Building Information Modelling (BIM) software to inventory the building elements and if so, the exact type of software or method should be stated. The potential advantage of BIM is not only for preventing information loss or miscommunication of information between designers, the construction team and the building owner/operator. The digitalised information will also help guarantee that design for deconstruction features are available to demolition contractors when the building finally reaches its end of life.

Separating different streams of CDW is all well and good but only if there are suitable reuse markets or recycling technologies that can process these streams and find applications demanding such recycled materials. It is not only the maturity level of such recycling technologies that is important, but also the regional availability of such facilities.

Why no absolute benchmark for CDW? Setting absolute benchmarks for CDW (e.g. in terms of kg/m²) was decided against because absolute numbers depend a lot on site specific and building specific factors. This applies both for new-build and renovation projects. A percentage-based approach ensures that a similar degree of effort can be applied in all relevant projects. A percentage-based approach brings the Waste Framework Directive targets directly to the level of the individual building project.

What do Green Building Rating Systems or other initiatives say?

(To be completed).

Targeted questions to stakeholders about TS2.1 to 2.4:

Q13: Should the inventory of building elements required in TS2.1 for technical systems, construction products and materials purchased exactly mirror the hierarchy of elements set out in the [International Cost Management Standard \(ICMS-3\)](#), which is used for costing building materials?

Q14: For TS2.2, how should the m2 be defined exactly? (e.g. usable internal floor area, gross internal floor area, how to deal with external floor areas like patios or balconies or other areas like underground parking?)

Q15: For TS2.2, would it reasonable to assume that all hazardous CDEW is disposed of? (i.e. not reused, recycled or subject to material recovery?).

Q16: Any suggestions on a scoring matrix for adaptability of residential buildings?

Q17: Do you think design for accessibility features, or ease of future adaptation for accessibility (i.e. for persons with disabilities), should be included in adaptability scoring? If so, how exactly?

Q18: Any good examples or case studies of adaptability features being specified in building designs?

Working draft

2.5. Operational waste management

Core criteria	Comprehensive criteria			
TECHNICAL SPECIFICATIONS (TSs)				
	Design	Site prep.	Construction	Management
	<p>TS2.5: Operational waste management</p> <p><i>Note: this criterion is especially relevant to educational buildings or office buildings where waste from large numbers of occupants can be collected and managed privately. It could in principle also be applied at community level for blocks of social housing.</i></p> <p>Routine waste production caused by occupant activity shall be collected and managed by the facility manager.</p> <p>The building(s) will be served by separated waste collection for the following fractions:</p> <ul style="list-style-type: none"> • Paper and cardboard; • Plastic containers (not tetra-paks); • Metal packaging and containers; • Coffee capsules; • Glass bottles (not mirror glass); • Food waste and garden waste; • Small waste electronic and electrical waste (e.g. separate collection of batteries, light bulbs, mobile phones, cables etc.); • Furniture; • Textiles, clothing and footwear; • Difficult-to-recycle, high calorific value wastes for making refuse derived fuel (e.g. tetra-paks, plastic film, wrappers and bags, used nappies, feminine care products, wet wipes, laminated paper, food-stained paper or cardboard, paper coffee cups etc.). <p>The collected waste fractions shall be brought to a central repository on the building site from where it will be weighed prior to periodic collection by or delivery to economic operators that have access to reuse markets (where relevant), recycling processes, composting or energy recovery processes for the relevant waste fractions.</p> <p>The building management shall collect data on the quantities of each waste fraction collected and provide annual reports of total and normalised (i.e. per occupant) waste production, recycling and recovery rates.</p> <p>Verification:</p> <p>A waste management plan shall be provided to the contracting authority that clearly explains the number and locations of waste containers, the economic operators involved and the final outcomes for the different collected waste fractions.</p> <p>Annual waste management reports shall be submitted by the building management to the</p>			

Supporting rationale for TS2.5:

The waste streams described in TS2.5 would normally end up in municipal waste streams. Depending on the municipality, containers to separately collect some of these waste streams for recycling may be in place. The overall aim of this criterion is two-fold:

- To provide a comprehensive waste separation collection system that maximises recycling opportunities and educates building occupants at the same time.
- To take responsibility for the quality of collected waste fractions by directly connecting to waste contractors who reuse, process and/or recycle these waste streams.

Environmental relevance:

To be completed, but this section will include a summary of more detailed information to be compiled in the background report about different recycling rates and LCA benefits of recycling, energy recovery and composting of different waste streams.

Policy relevance:

These requirements are directly relevant to the goals of the Circular Economy Action Plan. By diverting food waste, paper and cardboard in particular, the requirements are helping support the aim of the Landfill Directive to reduce quantities of biodegradable waste going to landfill as per Article 5 of that Directive. Another highly relevant goal of the Landfill Directive, following its 2018 amendment, is that by 2035, the quantity of municipal waste going to landfill must be less than 10% by weight. The requirements also present an important aspect of facilitating the collection of waste electrical and electronic equipment in the most convenient locations for occupants.

Market considerations:

The main disadvantage of kerb-side collection systems for post-consumer recyclates is that correctly separated materials are combined with incorrectly separated materials and then need to be separated again later on. Even when correctly segregated, the sheer diversity of plastic wastes (e.g. in terms of polymers, fillers, plasticisers and other additives) complicates separation by density and makes the closed loop recycling difficult to achieve.

Consequently, it is better to achieve the correct separation at source (in occupied buildings) and to take these correctly separated streams to waste operators who have suitable waste processing options available. In the case of plastic wastes, the high value plastic bottles (generally PET or PE) are clearly separated from composite materials such as tetra-paks, coffee cups, carrier bags and so on that would be complicated to recycle but which have a high calorific value suitable for energy recovery.

The separate collection of waste streams such as furniture, computers, clothing and footwear, due to their high value reuse potential, could be collected by or periodically donated to social enterprises or similar organisations.

What do Green Building Rating Systems or other initiatives say?

(To be completed).

Theme 3: Efficient use of water resources

All of the criteria under theme 3 contribute to reducing pressure on the abstraction of natural water resources. While efficient water use has environmental and economic benefits in all climate zones, it assumes a higher priority in areas that suffer from seasonal or permanent water stress.

3.1.1. Per capita potable water use

Core criteria				Comprehensive criteria			
TECHNICAL SPECIFICATIONS (TSs)							
<p>Note: Requirements under TS3.1.2, 3.1.3 and 3.1.4 can all contribute to good results in TS3.1.1. In order to set an appropriate benchmark, it is vital that the contracting authority states the assumed usage factors and that all tenderers work with the same assumed factors.</p>							
Design	Site prep.	Construction	Management	Design	Site prep.	Construction	Management
<p>TS3.1.1: Per person potable water consumption</p> <p>(i) At least 20% of estimated potable water demand of the sanitary fittings listed below shall be substituted by non-potable water (harvested rainwater or reused greywater).</p> <p>(ii) Considering the following usage factors and occupation rates, the per occupant potable water consumption shall not exceed X m³/occupant/yr.</p> <p>Residential buildings/ Office building/ Educational building usage factors:</p> <ul style="list-style-type: none"> • Toilet (full flush) X flushes/occupant/day • Toilet (small flush) X flushes/occupant/day • Wash basins: X min/occupant/day • Showers: X min/occupant/day • *Bathtub: X baths/occupant/day • Kitchen tap: X min/occupant/day • Average full time occupation: Y days/year <p>The applicant shall apply specific consumption rates of specified sanitary fittings and water using appliances wherever possible or use justifiable assumptions if not available.</p> <p>Any rainwater harvesting or greywater reuse systems shall also be factored into the calculation using the Level(s) methodology.</p> <p>Verification:</p> <p>The tenderer shall provide the contracting authority with an estimated average daily potable water consumption rate per occupant.</p> <p>This number shall have been calculated using the Level(s) indicator 3.1 excel-based calculation spreadsheet.</p> <p>A copy of the spreadsheet shall be provided, together with a declaration explaining any additional details and assumptions of the calculation that should be known by the contracting authority.</p>				<p>TS3.1.1: Per person potable water consumption</p> <p>(i) At least 35% of the estimated potable water demand of the sanitary fittings and water using appliances and irrigation listed below shall be substituted by non-potable water (harvested rainwater or reused greywater).</p> <p>(ii) Considering the following usage factors and occupation rates, the per occupant potable water consumption shall not exceed X m³/occupant/yr.</p> <p>Residential buildings/ Office building/ Educational building usage factors and occupation data:</p> <ul style="list-style-type: none"> • Toilet (full flush) X flushes/occupant/day • Toilet (small flush) X flushes/occupant/day • Wash basins: X min/occupant/day • Showers: X min/occupant/day • *Bathtub: X baths/occupant/day • Kitchen tap: X min/occupant/day • *Dishwasher: Y cycles/occupant/day • *Washing machine: Y cycles/occupant/day • Average irrigation rate: Z litres/day • Average number of full time occupants: X • Average full time occupation: Y days/year <p><i>*For residential buildings only.</i></p> <p>The applicant shall apply specific consumption rates of specified sanitary fittings and water using appliances wherever possible or use justifiable assumptions if not available.</p> <p>Any rainwater harvesting or greywater reuse systems shall also be factored into the calculation using the Level(s) methodology.</p> <p>Verification:</p> <p>The tenderer shall provide the contracting authority with an estimated average daily potable water consumption rate per occupant.</p> <p>This number shall have been calculated using the Level(s) indicator 3.1 excel-based calculation</p>			

Core criteria	Comprehensive criteria
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TECHNICAL SPECIFICATIONS (TSs)

Note: Requirements under TS3.1.2, 3.1.3 and 3.1.4 can all contribute to good results in TS3.1.1. In order to set an appropriate benchmark, it is vital that the contracting authority states the assumed usage factors and that all tenderers work with the same assumed factors.

	<p>spreadsheet.</p> <p>A copy of the spreadsheet shall be provided, together with a declaration explaining any additional details and assumptions of the calculation that should be known by the contracting authority.</p>
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Explanatory note for TS3.1.1:

This criterion applies at the design stage. However, if contracting authorities wish to check real life performance against design estimates, they should verify the actually installed sanitary fittings and water using appliances and also monitor occupancy rates and user behaviour, because these will influence the data on real meter readings and per person consumption rates.

The automatically generated output format from the Level(s) excel-based calculation spreadsheet shown below (numbers purely indicative and for example only) should be the basis for deciding on the preferred design option in terms of per person potable water consumption.

Example output for residential buildings:

Summer WEI+ =	4.09	Total Water Consumption (m ³ /o/a)	Of which potable (m ³ /o/a)	Of which non-potable (m ³ /o/a)
Sanitary fittings and devices (e.g. toilets, taps, baths and showers).	Toilets	8.54	0.00	8.54
	Bathroom taps	4.19	4.19	0.00
	Showers	24.12	24.12	0.00
	Bath-tub	6.82	6.82	0.00
	Kitchen taps	16.08	16.08	0.00
	Sub-Total	59.75	51.20	8.54
Water using appliances (e.g. dishwashers and washing machines).	Dishwashers	1.54	1.54	0.00
	Washing machines	4.37	4.37	0.00
	Sub-Total	5.91	5.91	0.00
Irrigation	Irrigation	11.49	0.00	11.49
TOTAL (m³/o/a)		77.15	57.12	20.04
TOTAL (%)		100	74.0	26.0

Example output for non-residential buildings:

Summer WEI+ =	4.09	Total Water Consumption (m ³ /o/a)	Of which potable (m ³ /o/a)	Of which non-potable (m ³ /o/a)
Sanitary fittings and devices (e.g. toilets, taps, baths and showers).	Toilets & urinals	3.75	0.00	3.75
	Bathroom taps	1.88	1.88	0.00
	Showers	1.50	1.50	0.00
	Kitchenette taps	1.50	1.50	0.00
	Sub-Total	8.63	4.88	3.75
Cleaning	Floor cleaning	0.16	0.16	0.00
	Window cleaning	0.02	0.02	0.00
	Sub-Total	0.17	0.17	0.00

Core criteria		Comprehensive criteria		
TECHNICAL SPECIFICATIONS (TSs)				
<i>Note: Requirements under TS3.1.2, 3.1.3 and 3.1.4 can all contribute to good results in TS3.1.1. In order to set an appropriate benchmark, it is vital that the contracting authority states the assumed usage factors and that all tenderers work with the same assumed factors.</i>				
Irrigation	Irrigation	11.49	0.00	11.49
Other uses (e.g. fountains, swimming pools, HVAC etc.)	Other-1 (please specify)	0.00	0.00	0.00
	Other-2 (please specify)	0.00	0.00	0.00
	Other-3 (please specify)	0.00	0.00	0.00
	Sub-Total	0.00	0.00	0.00
	TOTAL (m³/o/a)	20.29	5.05	15.24
	TOTAL (%)	100	24.9	75.1
<p>The summer WEI+ stands for the Water Exploitation Index and for buildings in river catchments with a summer WEI+ value >20, it is recommended that the comprehensive level criteria be applied. These values can also be obtained from the Level(s) excel-based calculation spreadsheet for indicator 3.1.</p>				

Supporting rationale for TS3.1.1: this is grouped together with the rationale for TS 3.1.2, 3.1.3 and 3.1.4, presented at the end of TS3.1.4.

3.1.2. Water efficient devices and appliances

Core criteria				Comprehensive criteria			
TECHNICAL SPECIFICATIONS (TSs)							
Design	Site prep.	Construction	Management	Design	Site prep.	Construction	Management
<p>TS3.1.2: Water efficient devices and appliances.</p> <p>The following water consuming sanitary fittings installed in the new or renovated building shall be compliant with requirements of any relevant EN standards and have specific consumption rates not exceeding the following limits:</p> <ul style="list-style-type: none"> - Wash hand basin taps: ≤ 6 litres/min; - Kitchen taps: ≤ 6 litres/min; - Showerheads: ≤ 8 litres/min; - Manual flush urinals: ≤ 1 litre/flush - Automatic flush urinals: ≤ 2 litres/bowl/hr; - Water Closets (WCs), including suites, bowls and flushing cisterns: maximum average flush volume* ≤ 3.75 litres. <p><i>*The maximum average flush volume for dual flush toilets is the result of ((1x full flush volume)+(3x small flush)) divided by 4.</i></p> <p>Verification:</p> <p>The contractor shall provide invoices of the water consuming sanitary fittings that are to be installed and any relevant information about the performance class of the fitting that corresponds to its specific water consumption rate in line with testing conditions specified by relevant EN standards.</p> <p>More precise information should also be provided by a declaration of specific water consumption rate from the manufacturer and ideally a water label for the product, such as the Unified Water Label, or via a declaration from the manufacturer that is supported by relevant reports based on EN or ISO methods at standard temperature and pressure.</p> <p>The contractor shall guarantee that all plumbing connections and drains are compliant with regional building codes and overarching EN standards.</p>				<p>TS3.1.2: Water efficient devices and appliances.</p> <p>The following water consuming sanitary fittings installed in the new or renovated building shall be compliant with requirements of any relevant EN standards and have specific consumption rates not exceeding the following limits:</p> <ul style="list-style-type: none"> - Wash hand basin taps: ≤ 4 litres/min; - Kitchen taps: ≤ 5 litres/min; - Showerheads: ≤ 7.5 litres/min; - Manual flush urinals: ≤ 0.5 litre/flush - Automatic flush urinals: ≤ 1 litres/bowl/hr; - Water Closets (WCs), including suites, bowls and flushing cisterns: maximum average flush volume* ≤ 3.75 litres. <p><i>*The maximum average flush volume for dual flush toilets is the result of ((1x full flush volume)+(3x small flush)) divided by 4.</i></p> <p>Verification:</p> <p>The contractor shall provide invoices of the water consuming sanitary fittings that are to be installed and any relevant information about the performance class of the fitting that corresponds to its specific water consumption rate in line with testing conditions specified by relevant EN standards.</p> <p>More precise information should also be provided by a declaration of specific water consumption rate from the manufacturer and ideally a water label for the product, such as the Unified Water Label, or via a declaration from the manufacturer that is supported by relevant reports based on EN or ISO methods at standard temperature and pressure.</p> <p>The contractor shall guarantee that all plumbing connections and drains are compliant with regional building codes and overarching EN standards.</p>			

Supporting rationale for TS3.1.2: this is grouped together with the rationale for TS 3.1.1, 3.1.3 and 3.1.4, presented at the end of TS3.1.4.

3.1.3. Rainwater harvesting systems

Core criteria				Comprehensive criteria			
TECHNICAL SPECIFICATIONS (TSs)							
<i>Note: This criterion becomes more relevant for sites where roof areas and annual rainfalls are higher. Before specifying this criterion, the contracting authority should be certain that adequate volume will be available for underground storage of harvested rainwater.</i>							
Design	Site prep.	Construction	Management	Design	Site prep.	Construction	Management
<p>TS3.1.3: Rainwater harvesting systems.</p> <p>The building design shall include a rainfall harvesting system that captures rainfall from roof areas and any designated paved areas following EN 16941-1 design principles.</p> <p>The harvested rainwater shall be used for irrigation and toilet flushing and be supported by a potable water back-up supply for extended dry periods.</p> <p>The rainwater storage capacity shall be designed to cope with a typical 15 day dry period.</p> <p>System maintenance shall form part of the routine maintenance of all plumbing systems in the building.</p> <p>Verification:</p> <p>The design team shall submit calculations and technical drawings of the rainwater harvesting system that demonstrate how it complies with the requirements of TS3.1.3.</p> <p>The installed system shall be checked for compliance with the design details and any other requirements of EN 16941-1.</p>				<p>TS3.1.3: Rainwater harvesting systems.</p> <p>The building design shall include a rainfall harvesting system that captures rainfall from roof areas and any designated paved areas following EN 16941-1 design principles.</p> <p>The harvested rainwater shall be used for irrigation and toilet flushing and be supported by a potable water back-up supply for extended dry periods.</p> <p>The rainwater storage capacity shall be designed to cope with a typical 21 day dry period.</p> <p>The overflow of rainwater shall be channelled to artificial rainwater runoff storage or infiltration systems or directly to the local watercourse wherever this is possible instead of channelling overflows to the sewer system.</p> <p>The flows of filtered rainwater and potable water back-up supply flows into the rainwater storage system, as well as normal flows out of the storage system, shall be metered.</p> <p>System maintenance shall form part of the routine maintenance of all plumbing systems in the building.</p> <p>Verification:</p> <p>The design team shall submit calculations and technical drawings of the rainwater harvesting system that demonstrate how it complies with the requirements of TS3.1.3.</p> <p>The installed system shall be checked for compliance with the design details and any other requirements of EN 16941-1.</p> <p>The building manager shall routinely record flows into and out of the rainfall storage system (including storage tank levels and overflow events), match this with local rainfall data, and periodically (e.g. once per year) report on system performance and potable water savings achieved.</p>			

Supporting rationale for TS3.1.3: this is grouped together with the rationale for TS 3.1.1, 3.1.2 and 3.1.4, presented at the end of TS3.1.4.

3.1.4. Greywater reuse systems

Core criteria				Comprehensive criteria			
TECHNICAL SPECIFICATIONS (TSs)							
<i>Note: This criterion is equally relevant for all buildings in all climate zones.</i>							
Design	Site prep.	Construction	Management	Design	Site prep.	Construction	Management
<p>TS3.1.4: Greywater reuse systems.</p> <p>The building design shall include a greywater reuse system that captures "light greywater" (from showers, bathtubs and wash basins) following prEN 16941-2 design principles.</p> <p>The light greywater shall be used for toilet flushing and be supported by a potable water or harvested rainwater back-up supply.</p> <p>The greywater storage capacity shall be sized to account for 50% of daily estimated greywater demand (i.e. 50% of daily estimated toilet flushing volumes).</p> <p>Any excess greywater shall overflow to the drains for blackwater from toilet flushing.</p> <p>System maintenance shall form part of the routine maintenance of all plumbing systems in the building.</p> <p>Verification:</p> <p>The design team shall submit calculations and technical drawings of the greywater reuse system that demonstrate how it complies with the requirements of TS3.1.4.</p> <p>The installed system shall be checked for compliance with the design details and any other requirements of prEN 16941-2.</p>				<p>TS3.1.4: Greywater reuse systems.</p> <p>The building design shall include a greywater reuse system that captures greywater from showers, bathtubs, wash basins, washing machines, kitchen sinks and dishwashers, following prEN 16941-2 design principles.</p> <p>The greywater shall be used for toilet flushing as a priority and then for subsurface irrigation of planted reed-beds on or next to the building site. The system shall be supported by a potable water or harvested rainwater back-up supply.</p> <p>The greywater storage capacity shall be sized to account for 50% of daily estimated greywater demand (i.e. 50% of daily estimated toilet flushing and reed-bed irrigation volumes).</p> <p>Any excess greywater shall be channelled through planted reed beds, which will then drain to artificial rainwater runoff storage, or to infiltration systems or to the drains for blackwater from toilet flushing.</p> <p>The flows of reused greywater and potable water or rainwater back-up supply flows into the greywater storage system, as well as normal flows out of the storage system, shall be metered.</p> <p>System maintenance shall form part of the routine maintenance of all plumbing systems in the building.</p> <p>Verification:</p> <p>The design team shall submit calculations and technical drawings of the greywater reuse system that demonstrate how it complies with the requirements of TS3.1.4.</p> <p>The installed system shall be checked for compliance with the design details and any other requirements of prEN 16941-2.</p> <p>The building manager shall routinely record flows into and out of the greywater reuse system (including storage tank levels and overflow events), match this with occupancy data, and periodically (e.g. once per year) report on system performance and potable water savings achieved.</p>			

Supporting rationale for TS3.1.1 to 3.1.4:

Environmental relevance:

Around 21% of all water abstracted in the EU is used for public supply, the majority of which is used in buildings. On average, each EU citizen directly uses 160 L/day of water. The trend towards larger urban

populations is placing more pressure on water supply in urban areas. Water consumption is also an operational cost to building owners/users.

Reducing water consumption will reduce the embodied environmental impacts of delivering water to the point of demand (i.e. from water abstraction, treatment and pumping through the distribution network). In the case of hot water, better efficiency also delivers significant energy savings for consumers. A more efficient use of water will reduce pressure on freshwater resources, especially in river basins that experience continual or seasonal water scarcity. In areas where desalination is necessary for water supply (especially in southern Europe), the cost and environmental benefits of efficient water use are significantly higher because much more energy is needed to desalinate brackish water or sea water than to simply treat freshwater.

Policy relevance:

The EU Taxonomy, in the do no significant harm criteria for climate change mitigation (and adaptation) for new construction and renovation of buildings, has set minimum requirements for the efficiency of a number of different fittings and sanitary appliances. These EU Taxonomy requirements form the basis of the core level criteria proposal for TS3.1.1.

The Level(s) framework allows for a more holistic approach to be taken to minimising final potable water demand. Final results can be influenced by the use of rainwater harvesting (TS3.1.2) and greywater reuse (TS3.1.3), as well as the efficiency of fittings and appliances (TS3.1.1). All of these factors are brought together in a bespoke, excel-based calculator for Level(s) indicator 3.1, and so TS3.1.4 in the GPP criteria aligns with the Level(s) reporting format.

Market considerations:

The use of a voluntary label (e.g. the Unified Water Label or the European Water Label) can help contractors to easily identify and purchase products that meet the specifications in TS3.1.1. The level of expertise and experience in rainwater harvesting systems and greywater reuse systems may vary significantly from one Member State to another.

While the usefulness of rainwater harvesting systems will vary a lot from one project to another, it could also form an integral part of sustainable drainage systems linked to larger areas beyond the building plot. With greywater reuse, these systems can deliver benefits in any building and there is no reason not to do this in all new buildings and to renovate into existing buildings, especially in water scarce areas.

What do Green Building Rating Systems or other initiatives say?

(To be completed).

Targeted questions to stakeholders about TS3.1.1 to 3.1.4:

Q19: Can you share any national or regional level building regulations that specify upper limits on the water efficiency of sanitary fittings or appliances, rainwater harvesting or greywater reuse?

Q20: Are you aware of any accurate (and relatively recent) data reporting per capita water consumption rates in buildings? Ideally by building type (e.g. residential, office and school).

Q21: Would you be able to provide more information on good practice for irrigation systems in the EU?

Theme 4: Occupant comfort and health

Although there are clear social benefits from the criteria set out under theme 4, all of the criteria are directly or indirectly linked to environmental impacts, and thus merit a place in EU GPP criteria. The general concept of pollution means the presence of unnaturally high contaminants that can cause harm to exposed biological organisms. However, while this is well understood for many chemicals and well-defined exposure pathways such as skin contact, ingestion, inhalation, it is only recently that the more subtle health impacts of exposure to unnatural levels and forms of sound, light and other electromagnetic radiation are being recognised.

The requirements on indoor air quality, thermal comfort, lighting and, to a lesser extent, acoustics, all have some degree of inter-connection. For example, higher ventilation rates can mean cleaner air but also larger volumes of air to heat or cool. If ventilation is achieved passively by window opening, this energy saving will come at the cost of bringing in background noise from the surrounding environment and any unfiltered environmental pollutants present in the ambient air. If windows are made larger to increase daylighting and reducing the energy consumption of electric lighting systems, this will increase the risk of excessive solar gain and thus overheating in summer.

The optimisation of these four parameters all rely on a good knowledge of the expected occupation patterns, occupant activities and the surrounding environmental conditions. Consequently, dynamic modelling efforts and the same expected occupancy patterns should be shared between different specialists working on these aspects of building design optimisation to reflect client priorities.

4.1. Indoor air quality

Core criteria				Comprehensive criteria			
TECHNICAL SPECIFICATIONS (TSs)							
<p><i>Note: All of the design and construction phase criteria under theme 4 are applicable to the construction of new buildings, but individual judgement of the contracting authority shall be required before deciding if and how they should be applied in renovation projects.</i></p> <p><i>For all criteria under theme 4, it is vital that the contracting authority provides tenderers with a planned occupancy schedule, so that they can tailor the design and any modelling to this occupancy pattern.</i></p> <p><i>For criterion 4.1.1 and in the case of school and office buildings in particular, the contracting authority should provide a preliminary assessment of the ambient air quality in the surrounding environment shall be conducted in order to determine what type of filter would be most suitable for intakes of ventilation systems.</i></p>							
Design	Site prep.	Construction	Management	Design	Site prep.	Construction	Management
<p>TS4.1.1: Ventilation system performance.</p> <p><i>For residential buildings</i></p> <p>Passive design features should be incorporated that allow for occupant adjustable openings on different sides and at different heights of the building envelope to provide cross-ventilation by natural pressure or temperature gradients.</p> <p><i>For school and office buildings:</i></p> <p>The building shall be designed with a hybrid approach of passive and mechanical ventilation. Passive ventilation shall provide for the baseline ventilation needs of the building while the mechanical system will be able to deliver higher ventilation rates for defined areas as and when needed.</p> <p>The design should aim to maintain indoor CO2 concentrations within 800 ppm above the outdoor CO2 level.</p> <p>The need for additional ventilation will be triggered automatically by feedback from installed CO2 sensors.</p> <p>The correct construction and installation of the</p>				<p>TS4.1.1: Ventilation system performance.</p> <p><i>For residential buildings</i></p> <p>Passive design features should be incorporated that allow for occupant adjustable openings on different sides and at different heights of the building envelope to provide cross-ventilation by natural pressure or temperature gradients.</p> <p>The total openable window area (m²) shall be at least 4% of the space that can be occupied (m²).</p> <p><i>For school and office buildings:</i></p> <p>The building shall be designed with a hybrid approach of passive and mechanical ventilation. Passive ventilation shall provide for the baseline ventilation needs of the building while the mechanical system will be able to deliver higher ventilation rates for defined areas as and when needed.</p> <p>The design should aim to maintain indoor CO2 concentrations within 550 ppm above the outdoor CO2 level.</p> <p>The need for additional ventilation will be triggered automatically by feedback from installed CO2</p>			

Core criteria	Comprehensive criteria				
TECHNICAL SPECIFICATIONS (TSs)					
<p><i>Note: All of the design and construction phase criteria under theme 4 are applicable to the construction of new buildings, but individual judgement of the contracting authority shall be required before deciding if and how they should be applied in renovation projects.</i></p> <p><i>For all criteria under theme 4, it is vital that the contracting authority provides tenderers with a planned occupancy schedule, so that they can tailor the design and any modelling to this occupancy pattern.</i></p> <p><i>For criterion 4.1.1 and in the case of school and office buildings in particular, the contracting authority should provide a preliminary assessment of the ambient air quality in the surrounding environment shall be conducted in order to determine what type of filter would be most suitable for intakes of ventilation systems.</i></p>					
<p>ventilation system(s) and of building elements especially relevant to predicted ventilation performance shall be ensured by the project manager during the construction and installation stages.</p> <p>Verification:</p> <p>For residential buildings, the design team shall highlight the passive ventilation features in technical drawings and explain how they operate in principle.</p> <p>For office and educational buildings, the preliminary assessment of ambient air quality shall report at least on levels of particular matter (PM₁₀ and PM_{2.5}) to provide outdoor air quality (ODA) ratings for particulate matter (P). The specific location of air intake(s), and any aspects that would reduce the potential of particulate matter to enter in the first place shall also be explained.</p> <p>Tenderers shall commit to providing a hybrid ventilation system that can maintain category II indoor air quality in line with the method 2 approach (based on CO₂ concentrations) defined in EN 16798-1. The filtration system shall be able to remove particulate material to meet category II supply air or better (SUP 2 or SUP 1) as per EN 16798-3.</p> <p>The design team shall provide details of the ventilation system capacity, calculations and control logic and which, when matched with the occupancy patterns provided by the contracting authority, demonstrate that the system is capable of maintaining CO₂ levels within the desired limits of 800ppm above background.</p>	<p>sensors.</p> <p>At least 75% of the regularly occupied spaces shall have operable windows that provide access to outdoor air.</p> <p>The correct construction and installation of the ventilation system(s) and of building elements especially relevant to predicted ventilation performance shall be ensured by the project manager during the construction and installation stages.</p> <p>Verification:</p> <p>For residential buildings, the design team shall highlight the passive ventilation features in technical drawings and explain how they operate in principle. Technical drawings shall be provided that identify and measure the openable window area and the total usable floor area.</p> <p>For office and educational buildings, the preliminary assessment of ambient air quality shall report on levels of particular matter (PM₁₀ and PM_{2.5}) and gaseous pollutants (SO_x, NO_x, ozone and benzene) to provide outdoor air quality (ODA) ratings for particulate matter (P) and gaseous pollutants (G). The specific location of air intake(s), and any aspects that would reduce the potential of particulate matter or gaseous pollutants to enter in the first place shall also be explained.</p> <p>Tenderers shall commit to providing a hybrid ventilation system that can maintain category II indoor air quality in line with the method 2 approach (based on CO₂ concentrations) defined in EN 16798-1. The filtration system shall be able to remove particulate material to meet category II supply air or better (SUP 2 or SUP 1) as per EN 16798-3. The filtration system shall also reduce gaseous pollutants present in intake air if the ODA is rated as ODA(G) 2 or ODA(G) 3.</p> <p>The design team shall provide details of the ventilation system capacity, calculations and control logic and which, when matched with the occupancy patterns provided by the contracting authority, demonstrate that the system is capable of maintaining CO₂ levels within the desired limits of 550ppm above background.</p>				
	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 25%;">Design</td> <td style="width: 25%;">Site prep.</td> <td style="width: 25%;">Construction</td> <td style="width: 25%;">Management</td> </tr> </table>	Design	Site prep.	Construction	Management
Design	Site prep.	Construction	Management		

Core criteria				Comprehensive criteria			
TECHNICAL SPECIFICATIONS (TSs)							
<p><i>Note: All of the design and construction phase criteria under theme 4 are applicable to the construction of new buildings, but individual judgement of the contracting authority shall be required before deciding if and how they should be applied in renovation projects.</i></p> <p><i>For all criteria under theme 4, it is vital that the contracting authority provides tenderers with a planned occupancy schedule, so that they can tailor the design and any modelling to this occupancy pattern.</i></p> <p><i>For criterion 4.1.1 and in the case of school and office buildings in particular, the contracting authority should provide a preliminary assessment of the ambient air quality in the surrounding environment shall be conducted in order to determine what type of filter would be most suitable for intakes of ventilation systems.</i></p>							
				<p>TS4.1.2: In-situ monitoring and feedback control of ventilation performance:</p> <p>The building ventilation system shall be wired to a segregated power circuit, if separate from the heating and air conditioning system. If not, then the ventilation system should share the same segregated power circuit for the heating and air conditioning system.</p> <p>Real-time CO₂ concentration monitoring should provide data that is both visible to building occupants and can trigger mechanical ventilation to increase or decrease when reaching defined setpoints for the whole building or for defined zones. The CO₂ data shall be logged, together with mechanical ventilation energy consumption, via a building energy management system.</p> <p>The designer shall provide clear installation instructions and further instructions about the routine operation and maintenance of the ventilation system.</p> <p>Verification:</p> <p>The design team shall provide a brief description of the HVAC system design and control philosophy that is sufficiently detailed, together with:</p> <ul style="list-style-type: none"> • installation instructions, • an explanation of how the controls and sensors can be installed, programmed and adjusted • an operation manual and maintenance instructions. <p>Details of suppliers or manufacturers shall be provided for any future procurement of spare parts or specialised inspections, software updates or CO₂ sensor calibration etc.</p> <p>The building manager shall provide periodic (e.g. once per year) reports about the specific energy consumption trends and performance of the ventilation system, in units of kWh/m²/year for the whole building and for any defined sub areas of interest. This report should be complemented by trends in indoor CO₂ levels and the results of an annual occupant satisfaction survey in line with EN ISO 7730.</p>			
Design	Site prep.	Construction	Management	Design	Site prep.	Construction	Management
TS4.1.3: Low Volatile Organic Compound (VOC)				TS4.1.3: Low Volatile Organic Compound (VOC)			

Core criteria				Comprehensive criteria			
TECHNICAL SPECIFICATIONS (TSs)							
<p><i>Note: All of the design and construction phase criteria under theme 4 are applicable to the construction of new buildings, but individual judgement of the contracting authority shall be required before deciding if and how they should be applied in renovation projects.</i></p> <p><i>For all criteria under theme 4, it is vital that the contracting authority provides tenderers with a planned occupancy schedule, so that they can tailor the design and any modelling to this occupancy pattern.</i></p> <p><i>For criterion 4.1.1 and in the case of school and office buildings in particular, the contracting authority should provide a preliminary assessment of the ambient air quality in the surrounding environment shall be conducted in order to determine what type of filter would be most suitable for intakes of ventilation systems.</i></p>							
<p>emission construction materials.</p> <p>For any construction products or materials that can be expected to contribute to VOC emissions (e.g. ceiling tiles, paints and varnishes, textile floor and wall coverings, wooden floor and wall coverings, laminate and flexible floor coverings and insulation materials) shall have been tested for VOC emissions and meet the requirements below:</p> <ul style="list-style-type: none"> • Formaldehyde: $\leq 60 \mu\text{g}/\text{m}^3$ chamber air • Individual carcinogenic 1A and 1B VOCs (except formaldehyde and acetaldehyde): $\leq 1 \mu\text{g}/\text{m}^3$ chamber air. <p><i>*After 28 days and according to EN 16516 and ISO 16000 standards.</i></p> <p>The project manager shall check that the correct low VOC emission products and materials are actually purchased and installed during the construction and installation stages.</p> <p>Verification:</p> <p>The design team shall specify materials that comply with the VOC emission requirements above, as per testing according to the EN 16516 and ISO 16000 standards.</p> <p>If compliance with emissions limits can be demonstrated before 28 days in the test chamber, then results from shorter tests may be accepted.</p> <p>Products carrying a third party verified VOC emission label or ISO Type I ecolabel shall also be deemed to comply so long as the relevant criteria behind these labels guarantee emissions to be lower than those stated above.</p> <p>If it is not possible to find products on the market meeting these criteria, the use of alternative materials or exemptions to this requirement should be discussed with the contracting authority.</p>				<p>emission construction materials.</p> <p>For any construction products or materials that can be expected to contribute to VOC emissions (e.g. ceiling tiles, paints and varnishes, textile floor and wall coverings, wooden floor and wall coverings, laminate and flexible floor coverings and insulation materials) shall have been tested for VOC emissions and meet the requirements below:</p> <ul style="list-style-type: none"> • Total VOCs: $<1000 \mu\text{g}/\text{m}^3$ chamber air • Total SVOCs $<100 \mu\text{g}/\text{m}^3$ chamber air • Formaldehyde: $\leq 60 \mu\text{g}/\text{m}^3$ chamber air • Individual carcinogenic 1A and 1B VOCs (except formaldehyde and acetaldehyde): $\leq 1 \mu\text{g}/\text{m}^3$ chamber air. <p><i>*After 28 days and according to EN 16516 and ISO 16000 standards.</i></p> <p>The project manager shall check that the correct low VOC emission products and materials are actually purchased and installed during the construction and installation stages.</p> <p>Verification:</p> <p>The design team shall specify materials that comply with the VOC emission requirements above, as per testing according to the EN 16516 and ISO 16000 standards.</p> <p>If compliance with emissions limits can be demonstrated before 28 days in the test chamber, then results from shorter tests may be accepted.</p> <p>Products carrying a third party verified VOC emission label or ISO Type I ecolabel shall also be deemed to comply so long as the relevant criteria behind these labels guarantee emissions to be lower than those stated above.</p> <p>If it is not possible to find products on the market meeting these criteria, the use of alternative materials or exemptions to this requirement should be discussed with the contracting authority.</p>			
Design	Site prep.	Construction	Management	Design	Site prep.	Construction	Management
<p>TS4.1.4: Access to fresh air spaces</p> <p>The building design will such that:</p> <p>For office buildings:</p> <ul style="list-style-type: none"> • Each building floor will have access to open air terraces for occupants. 				<p>TS4.1.4: Access to fresh air spaces</p> <p>The building design will such that:</p> <p>For office buildings:</p> <ul style="list-style-type: none"> • Each building floor will have access to open air terraces for occupants. 			

Core criteria	Comprehensive criteria
TECHNICAL SPECIFICATIONS (TSs)	
<p><i>Note: All of the design and construction phase criteria under theme 4 are applicable to the construction of new buildings, but individual judgement of the contracting authority shall be required before deciding if and how they should be applied in renovation projects.</i></p> <p><i>For all criteria under theme 4, it is vital that the contracting authority provides tenderers with a planned occupancy schedule, so that they can tailor the design and any modelling to this occupancy pattern.</i></p> <p><i>For criterion 4.1.1 and in the case of school and office buildings in particular, the contracting authority should provide a preliminary assessment of the ambient air quality in the surrounding environment shall be conducted in order to determine what type of filter would be most suitable for intakes of ventilation systems.</i></p>	
<p>For residential buildings:</p> <ul style="list-style-type: none"> Individual houses shall each have a private garden section for occupants or, if plot area constraints prevent this, a rooftop terrace and/or balconies of at least 12m² per house shall be included in the design. Apartment blocks shall be designed to provide outdoor terraces/balconies of at least 12m² per apartment for each individual apartment unit (or patio area for ground floor apartments). <p>Verification:</p> <p>The design team shall provide technical drawings of the building layout, highlighting the spaces that provide open air access for occupants.</p> <p>The open air spaces may optionally be equipped with fittings that allow for its partial enclosure to shelter from rainfall or strong winds or for privacy purposes.</p>	<p>For residential buildings:</p> <ul style="list-style-type: none"> Individual houses shall each have a private garden section for occupants or, if plot area constraints prevent this, a rooftop terrace and/or balconies of at least 20m² per house shall be included in the design. Apartment blocks shall be designed to provide outdoor terraces/balconies of at least 20m² per apartment for each individual apartment unit (or patio area for ground floor apartments). <p>Verification:</p> <p>The design team shall provide technical drawings of the building layout, highlighting the spaces that provide open air access for occupants.</p> <p>The open air spaces may optionally be equipped with fittings that allow for its partial enclosure to shelter from rainfall or strong winds or for privacy purposes.</p>

Supporting rationale for technical specifications 4.1.1, 4.1.2 and 4.1.3:

Health and wellbeing benefits:

Good quality indoor air is paramount to occupant health and wellbeing. To optimise air quality inside buildings, it is first necessary to consider what types of pollutants are most common and where they come from. The most common sources are:

- Outdoor particulate matter, which can come from a variety of sources, of which vehicle fuel combustion is normally the most significant. Pollen from plants can also be seasonally significant.
- Indoor particulate matter, which can come from any combustion processes taking place indoors, or from the dispersion of dust particles that have diverse origins (e.g. dead skin cells from occupants, hair, textile fibres lost by friction of clothes or carpets, paper shredding and so on).
- Outdoor gaseous pollutants, especially NO_x, SO_x, ozone and benzene, which are strongly related to fuel consumption in vehicles.
- Volatile organic compounds (VOCs), especially from interior construction materials and furnishings that have been treated with formaldehyde resins, from painted walls, varnished floors and so on. More dynamic sources of VOCs are from cleaning products, preparation and consumption of food and beverages and bio-effluents due to occupant metabolic processes.
- Radon, mainly sourced from radioactive decay of Radium present in the underlying bedrock. Because Radon is a gas and comes from the ground underneath, the potential build up above background levels is most likely in poorly ventilated basement floors. A potential interior source of Radon emissions could be certain construction materials that use clays, granite, blast furnace slag or phosphogypsum.

The use of natural ventilation has been reported to have a better effect on occupant wellbeing than purely mechanically ventilated buildings and can have a benefit on occupant productivity (Wargoeki et al., 2000; Nazaroff, 2013; Horr et al., 2016).

It can be argued that buildings with high occupation densities are efficiently used, but one of the trade-offs of such intense use will be the need to increase ventilation rates. In order to minimise additional energy consumption, the potential contribution of passive ventilation via openable windows should be maximised wherever possible (subject to potential constraints of pollution in ambient air and outdoor noise).

The choice of CO₂ as the method for controlling ventilation rates was considered as the best approach since the massive shift to teleworking and online classes for students means that traditional approaches to ventilation may deliver unnecessarily high ventilation rates on many occasions. By having a ventilation system that is responsive in real time, excessive ventilation is avoided and extra ventilation can be delivered where and when it is needed in extreme occupancy situations. This level of dynamic control may be essential in helping building managers justify lower COVID-related restrictions on occupancy rates or to allow workers to share indoor spaces without wearing masks.

What are the relevant policies and standards?

It is worth noting the European Collaborative Action “Urban Air, Indoor Environment and Human Exposure”, which is a decades long effort to bring together experts from different fields in order to understand how best to provide healthy and environmentally sustainable buildings.

Within this action, Report No 30 (Carrer et al., 2020) is particularly relevant due to its subject matter and recent publication. The authors explain how building regulations in different European countries can show a factor of 4 or a factor of 6 difference in specific ventilation rates for residential and school buildings respectively. The report also explains clearly how different occupation rates (m²/person) and different per person ventilation rates (L/second/person) affect the equilibrium CO₂ level in the occupied space.

The main EN standards relating to ventilation systems are the EN 16798 series relating to design parameters and also the EN ISO 16890 series of standards relating to air filter specifications and performance.

Supporting rationale for technical specifications 4.1.4:

The effect of access to outdoor spaces on occupant wellbeing was brought into sharp focus during the lockdown restrictions that were implemented by governments in many countries in response to the COVID outbreak.

Even during normal times when people can freely access public spaces, the benefits of having convenient access to outdoor space brings multiple benefits for occupants, which include:

- Ability to have exposure to fresh air without compromising indoor noise or temperature levels.
- Rapid access saves time descending or climbing stairs or taking an elevator for fresh air breaks (to smoke, have a coffee, or take a private phone call etc.). In a workplace this is beneficial for productivity, in a residential building, it is both convenient and private, meaning no need to necessarily change clothes as if you were going to a public outdoor space.
- Offers access to direct sun for workers not near windows or any occupants in residential buildings where sun does not enter directly (direct entry would not necessarily be a good thing either due to potentially excessive solar gain in summer or glare all year round).

What do Green Building Rating Systems or other initiatives say?

The **BREEAM** International New Construction (2016) technical manual (SD233 2.0) sets out its criterion “Hea 02 Indoor air quality”, which is structured as follows:

- Prerequisite: that no materials containing asbestos shall be specified or used in the building.
- Indoor air quality (IAQ) plan (1 credit): To have a plan in place that ensures that design, specification and installation decisions consider the potential to minimise indoor air pollution, both during construction and during occupation phases.
- Ventilation (1 credit): fresh air is provided to the building in line with national best practice. Ventilation intakes and exhausts are distanced from each other in accordance with Annex A2 of EN 13779 or be at least 10m apart from each other (horizontally) and intakes, openable windows or

ventilators are at least 10m from sources of external pollution. A number of other measures are also specified for this credit.

- Emissions from building products (1 credit): makes reference to formaldehyde and general VOC limits for interior paints and coatings, wood-based products, flooring materials, ceiling, wall and insulation materials and interior adhesives and sealants.
- Post-construction indoor air quality measurement (1 credit): Sets a post-construction, pre-occupancy limit of 100 µg/m³ (30 minute sample) for formaldehyde and 300 µg/m³ (8 hour sample) for total VOCs.
- Adaptability and potential for natural ventilation (1 credit): openable window area in each occupied space is equivalent to 5% of the gross internal floor area of that space or, natural ventilation is shown to be able to provide adequate cross-ventilation rates.

The **WELL Building Standard** (version 2) makes a number of provisions relating to indoor air quality as follows:

- A01: Air quality (precondition): Provide a basic level of indoor air quality that contributes to the health and well-being of building users.
- A02: Smoke-free environment (precondition): Deter smoking, minimize occupant exposure to second-hand smoke and reduce smoke pollution.
- A03: Ventilation design (precondition): Minimize indoor air quality issues through the provision of adequate ventilation.
- A04: Construction pollution management: Minimize the introduction of construction-related pollutants into indoor air, remediate construction-related indoor air contamination for human health and protect building products from degradation.
- A05: Enhanced air quality: Encourage and recognize buildings with enhanced levels of indoor air quality that promote the health and well-being of people.
- A06: Enhanced ventilation design: Expel internally generated pollutants and improve air quality in the breathing zone through an increased supply of outdoor air or increased ventilation efficiency.
- A07: Operable windows: Increase the supply of high-quality outdoor air and promote a connection to the outdoor environment, by encouraging building users to open windows when outdoor air quality is acceptable.
- A08: Air quality monitoring and awareness: Monitor indoor air quality issues, as well as inform and educate individuals on the quality of the indoor environment.
- A09: Pollution infiltration management: Minimize the introduction of pollutants into indoor air through the building envelope and at building entrances.
- A10: Combustion minimisation: Reduce human exposure to combustion-related air pollution from heating and transportation sources.
- A11: Source separation: Preserve indoor air quality and maximize olfactory comfort in occupied spaces through the isolation and proper ventilation of indoor pollution sources and chemical storage areas.
- A12: Air filtration: Reduce indoor and outdoor airborne contaminants through air filtration.
- A13: Enhanced supply air: Mitigate risks from indoor contamination and pollution sources, such as infectious disease particles and volatile organic compounds (VOC).
- A14: Microbe and mould control: Reduce mould and bacteria growth within the building mechanical system.

4.2. Thermal comfort

Core criteria				Comprehensive criteria			
TECHNICAL SPECIFICATIONS (TSs)							
<p><i>Note: All of the design and construction phase criteria under theme 4 are applicable to the construction of new buildings, but individual judgement of the contracting authority shall be required before deciding if each individual design or construction stage criterion should be applied in renovation projects.</i></p> <p><i>Specifically about thermal comfort, passive design principles should be at the core of providing thermal comfort, especially for cooling, with a mechanical system only being installed to play a supporting role as and when needed, either due to extreme external temperatures and/or extreme occupancy events.</i></p>							
Design	Site prep.	Construction	Management	Design	Site prep.	Construction	Management
<p>TS4.2.1: Thermal comfort: time out of range.</p> <p>For occupancy patterns defined by the contracting authority, the indoor air temperatures shall be dynamically modelled for the detailed building design with hourly climate data.</p> <p>The building design and the Heating, Ventilation and Air Conditioning (HVAC) system shall be capable of providing at least a category II (or category I) thermal environment as defined in EN 16798-1, or maintain the temperature within other specific ranges defined by the contracting authority, for the building interior during at least:</p> <ul style="list-style-type: none"> • 80% of occupied hours for any week, • 88% of occupied hours for any month; • 97% of occupied hours for the year. <p>The correct construction and installation of the HVAC systems and of building elements especially relevant to predicted thermal performance shall be ensured by the project manager during the construction and installation stages.</p> <p>Verification:</p> <p>The contracted design team shall provide a design report explaining the calculation methodology, climate data used, any assumptions (e.g. occupation patterns, metabolic factors for activities, clothing factors), the heating system design, any mechanical cooling system design and capacity, thermal properties of the building envelope, interior wall and floor surfaces and any passive design features for cooling or solar gain.</p> <p>The results, at hourly scale, will clearly show the time when occupied spaces are out of the defined thermal comfort range and the extent to which they are out of range.</p> <p>In cases where the defined ranges correspond to EN 16798-1 categories, the category II criteria:</p> <ul style="list-style-type: none"> • from Annex B2.1 to EN 16798-1 shall be applied if the design includes a mechanical cooling system • from Annex B2.2 to EN 16798-1 shall be applied if the design does not include a mechanical system. 				<p>TS4.2.1: Thermal comfort: time out of range.</p> <p>For occupancy patterns defined by the contracting authority, the indoor air temperatures shall be dynamically modelled for the detailed building design with hourly climate data for the following two situations:</p> <ul style="list-style-type: none"> • With no mechanical cooling system installed. • With a mechanical cooling system installed. <p>If no mechanical cooling system is installed, the passive features of the building design and the Heating, Ventilation and Air Conditioning (HVAC) system shall be capable of providing a category II (or category I) thermal environment as defined in EN 16798-1, or maintain the temperature within specific ranges defined by the contracting authority, for the building interior during at least:</p> <ul style="list-style-type: none"> • 80% of occupied hours for any week, • 88% of occupied hours for any month; • 97% of occupied hours for the year. <p>If a mechanical cooling system is installed, it should be sized to guarantee a category II thermal environment during 97% of the occupied hours for any week.</p> <p>The correct construction and installation of the HVAC systems and of any building elements especially relevant to predicted thermal performance shall be ensured by the project manager during the construction and installation stages.</p> <p>Verification:</p> <p>The contracted design team shall provide a design report explaining the calculation methodology, climate data used, any assumptions (e.g. occupation patterns, metabolic factors for activities, clothing factors), the heating system design, any mechanical cooling system design and capacity, thermal properties of the building envelope, interior wall and floor surfaces and any passive design features for cooling or solar gain.</p> <p>The results, at hourly scale, will clearly show the time when occupied spaces are out of the defined thermal comfort range and the extent to which they</p>			

Core criteria	Comprehensive criteria								
TECHNICAL SPECIFICATIONS (TSs)									
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<p>The HVAC system and any design features that are crucial to delivering the design thermal environment should be carefully checked by the design team during the construction and installation stage.</p>	<p>are out of range.</p> <p>In cases where the defined ranges correspond to EN 16798-1 categories, the category II criteria:</p> <ul style="list-style-type: none"> from Annex B2.1 to EN 16798-1 shall be applied if the design includes a mechanical cooling system from Annex B2.2 to EN 16798-1 shall be applied if the design does not include a mechanical system. <p>The HVAC system and any design features that are crucial to delivering the design thermal environment should be carefully checked by the design team during the construction and installation stage.</p>								
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Design	Site prep.	Construction	Management						
Design	Site prep.	Construction	Management						
<p>TS4.2.2: Thermal zoning and individual thermal comfort control:</p> <p>The mechanical heating system (and cooling system, if installed) shall operate to pre-defined time and temperature set-points for different building zones but shall also permit the manual adjustment of temperatures via occupant accessible (manual) thermostatic controls that are unique to defined zones (e.g. meeting rooms, office spaces, bedroom, living room).</p> <p>The designer shall provide clear installation instructions and further instructions about the routine operation and maintenance of the temperature control system.</p> <p>Verification:</p> <p>The design team shall provide a brief description of the HVAC system design and control philosophy that is sufficiently detailed, together with:</p> <ul style="list-style-type: none"> installation instructions, an explanation of how the controls and sensors can be installed, programmed and adjusted an operation manual and maintenance instructions. <p>Details of suppliers or manufacturers shall be provided for any future procurement of spare parts.</p>	<p>TS4.2.2: Thermal zoning and individual thermal comfort control:</p> <p>The mechanical heating system (and cooling system, if installed) shall operate to pre-defined time and temperature set-points for different building zones but shall also permit the manual adjustment of temperatures via occupant accessible (manual or web-based) thermostatic controls that are unique to defined zones (e.g. meeting rooms, office spaces, bedroom, living room).</p> <p>The building temperature control system shall be wired to a segregated power circuit. Real-time temperature data and energy consumption for the whole building and for defined zones shall be logged via a building energy management system.</p> <p>The designer shall provide clear installation instructions and further instructions about the routine operation and maintenance of the temperature control system.</p> <p>Verification:</p> <p>The design team shall provide a brief description of the HVAC system design and control philosophy that is sufficiently detailed, together with:</p> <ul style="list-style-type: none"> installation instructions, an explanation of how the controls and sensors can be installed, programmed and adjusted an operation manual and maintenance instructions. <p>Details of suppliers or manufacturers shall be provided for any future procurement of spare parts.</p> <p>The building manager shall provide periodic (e.g.</p>								

Core criteria	Comprehensive criteria
TECHNICAL SPECIFICATIONS (TSs)	
<p><i>Note: All of the design and construction phase criteria under theme 4 are applicable to the construction of new buildings, but individual judgement of the contracting authority shall be required before deciding if each individual design or construction stage criterion should be applied in renovation projects.</i></p> <p><i>Specifically about thermal comfort, passive design principles should be at the core of providing thermal comfort, especially for cooling, with a mechanical system only being installed to play a supporting role as and when needed, either due to extreme external temperatures and/or extreme occupancy events.</i></p>	
	<p>once per year) reports about the specific energy consumption trends and performance of the temperature control system, in units of kWh/m²/year for the whole building and for any defined sub areas of interest. This report should be complemented by the results of an annual occupant satisfaction survey in line with EN ISO 7730.</p>

Supporting rationale for technical specifications 4.2.1 and 4.2.2:

Health and wellbeing benefits:

Overheating in buildings is linked to a variety of potential health issues for occupants (Lan et al., 2011). Work productivity of office workers can be affected by a too-cold or too-warm environment (Vimalanathan and Babu, 2014). Conversely, improving thermal comfort can increase productivity. According to Huizenga et al., (2006), only 11% of US office buildings provided adequate thermal environments.

However, thermal comfort is a highly subjective factor that can vary from one person to another as a function of age profile (van Hoof et al., 2017), gender (Karjalainen, 2012) and underlying physiologies (Luo et al., 2016) amongst other personal factors that can be varied from day to day (such as metabolism, clothing factors). So regardless of the EN 16798-1 thermal category chosen, or specific temperature ranges defined by the contracting authority for heating and cooling seasons, there will always be some occupants that are not satisfied with the thermal environment.

Consequently, it is important that occupants have access to adjusting the temperature of the room they are occupying. For example, a meeting room may need mechanical cooling when the room is fully occupied, but not need any mechanical cooling if only a few people are present.

In shared spaces, adjustment of the temperature could potentially cause disagreement with fellow occupants. It is important that building managers take into account these potential disagreements and minimise them by having more flexible policies in place regarding what occupants can wear and to allow for the use of portable fans that can provide cooling at the individual workstation level without actually changing the room temperature for others.

Environmental relevance (in terms of energy): The regulation of internal temperatures in building spaces is the most dominant aspect of use stage energy consumption that can be optimised during building design. The specific energy consumption (in terms of kWh/m²) can be minimised by incorporating passive heating and cooling features into the building design, encouraging user behaviour that adapts to changes in internal temperature (e.g. more appropriate clothing options matched to occupant activities) and implementing a heating and cooling strategy that prioritises temperature control in the most relevant parts of the building, thus allowing for individual control temperature of defined spaces.

Typical per m² performances of heating and cooling systems in residential, office and educational buildings could be changing significantly with the recent massive switch towards teleworking and online classes. This will lead to increases in energy consumption in residential buildings and potential decreases in office and educational buildings. To achieve the decreases in office and educational buildings, and to avoid excessive increase of energy demands in residential buildings, it is crucial that temperature controls can be tailored for specific zones of a building. This also allows for thermal comfort to be optimised for occupants in different zones who have different opinions on what is a satisfactory temperature range.

Building managers and occupants can also learn how to optimise their behaviour to reduce heating and cooling energy consumption if they are clearly informed about the specific energy consumption rates in the areas where they work or live (e.g. in terms of kWh/m²/year). The clearest way to do this would be to have a

segregated power circuit for the HVAC system with sub-metering and data transmission to a centralised building energy management system.

The monitoring of the ventilation system energy consumption is for two main reasons. First of all, often the two systems are closely inter-related in terms of fans and ducts used. And secondly, a more air-tight building envelope while influence both the thermal environmental (reduce the need for heating and cooling energy) and the indoor air quality (increase the need for ventilation).

Policy relevance:

There is no EU policy that the authors are aware of when drafting this document that is specifically focussed on setting a framework for thermal comfort in Europe. This is part is due to the broad range of climates, cultural behaviours and building architecture in Europe, and partly due to the fact that it is already covered as a part of the broader Energy Performance of Buildings Directive.

EU policy is focussed on developing heating and cooling systems that are energy efficient and that rely on renewable energy to the largest extent possible. However, this is more about theme 1 of the GPP criteria, and is only loosely related to the objective of theme 4, which is the maintenance of the thermal comfort of occupants.

Other policies of direct relevance to the energy performance of the heating and cooling systems are the ecodesign and energy labelling requirements are in place for air conditioners, residential ventilation units, local space heaters, solid fuel boilers, water heaters, space heaters/combination heaters, temperature controls for space heaters, hot water storage tanks for water heaters and solar devices for space heaters. It is likely that the energy labelling classes will be rescaled in the next few years (from the current scale to typically goes from A+++ to D or E, to a new scale that goes from A to G).

Market considerations:

There are a diverse range of passive design features that can be incorporated into buildings by architects to improve thermal comfort. However, in many cases the design focuses entirely on mechanical heating and cooling systems or uses them as a guarantee to account for times when passive features are unable to account for temperature extremes or extreme occupant behaviour.

The European Product Registry for Energy Labelling (EPREL) will be made available to the public in the near future, where it will be possible to see the energy labels for all of the relevant products covered by the Energy Labelling Regulation. The EPREL database shall permit users to filter data by certain product characteristics, including energy class. Contracting authorities should consult the EPREL database before setting any energy class requirements for heating or cooling equipment.

A longer term consequence of the COVID-response is the much greater extent of teleworking and online classes, meaning that thermal comfort requirements in residential buildings are also becoming more relevant, especially the risk of overheating when teleworking in summer afternoons.

What do Green Building Rating Systems or other initiatives say?

The **BREEAM** International New Construction (2016) technical manual (SD233 2.0) sets out its criterion “Hea 04 Thermal comfort”, which offers a total of three credits. One credit is more relevant to theme 5, and so is not mentioned here, the other two credits are as follows:

One credit – Thermal modelling

1. Thermal modelling (or an analytical measurement or evaluation of the thermal comfort levels of the building) has been carried out using the predicted mean vote (PMV) and predicted percentage of dissatisfied (PPD) indices in accordance with ISO 7730:2005 taking full account of seasonal variations.
2. Local thermal comfort criteria have been used to determine the level of thermal comfort in the building, in particular internal winter and summer temperature ranges will be in line with the recommended comfort criteria within ISO 7730:2005, with no areas falling within the levels defined as representing local dissatisfaction.
3. Thermal comfort levels in occupied spaces meet the Category B requirements set out in Table A.1 of Annex A of ISO 7730:2005.
4. For air-conditioned buildings, the PMV and PPD indices based on the above modelling are reported via the BREEAM assessment scoring and reporting tool.

One credit – Thermal zoning and controls

9. Criteria 1 to 4 are achieved.
10. The thermal modelling analysis (undertaken for compliance with criteria 1 to 4 above) has informed the temperature control strategy for the building and its users.
11. The strategy for proposed heating or cooling systems demonstrates that it has addressed the following:
 - a. Zones within the building and how the building services could efficiently and appropriately heat or cool these areas. For example, consider the different requirements for the central core of a building compared with the external perimeter adjacent to the windows.
 - b. The degree of occupant control required for these zones, based on discussions with the end user (or alternatively the building type or use specific design guidance, case studies, feedback) considers:
 - i. User knowledge of building systems
 - ii. Occupancy type, patterns and room functions (and therefore the appropriate level of control required)
 - iii. How the user is likely to operate or interact with the systems, e.g. are they likely to open windows, access thermostatic radiator valves (TRVs) on radiators, change air-conditioning settings etc.
 - iv. The user expectations (this may differ in the summer and winter) and degree of individual control (i.e. obtaining the balance between occupant preferences, for example some occupants like fresh air and others dislike drafts).
 - c. How the proposed systems will interact with each other (where there is more than one system) and how this may affect the thermal comfort of the building occupants.
 - d. The need or otherwise for an accessible building user actuated manual override for any automatic systems.

The **WELL Building Standard** (version 2) makes a number of provisions relating to thermal comfort as follows:

- T01: Thermal performance: Provide a thermal environment that the majority of building users find acceptable.
- T02: Verified thermal comfort: Enhance thermal comfort and promote human productivity, by ensuring that a substantial majority of building users (above 80%) perceive their environment as thermally acceptable.
- T03: Thermal zoning: Enhance thermal control of building occupants through the provision of thermal zones.
- T04: Individual thermal control: Maximize and personalize thermal comfort among all individuals..
- T05: Radiant thermal comfort: Maximize volume of the space, reduce dust transmission, improve ventilation control and increase thermal comfort by incorporating radiant heat and cooling systems into the building design.
- T06: Thermal comfort monitoring: Monitor and effectively address unacceptable thermal comfort conditions and inform building managers and users of the thermal comfort parameters of their indoor environment.
- T07: Humidity control: Limit the growth of pathogens, reduce off-gassing and maintain thermal comfort by providing the appropriate level of humidity.
- T08: (Beta) Enhanced operable windows: Provide the benefits of increased outdoor air supply while minimizing any resulting thermal discomfort.
- T09: (Beta) Outdoor thermal comfort: Address the thermal comfort needs of project occupants in the exterior spaces of the project.

4.3. Lighting

Core criteria				Comprehensive criteria			
TECHNICAL SPECIFICATIONS (TSs)							
<p><i>Note: All of the design and construction phase criteria under theme 4 are applicable to the construction of new buildings, but individual judgement of the contracting authority shall be required before deciding if each individual design or construction stage criterion should be applied in renovation projects.</i></p>							
Design	Site prep.	Construction	Management	Design	Site prep.	Construction	Management
<p>TS4.3.1: Electric lighting equipment requirements</p> <p>Interior light sources shall meet the following requirements:</p> <ul style="list-style-type: none"> • Colour Rendering Index (Ra) >80 for light sources in all areas where people work permanently. • Correlated Colour Temperature (CCT) ≤4000K in all areas where people work permanently during daytime or ≤3000K in areas where people work permanently during night-time (this requirement may vary depending on occupant preferences). • Energy class rating of B or better. • Be mercury free. • Be dimmable via a manual control. <p>Verification:</p> <p>The lighting system design shall generally specify the types, numbers and positioning of light sources required.</p> <p>The contractor shall provide invoices for the lighting equipment to be installed, together with product specifications, labels or supplier declarations that confirm compliance with the requirements above.</p>				<p>TS4.3.1: Electric lighting equipment requirements</p> <p>Interior light sources shall meet the following requirements:</p> <ul style="list-style-type: none"> • Colour Rendering Index (Ra) >80 for light sources in all areas where people work permanently. • Correlated Colour Temperature (CCT) ≤4000K in all areas where people work permanently during daytime or ≤3000K in areas where people work permanently during night-time (this requirement may vary depending on occupant preferences). • Energy class rating of A or better. • Be mercury free. • Be dimmable via a manual and a wireless control system. <p>Verification:</p> <p>The lighting system design shall generally specify the types, numbers and positioning of light sources required.</p> <p>The contractor shall provide invoices for the lighting equipment to be installed, together with product specifications, labels or supplier declarations that confirm compliance with the requirements above.</p>			
Design	Site prep.	Construction	Management	Design	Site prep.	Construction	Management
<p>TS4.3.2: Lighting levels and control</p> <p><i>For office and educational buildings:</i></p> <p>Unless otherwise specified, the lighting system shall be designed to meet the relevant illuminance levels set out in EN 12464-1 for different building types, spaces and task areas within buildings (see explanatory note for more details).</p> <p>Illuminance may be provided by a combination of daylight ingress and electric lighting.</p> <p>The lighting shall be occupant adjustable via manual dimming controls and shall be programmed to automatically switch-off after a defined period (e.g. 20 minutes) if no signal is received by the local movement sensor(s) for the relevant target area.</p> <p>The lighting system designer shall provide clear installation instructions and further instructions about the routine operation and maintenance of the lighting system.</p>				<p>TS4.3.2: Lighting levels and control</p> <p><i>For office and educational buildings:</i></p> <p>Unless otherwise specified, the lighting system shall be designed to meet the relevant illuminance levels set out in EN 12464-1 for different building types, spaces and task areas within buildings (see explanatory note for more details).</p> <p>Illuminance may be provided by a combination of daylight ingress and electric lighting.</p> <p>The installation of adaptive lighting that reduces electric light output in response to increasing daylight in occupied spaces.</p> <p>The lighting shall be occupant adjustable, overriding any adaptive controls, via manual or web-based dimming controls and shall be programmed to automatically switch-off after a defined period (e.g. 20 minutes) if no signal is received by the local movement sensor(s) for the relevant target area.</p>			

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<p>Verification:</p> <p>Tenderers shall provide a brief description of the lighting system design and control philosophy that is sufficiently detailed to make an estimate of purchasing and installation costs.</p> <p>The contractor shall provide a more detailed design, together with:</p> <ul style="list-style-type: none"> • installation instructions, • an explanation of how the controls and sensors can be installed, programmed and adjusted • an operation manual and maintenance instructions. <p>Details of suppliers or manufacturers shall be provided for any future procurement of spare parts.</p>				<p>When sensors indicate that spaces are occupied and occupants do not initiate dimming, the lighting system shall automatically deliver pre-programmed constant illuminance levels by adjusting electric light output to account for varying daylight levels and the maintenance factor of electric lighting.</p> <p>The building lighting system shall be wired to a segregated power circuit. Real-time energy consumption for the whole building and for defined sub-areas shall be logged via a building energy management system.</p> <p>The lighting system designer shall provide clear installation instructions and further instructions about the routine operation and maintenance of the lighting system.</p> <p>Verification:</p> <p>Tenderers shall provide a brief description of the lighting system design and control philosophy that is sufficiently detailed to make an estimate of purchasing and installation costs.</p> <p>The contractor shall provide a more detailed design, together with:</p> <ul style="list-style-type: none"> • installation instructions, • an explanation of how the controls and sensors can be installed, programmed and adjusted • an operation manual and maintenance instructions. <p>Details of suppliers or manufacturers shall be provided for any future procurement of spare parts.</p> <p>The building manager shall provide periodic (e.g. once per year) reports about the specific energy consumption trends and performance of the lighting system, in units of kWh/m²/year for the whole building and for defined sub areas of interest.</p>																																					
Design	Site prep.	Construction	Management	Design	Site prep.	Construction	Management																																		
<p>TS4.3.3: Daylight factor and glare control</p> <p>The average daylight factor (D)*, measured in a reference horizontal plane (0.85m above the floor area unless otherwise specified), shall meet or exceed the relevant thresholds defined below for at least 80% of the occupied spaces defined below.</p>				<p>TS4.3.3: Daylighting and glare control</p> <p>Dynamic modelling shall be used to demonstrate that the following average daylight illuminance and times are achieved for the relevant building spaces as specified below:</p> <p><i>Residential buildings:</i></p> <ul style="list-style-type: none"> • Living rooms, dining rooms and home offices: at least 100 lux averaged across the entire area for at least 3450 hours per year. • Kitchens: at least 100 lux averaged across the entire area for at least 3450 hours per year. 																																					
<table border="1"> <thead> <tr> <th rowspan="2"></th> <th colspan="6">Average daylight factor as a function of building site latitudes</th> </tr> <tr> <th>≤ 40</th> <th>40-45</th> <th>45-50</th> <th>50-55</th> <th>55-60</th> <th>≥ 60</th> </tr> </thead> <tbody> <tr> <td>Classrooms</td> <td>1.5%</td> <td>1.7%</td> <td>1.8%</td> <td>2.0%</td> <td>2.1%</td> <td>2.2%</td> </tr> <tr> <td>Offices</td> <td>1.5%</td> <td>1.7%</td> <td>1.8%</td> <td>2.0%</td> <td>2.1%</td> <td>2.2%</td> </tr> <tr> <td>Residential – kitchen</td> <td>1.5%</td> <td>1.7%</td> <td>1.8%</td> <td>2.0%</td> <td>2.1%</td> <td>2.2%</td> </tr> </tbody> </table>					Average daylight factor as a function of building site latitudes						≤ 40	40-45	45-50	50-55	55-60	≥ 60	Classrooms	1.5%	1.7%	1.8%	2.0%	2.1%	2.2%	Offices	1.5%	1.7%	1.8%	2.0%	2.1%	2.2%	Residential – kitchen	1.5%	1.7%	1.8%	2.0%	2.1%	2.2%				
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Residential – living room or study	1.2%	1.3%	1.4%	1.5%	1.6%	1.6%	<p>Educational buildings:</p> <ul style="list-style-type: none"> Occupied spaces in preschools and schools: at least 300 lux across 80% of the areas for at least 2000 hours per year. Occupied spaces and lecture theatres in universities, colleges or higher education: at least 300 lux across 60% of the areas for at least 2000 hours per year. <p>Office buildings:</p> <ul style="list-style-type: none"> Occupied spaces: at least 300 lux across 80% of the areas for at least 2650 hours per year. <p>The calculation shall be carried out using hourly (or sub-hourly) internal daylight illuminance values for a typical year and sun conditions derived from climate data appropriate to the site.</p> <p>To protect against daylight glare, shutters, external blinds or internal blinds that can be manually controlled by occupants shall be installed.</p> <p>Verification:</p> <p>Tenderers shall commit to achieving these daylight factors in their designs for the appropriate levels defined by the contracting authority.</p> <p>The contracted design team shall carry out daylight factor calculations for the detailed building design for the relevant spaces and provide a design report explaining the calculation methodology, any assumptions (e.g. dimensions and configuration of defined space, reflection/transmission properties of glazing, wall and floor surfaces) and the final results.</p> <p>The actual daylight factor in the as-built building can later be tested in-situ by taking paired readings of internal and external illuminance levels.</p>																																										
<p>*daylight factor is ratio between: (i) illuminance at a given point on a given horizontal plane due to light received directly or indirectly from a sky of assumed or known luminance distribution and (ii) illuminance on the same horizontal plane from an unobstructed hemisphere of the same sky, excluding the contribution of direct sunlight to both (i) and (ii).</p> <p>The calculation shall be carried out by any reliable method that is based on the ISO 15469:2004 standard overcast sky (Type 1 or Type 16).</p> <p>To protect against daylight glare, shutters, external blinds or internal blinds that can be manually controlled by occupants shall be installed.</p> <p>Verification:</p> <p>Tenderers shall commit to achieving these daylight factors in their designs for the appropriate levels defined by the contracting authority.</p> <p>The contracted design team shall carry out daylight factor calculations for the detailed building design for the relevant spaces and provide a design report explaining the calculation methodology, any assumptions (e.g. dimensions and configuration of defined space, reflection/transmission properties of glazing, wall and floor surfaces) and the final results.</p> <p>The actual daylight factor in the as-built building can later be tested in-situ by taking paired readings of internal and external illuminance levels.</p>																																																	
<p><u>Explanatory note for TS4.3.1.:</u></p> <p>The energy classes refer to the new rescaled energy classes defined by Regulation (EU) No 2019/2015.</p> <p><u>Explanatory note for TS4.3.2:</u></p> <p>The scope of the lighting design requirements should cover at least the following areas:</p>																																																	
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<i>Note: All of the design and construction phase criteria under theme 4 are applicable to the construction of new buildings, but individual judgement of the contracting authority shall be required before deciding if each individual design or construction stage criterion should be applied in renovation projects.</i>					
Conference and meeting rooms	500	1000	0.60	80	19
Reception desk	300	750	0.60	80	22
Private parking areas	75	100	0.25	40	-
Public parking areas	150	200	0.40	40	-

Supporting rationale for technical specifications 4.3.1, 4.3.2 and 4.3.3:

Health and wellbeing benefits:

Many of the physiological functions of the human body are synchronised on a 24 hour cycle known as the circadian rhythm. One of the environmental cues considered to play a key role in the circadian rhythm is exposure to light. The disruption of the circadian rhythm has been linked to mental health (Boyce and Barriball, 2010; Germain and Kupfer, 2008) and to disruptions in metabolism (Challet and Kalsbeek, 2017; Plano et al., Fonken and Nelson, 2014) and myriad associated adverse health impacts (Cho et al., 2015).

Given that humans tend to spend the vast majority of their time indoors, indoor lighting can provide a two-pronged disruption to circadian rhythms: (i) inadequate exposure to light during the day and (ii) excessive exposure to light during the night. The COVID-related government restrictions on freedom of movement, where large proportions of entire populations were effectively confined to their houses, brought the importance of proper daylighting into sharp focus for citizens living in buildings with poor levels of daylighting.

In terms of office buildings, there is evidence that improved views and daylighting improve worker productivity and wellbeing (CEC, 2003; Boubekri et al., 2014). However, preferred light levels when working is to some extent subjective (Anshel, 2007). Since vision is different in different people, and for a given person can decline with age (Pokomy et al., 1987; Veitch and Newsham, 1996; Xu et al., 1997). dimming is an important control tool that gives occupants the ability to adjust light levels to a range that they are comfortable with.

It is important to distinguish that daylight has a much different output spectra than electric light. Lighting standards have traditionally focused on designs to simply provide enough light for the purpose of carrying out tasks indoors without glare, but not so much to be respectful of circadian rhythms or avoid overlighting. The same light output is generally used during the day as during the night, even though exposure to higher frequencies of light (which tend to be whiter light sources as observed by the human eye) are ideal in the daytime but may be more disruptive to circadian rhythms during the night-time when compared to “warmer” lights.

Environmental relevance (in terms of energy):

For a given necessary illumination, the energy consumption is determined by:

- The luminous efficacy of the electric light source, which is basically the luminous flux (in lumens) per Watt of power consumed.
- The extent to which daylight can contribute to meeting illumination needs.
- The ability for electric light levels to be adjusted to prevent overlighting in occupied areas or unnecessary lighting in unoccupied areas.

Consequently, to reduce energy consumption, the EU GPP criteria set requirements on all three points listed above.

- The specification on energy class rating is directly related to the energy efficiency of the light sources to be installed. For clarity, the classes refer to the new scales (A to G).

- Minimum requirements on daylighting are defined in TS4.3.2 for areas of prolonged daytime occupation that are closely related to the BREEAM Hea 01 Visual Comfort criterion for International New Construction. The minimum level is also nuanced depending on the latitude where the building is located, since, all else being equal, locations tending towards the equator will have more daylight potential than locations tending towards the North Pole. The daylight factors mentioned generally refer to a spatial daylight autonomy (sDA) of 300 lux for 50% of the occupied period (e.g. 8am to 6pm). The calculation method referred to in the comprehensive criterion (Method 2 according to EN 17037) is more complex but also more realistic.
- The ability for light sources to be dimmable also contributes to energy efficiency and the control system allows for automatic switch-off when no movement is detected. In the comprehensive level TS4.3.2, an illuminance sensor can automatically control dimming of electric lights to prevent overlighting when daylight levels are higher. The potential effect of dimming on the undesired “dirty electricity” phenomenon (see TS4.6) needs to be investigated further, as this could be an example of a trade-off within theme 4.

Building managers and occupants can also learn how to optimise their behaviour to reduce lighting energy consumption if they are clearly informed about the specific energy consumption rates in the areas where they work (e.g. in terms of kWh/m²/year). The clearest way to do this would be to have a segregated power circuit for the lighting system with sub-metering and data transmission to a centralised building energy management system.

However, efforts to save energy by increasing daylighting (in renovation or new construction) need to be carefully considered against the trade-off of poorer thermal performance of the building envelope, which would relate to additional heating and/or cooling needs.

Policy relevance:

New ecodesign and energy labelling requirements for light sources have recently been adopted (see Regulation (EU) 2019/2020 and Regulation (EU) 2019/2015 respectively). The result is that the old energy classes, which varied from A+++ to E, have been rescaled to A to G, with a transition period in place until for the old classes until 1 March 2023.

The requirement for mercury-free products is linked to the general push to not prolong exemptions to Mercury in lighting products that were allowed under Directive 2011/65/EU. It is now widely accepted that Mercury-free alternatives to normal light sources to be used in buildings exist (i.e. LED technology). Mercury-free products create less contamination and emission control issues when processing Waste Electrical and Electronic Equipment (WEEE).

Market considerations:

The European Product Registry for Energy Labelling (EPREL) will be made available to the public in the future, where it will be possible to see the energy labels for light source products covered by the Energy Labelling Regulation. The EPREL database shall permit users to filter data by certain product characteristics. Contracting authorities should consult the EPREL database before setting any energy class requirements for light sources. The “class B” and “class A” requirements set in core and comprehensive criteria for TS 4.3.1 are purely indicative. Depending on real market data, this could easily be “class C” and “class B”, or even “class D” and “class C”. Since it is not expected that these EU GPP criteria will be published before March 2023, reference is only made to the new energy class scale.

A longer term consequence of the COVID-response is the much greater extent of teleworking, meaning that illuminance requirements in offices are also becoming more relevant in households.

What do Green Building Rating Systems or other initiatives say?

The **BREEAM** International New Construction (2016) technical manual (SD233 2.0) sets out its criterion “Hea 01 Visual comfort”, which is structured as follows:

- Prerequisite: that all fluorescent and compact fluorescent lamps are fitted with high frequency ballasts.
- Glare control (1 credit): basically that there is a glare control strategy that does not unnecessarily compromise on daylighting. Glare can be limited using building integrated measures, occupant controlled devices with low transmittance value (but not curtains), bioclimatic design principles or external shading devices.

- Daylighting (up to 4 credits): minimum daylight factors are defined for different building types and spaces inside them, as a function of the latitude of the building location. Thresholds are set for average and minimum daylight illuminance levels for different building spaces for minimum hours per year.
- View out (1 credit): sets minimum requirements for 95% of the floor area space within relevant building areas to be within X metres of a window or permanent opening (the value of X depends on the relative size of the window to the surrounding wall area).
- Internal and external lighting (1 credit): general references to the illuminance levels being in line with local or EN standards and the occupant control of lighting in defined building spaces.

The **WELL Building Standard** (version 2) makes a number of provisions relating to lighting as follows:

- L01: Light exposure: Provide a minimum level of light in all regularly occupied spaces through daylight ingress through interior layout and/or building design or through electric lighting.
- L02: Visual lighting design: Align with a chosen lighting reference design guideline to ensure adequate illuminance is provided in all indoor and outdoor spaces, which considers types of tasks undertaken in the space, the location of the work plane and the ages of people using the space.
- L03: Circadian lighting design: Ensure that electric lighting provides an adequate amount of light during the daytime for proper circadian functioning in all spaces and ensure that electric lighting is dimmable in all dwelling units.
- L04: Electric light glare control: Ensure that luminaires do not introduce glare by meeting requirements on shielding angles or Unified Glare Rating (UGR) values.
- L05: Daylight design strategies: Part 1: Provide at least 70% of occupants with adequate exposure to daylight as defined by visible light transmittance (VLT) for interior layout and façade design in all spaces, and VLT of at least 40% in dwelling units. And Part 2: Provide adaptable solar glare controllable in the form of manual or automated shading devices or through tenant subsidies.
- L06: Daylight simulation: Provide daylight exposure for at least 50% of floor area and validate it through computer simulations.
- L07: Visual balance: Balance light levels by ensuring that luminance ratios, uniformity ratios and correlated color temperatures (CCT) are kept consistent, or lighting is designed by a professional to account for all preceding considerations.
- L08: Electric light quality: Part 1: Ensure electric lighting delivers color rendering per regulations and recommended guidelines in all spaces. And Part 2: Manage the flicker of electric lights per regulations and recommended guidelines in all spaces.
- L09: Occupant lighting control: Part 1: Ambient lighting systems provide adequate lighting zones and systems allow occupant control of light levels, color temperature and color of electric light in all spaces. And Part 2: Visually comfortable supplemental light fixtures that can double the amount of light on a task surface are available upon request at no additional cost to the occupant in all spaces except dwelling units.

4.4. Acoustics

Core criteria				Comprehensive criteria			
TECHNICAL SPECIFICATIONS (TSs)							
<p><i>Note: All of the design and construction phase criteria under theme 4 are applicable to the construction of new buildings, but individual judgement of the contracting authority shall be required before deciding if each individual design or construction stage criterion should be applied in renovation projects.</i></p> <p><i>Specifically for acoustics, the contracting authority should define areas where specific acoustic requirements are to be specified (e.g. bedrooms in buildings for night-time noise; or category I to IV areas in office or educational buildings, where category I would impose the strictest acoustic limits and category IV the least stringent limits.</i></p>							
Design	Site prep.	Construction	Management	Design	Site prep.	Construction	Management
<p>TS4.4: Limits for indoor weighted average sound pressure level.</p> <p>In addition to any acoustic performance requirements in national or regional building regulations, the design shall be tailored to deliver noise levels below the limits stated below:</p> <p><i>For residential buildings:</i></p> <p>The average background indoor, A-weighted continuous sound pressure level should be:</p> <ul style="list-style-type: none"> • ≤30 dB(L_{Aeq,T}) in bedrooms at night time. • ≤35 dB(L_{Aeq,T}) in living rooms during the day. <p><i>For office or educational buildings:</i></p> <p>The average background indoor, A-weighted continuous sound pressure level should be:</p> <ul style="list-style-type: none"> • ≤40 dB(L_{Aeq,T}) in areas for conferencing, learning or speaking (category I). • ≤45 dB(L_{Aeq,T}) in enclosed areas for concentration (category II). • ≤50 dB(L_{Aeq,T}) in open areas for concentration, areas with regularly used PA systems and areas for dining (category III). • ≤55 dB(L_{Aeq,T}) in areas with machinery and appliances used by occupants (category IV). <p>Verification:</p> <p>The indoor sound pressure levels shall be measured in accordance with any relevant national or regional testing protocols.</p> <p>In case such protocols are not available, measurements should follow the details of the WELL Building Standard for “S02 Maximum Noise Levels”.</p>				<p>TS4.4: Limits for indoor weighted average sound pressure level.</p> <p>In addition to any acoustic performance requirements in national or regional building regulations, the design shall be tailored to deliver noise levels below the limits stated below:</p> <p><i>For residential buildings:</i></p> <p>The average background indoor, A-weighted continuous sound pressure level should be:</p> <ul style="list-style-type: none"> • ≤30 dB(L_{Aeq,T}) in bedrooms at night time. • ≤35 dB(L_{Aeq,T}) in living rooms during the day. <p><i>For office or educational buildings:</i></p> <p>The average background indoor, A-weighted continuous sound pressure level should be:</p> <ul style="list-style-type: none"> • ≤35 dB(L_{Aeq,T}) in areas for conferencing, learning or speaking (category I). • ≤40 dB(L_{Aeq,T}) in enclosed areas for concentration (category II). • ≤45 dB(L_{Aeq,T}) in open areas for concentration, areas with regularly used PA systems and areas for dining (category III). • ≤50 dB(L_{Aeq,T}) in areas with machinery and appliances used by occupants (category IV). <p>Verification:</p> <p>The indoor sound pressure levels shall be measured in accordance with any relevant national or regional testing protocols.</p> <p>In case such protocols are not available, measurements should follow the details of the WELL Building Standard for “S02 Maximum Noise Levels”.</p>			

Supporting rationale for technical specifications 4.4:

Health and wellbeing benefits:

The human perception of sound is critical for our interaction with the surrounding environment although exposure to undesired anthropogenic sources of noise, especially traffic noise, has been shown to have an adverse effect on the health and well-being of people in different ways (Bluhm et al., 2007; Fyrhi et al., 2010; Babisch 2014). Of particular importance is the exposure to noise levels during periods of sleep.

Internal sources of noise can also be a major influence on occupant wellbeing, especially in meeting rooms and class rooms during the daytime, and in residential buildings especially at night-time. Unwanted noise can come from colleagues or co-habitants in buildings or from neighbouring occupants. Good acoustic performance of building spaces is a two way benefit, protecting occupants on one side from being disturbed by excessive noise generated internally, but also allowing occupants to generate noise as they please without the fear of disturbing people in adjacent spaces. A further benefit of this in office spaces (or home offices) would be the possibility to participate in webinars or video calls without needing to be constantly wearing headphones and be next to a microphone.

Potential environmental trade-offs: The improvement of acoustic insulation requires the use of insulation materials and high quality building elements that may increase the embodied energy (and carbon) associated with a building. Depending on the exact choice of materials used and how they are combined and installed, improved acoustic insulation of a building envelope, floor systems and wall systems may make it more difficult the deconstruct and recycled building elements at the end of life.

What do Green Building Rating Systems or other initiatives say?

The **BREEAM** International New Construction (2016) technical manual (SD233 2.0) sets out its criterion “Hea 05 Acoustic performance”, which is structured as follows:

- Prerequisite: that a suitable qualified acoustician is appointed to provide design advice on how to identify external noise sources for the site, optimising the site layout and zoning for good acoustics, considering requirements for users with special hearing and communication needs and applying acoustic treatments to different zones and facades.
- Indoor ambient noise and sound insulation (1 credit): indoor ambient noise level targets for finished but unfurnished rooms comply with whatever is the strictest between: national building regulations, good practice standards or predefined BREEAM limits ranging from $\leq 35\text{dB } L_{\text{AeqT}}$ to $50\text{dB } L_{\text{AeqT}}$ depending on the building space in question. The unoccupied noise levels need to be verified before handover to the occupants.
- Reverberation times (1 credit): rooms or areas used for speech (e.g. meeting rooms) comply with predefined BREEAM limits for speech, music and T_{mf} reverberation time if national building regulations or good practice levels are not available.
- Airborne and impact sound insulation values exceed minimum requirements in residential buildings (up to 4 credits).

The **WELL Building Standard** (version 2) makes a number of provisions relating to sound as follows:

- S01: Sound mapping (precondition): Incorporate strategic planning required to prevent issues of acoustic disturbance from various sources of noise.
- S02: Maximum noise levels: Achieve desired ambient noise levels such that HVAC, exterior noise intrusion or other noise sources do not impact occupant health and well-being.
- S03: Sound barriers: Increase the level of sound isolation and speech privacy between enclosed spaces.
- S04: Reverberation time: Design spaces in accordance with comfortable reverberation times that support speech intelligibility, vocal effort and are conducive to concentration.
- S05: Sound reducing surfaces: Design spaces with sound reducing surfaces to minimize the buildup of speech or other unwanted sound.
- S06: Minimum background sound: Increase acoustical privacy within and between occupied spaces.
- S07: Impact noise management: Reduce the level of impact noise radiation by designing resilient floors.
- S08: Enhanced audio devices: Improve speech intelligibility and accessibility by providing dedicated, high-performance audio technology.
- S09: Hearing health conservation: Increase access to resources and structured programming for employees who are at risk of occupational hearing loss.

4.5. Electropollution

Core criteria				Comprehensive criteria			
TECHNICAL SPECIFICATIONS (TSs)							
Design	Site prep.	Construction	Management	Design	Site prep.	Construction	Management
<p>TS4.5.1: Design features to minimise exposure to building-related electromagnetic fields (EMFs).</p> <p>The building design shall specify the following design features to allow occupants to minimise their exposure to artificial EMFs.</p> <ul style="list-style-type: none"> • Locate meters and sub-panels in areas that are not heavily used and that are as far away as practical from heavily used areas, especially sleeping areas. • Use a router that has the option to provide internet connection by Ethernet connection or by wifi, and that allows wifi to be optionally switched off. • Install a hardwired, shielded and grounded Ethernet network throughout the building that provides potential connections at plug sockets or similarly convenient points as an alternative to wifi internet connections. • Bundle live and neutral wiring together as much as possible for the same circuits. • Make sure that the wiring system is properly grounded and that computers or laptops and any surge protectors are all grounded when plugged in. <p>Verification:</p> <p>Tenderers shall commit to incorporating these features into the detailed building design.</p> <p>The design team shall provide technical drawings for the building, highlighting the features listed above. Where relevant, reference shall be made to relevant national building regulations or EN or IEC standards.</p> <p>The project manager shall ensure that design features that are crucial to reducing occupant exposure to EMFs are installed and constructed as per the design.</p>				<p>TS4.5.1: Design features to minimise exposure to building-related electromagnetic fields (EMFs).</p> <p>The building design shall specify the following design features to allow occupants to minimise their exposure to artificial EMFs.</p> <ul style="list-style-type: none"> • Locate meters and sub-panels in areas that are not heavily used and that are as far away as practical from heavily used areas, especially sleeping areas. • Use a router that has the option to provide internet connection by Ethernet connection or by wifi, and that allows wifi to be optionally switched off. • Install a hardwired, shielded and grounded Ethernet network throughout the building that provides potential connections at plug sockets or similarly convenient points as an alternative to wifi internet connections. • Bundle live and neutral wiring together as much as possible for the same circuits. • Make sure that the wiring system is properly grounded and that computers or laptops and any surge protectors are all grounded when plugged in. • Install kill switches that can electrically isolate areas that are not heavily used when they are not in use. Kill switches for bedrooms should be installed as well in case occupants wish to sleep without the electric field generated by connected wiring. • If water supply piping is metallic, a dielectric coupler shall be installed to minimise return current from other households entering via metal water mains piping. • If any smart meters are installed, they must be located at least 3m away from any areas for sleeping or prolonged occupation. <p>Verification:</p> <p>Tenderers shall commit to incorporating these features into the detailed building design.</p> <p>The design team shall provide technical drawings for the building, highlighting the features listed above. Where relevant, reference shall be made to relevant national building regulations or EN or IEC</p>			

Core criteria				Comprehensive criteria			
TECHNICAL SPECIFICATIONS (TSs)							
				standards.			
				The project manager shall ensure that design features that are crucial to reducing occupant exposure to EMFs are installed and constructed as per the design.			
Design	Site prep.	Construction	Management	Design	Site prep.	Construction	Management
<p>TS4.5.2: In-situ assessment of wiring installation and electromagnetic fields (EMFs).</p> <p>The wiring installation shall be checked for correct neutral and ground connections with clamp on amp meters and gauss meters by a qualified professional.</p> <p><i>Sleeping areas in residential buildings:</i></p> <p>The levels of electromagnetic radiation in sleeping areas shall be assessed for compliance with the following limits:</p> <p>(i) For alternating current (AC) electric fields in sleeping areas in residential buildings (at night time):</p> <ul style="list-style-type: none"> • <5.0 V/m field strength with ground potential. • <1.5 V/m field strength potential-free. • <100 mV body voltage with ground potential. <p>(ii) For AC magnetic fields in sleeping areas in residential buildings (at night time):</p> <ul style="list-style-type: none"> • <100 nT or <1.0 mG flux density <p>(iii) For radio-frequency (RF) radiation in sleeping areas in residential buildings:</p> <ul style="list-style-type: none"> • <10 µW/m² power density <p>In case of non-compliance with the limits above, potential remedial actions shall be considered to reduce EMF levels in sleeping areas.</p> <p>Verification:</p> <p>Measurements shall be carried out by a suitably qualified expert in line with the standard of building biology test methods and guidelines.</p>				<p>TS4.5.2: In-situ assessment of wiring installation and electromagnetic fields (EMFs).</p> <p>The wiring installation shall be checked for correct neutral and ground connections with clamp on amp meters and gauss meters by a qualified professional.</p> <p><i>Sleeping areas in residential buildings:</i></p> <p>The levels of electromagnetic radiation in sleeping areas shall be assessed for compliance with the following limits:</p> <p>(i) For alternating current (AC) electric fields in sleeping areas in residential buildings (at night time):</p> <ul style="list-style-type: none"> • <2.0 V/m field strength with ground potential. • <0.6 V/m field strength potential-free. • <20 mV body voltage with ground potential. <p>(ii) For AC magnetic fields in sleeping areas in residential buildings (at night time):</p> <ul style="list-style-type: none"> • <40 nT or <0.4 mG flux density <p>(iii) For radio-frequency (RF) radiation in sleeping areas in residential buildings:</p> <ul style="list-style-type: none"> • <0.2 µW/m² power density <p>In case of non-compliance with the limits above, potential remedial actions shall be considered to reduce EMF levels in sleeping areas.</p> <p>Point sources in office or educational buildings:</p> <p>Measurements of electric field, magnetic field and radio-frequency radiation shall be taken from workstations during periods of normal use and results should not exceed 200 nT flux density for AC magnetic fields.</p> <p>Results should be used to optimise the workstation layout to reduce worker or student exposure and building management shall provide grounded earthing mats upon request.</p> <p>Verification:</p> <p>Measurements shall be carried out by a suitably qualified expert in line with the standard of building biology test methods and guidelines.</p>			

Supporting rationale for technical specifications 4.5.1 and 4.5.2:

All life on earth has developed within very stable, subtle and cyclical patterns of electromagnetic fields (EMFs) dominated by solar radiation, the movement of molten rock inside the earth, water cycles and the rotation of the earth, both on its axis and around the sun. Until the installation of telecommunications and electrical networks in the late 19th century, human activity had made very little impact on electromagnetic fields.

The last 150 years have seen a truly remarkable transformation in society, in no small part founded upon the use of fossil fuel energy to extract raw materials and construct major telecommunications infrastructure and electrical power grids that have spread across the whole world and continually grown in capacity. The use of these networks generates artificial EMFs of vastly different magnitudes, frequencies and wave patterns to naturally occurring EMFs.

These telecommunications networks have been continually optimised for the military purposes of providing faster, more accurate and more secure communications. In the public domain, the ability to send personal communications rapidly over long distances and to provide electric light at night were the main initial appeals to society. From these beginnings, the use of electricity and telecommunications has become synonymous with almost every single business and leisure activity, forming a fundamental part of day to day life and conveniences for people.

While much attention is turning towards pollution caused by greenhouse gas emissions from electricity consumption, remarkably little attention has been paid to the simultaneously produced “electropollution” throughout the electrical network, which can be considered as the emission of artificial electromagnetic radiation.

Nonetheless, it is easy to appreciate why more attention is paid to greenhouse gas emissions. The global warming concept is easy to identify with and historical trends of atmospheric CO₂ levels can clearly show how concentrations have gradually increased since the industrial revolution.

Electropollution is a much more complex phenomenon than greenhouse gas emissions and, since its emission is not perceived by humans, it is not generally flagged as a concern. Furthermore, if trying to assess the extent of electropollution, it must be understood that the intensity will vary greatly in terms of frequency, location and time. Unlike CO₂, it is not possible to obtain a single measure of electropollution that accounts for all sources in a given sampling point.

The original sources of electropollution relate to radio wave transmissions and power supply using alternating current across electrical grids. These sources have grown in intensity as networks grew and as power consumption across them increased. The digitalisation of many electrical devices and appliances, which need to step down to much lower voltages and switch to direct current, leads to changes in the waveforms of EMFs, making it much less regular than the analogue sine waves. This irregular EMF was coined as “dirty electricity” by the audio and computer industry due to the ability of higher frequencies of such electricity to create an undesired audible hum on high-end audio and video entertainment systems.

Especially in the last 25 years, a new source of electropollution has emerged via the rapid proliferation of mobile phones. While originally used for phone calls and text messages, today almost all mobile phones are “smart phones”, and can be used for many of the same functions as a computer or television would. Although they consume less power than a computer for a given task, the proximity and constancy of exposure is much greater. For example, these devices are generally carried around in pockets, placed on bedside tables at night and held in the hand or next to the ear when used. The additional functionalities of smart phones come with much greater wireless transmissions of data.

Why relevant to health and wellbeing:

People are being exposed to artificial EMF more and more due to a combination of societal and personal lifestyle megatrends, such as:

- The shift to people living in more urbanised and more densely populated environments (denser populations equate to more intense rates of electricity consumption and wireless data transfers).
- Almost everyone now owns a smart phone that uses wifi networks for data consumption.
- The quantity of digital devices and appliances (Internet of Things) that can connect to wireless networks has increased massively.
- The deployment of smart meters in buildings.

- People are accessing news and entertainment media more and more via wireless networks than cabled ones or paper-based media.

With increasing urbanisation, and the real estate value of certain land driving development in areas that are ever closer to power lines. To cope with increasing demand for wireless data, cell towers are becoming more numerous (and thus closer to buildings).

A thorough review of academic literature will be necessary before being able to summarise the main research findings as there are many conflicting results and just as many potential conflicts of interest. Care will need to be taken to identify impartial and reproducible results regarding health effects caused by well-defined EMF exposure protocols that are realistic for common environments.

Concerns about the effect of EMFs on health and wellbeing have often focussed on the investigation of unusual clusters of cancer cases (especially child cancer) in populations living near large radio transmitters (Dolk et al., 1997) or power lines (Wertheimer and Leeper, 1979; Skinner et al., 2002). In vitro studies of exposure of cancer cells to 60-Hz EMFs (typical of power lines in US) showed major effects on promoting cancer cell growth rates (Philips et al., 2006). Even assuming that 60-Hz EMFs from power lines do not cause cancer, the fact that they could promote the growth of cancerous cells already present in a person is a major cause for concern. Studies that attempt to find correlations between electric field strengths and adverse health effects but which ignore magnetic fields or vice versa, may result in incomplete conclusions. With radiofrequencies (RFs), the International Agency for Research on Cancer (IARC) has classified RF EMFs as possibly carcinogenic to humans. With regards to dirty electricity, some research in the academic literature is implying that dirty electricity in building electrical wiring could be a major factor in cancer risk for building occupants (Milham and Morgan, 2008) and in teacher wellbeing and student behaviour (Havas and Olstad, 2008).

The rate of technological progress has been so rapid and so widespread that it is extremely difficult for any potential medium and long term health effects to be pinned down to any specific type of electropollution and it is virtually impossible to reproduce real-life exposures in a laboratory. Nonetheless, isolated studies have investigated the potential of extremely low frequency (ELF) fields at levels well below those required to cause thermal effects and found mixed results about effects on animal embryo development (Maffeo et al., 1984) or animal fertility (Bernabo et al., 2010).

In reality, building occupants are exposed to a combination of EMFs that come from power and telecommunications infrastructure, their own electrical network and devices, and those of their neighbours. Ambient levels of EMF are undoubtedly a concern, but today it is perfectly plausible that the dominant source of exposure of individuals to electropollution can come from their own buildings. Consequently, the EU GPP criteria focus on measures that can be taken in the occupied building.

It is necessary to be able to measure EMFs throughout a building to determine if a where levels may be problematic, and then to take remedial action. This is why the EU GPP criteria propose an assessment of sleeping areas in residential buildings and workstations in offices or educational buildings. Further research is needed to determine exactly how dirty electricity could be assessed and what types of remedial action or design solutions could be recommended.

Potential environmental trade-offs:

Efforts to reduce EMFs in buildings can conflict with other environmentally-orientated design and management decisions. For example, the installation of onsite renewables and any transformers and inverters that come with them, will present potentially strong and highly modulated EMFs that would not be present in such levels if simply taking electricity from the grid. Another example would be the use of dimmable lighting to reduce energy consumption by avoiding overlighting, but many of the circuit set-ups for dimmable products also create so-called “dirty electricity”.

Creating a cabling network as an alternative to wifi will result in the need for more cables and conduits, may reduce the adaptability of building spaces and workstation layouts and may create certain inconveniences for occupants or sensor-based control systems.

Policy relevance:

In 2011, the Council of Europe passed [Resolution 1815](#) on the potential dangers of electromagnetic fields and their effect on the environment. In the Resolution, the serious limitations of present standards on exposure to electromagnetic fields set by the International Commission on Non-Ionising Radiation Protection where stated. It was recommended that ALARA (As Low As Reasonably Achievable) principles should be applied, especially

considering the needs and welfare of electrosensitive people and children. The Resolution also draws attention to the relevance of the Aarhus Convention regarding citizens to receive environmental information that is held by public authorities and to participate in environmental decision-making. In the case of EMFs, this could refer to participation in planning decisions to install cell towers, radio-transmitters or power lines and sub-stations.

What do Green Building Rating Systems or other initiatives say?

The 2015 Standard of Building Biology, which has a European-based and a US-based organisation, has been the main source of inspiration behind the EU GPP criteria proposals. The standard provides quantitative limits for EMFs in sleeping areas that are split into four levels.

Table 3. Building biology standard limits for fields, waves and radiation

		No anomaly	Slight anomaly	Severe anomaly	Extreme anomaly
AC electric fields	Field strength (with ground potential)	<1 V/m	1-5 V/m	5-50 V/m	>50 V/m
	Field strength (potential-free)	<0.3 V/m	0.3-1.5 V/m	1.5-10 V/m	>10 V/m
	Body voltage (with ground potential)	<10 mV	10-100 mV	100-1000 mV	>1000 mV
AC magnetic fields	Flux density	<20 nT	20-100 nT	100-500 nT	>500 nT
	Flux density	<0.2 mG	0.2-1.0 mG	1.0-5.0 mG	>5.0 mG
RF radiation	Power density	<0.1 $\mu\text{W}/\text{m}^2$	0.1-10 $\mu\text{W}/\text{m}^2$	10-1000 $\mu\text{W}/\text{m}^2$	>1000 $\mu\text{W}/\text{m}^2$

The ambition level for EU GPP criteria have been set to align with the upper limit of the “slight anomaly” range for the core criteria and the comprehensive criteria are set to be double the lower limit of the “slight anomaly” range, which is always considerably less than the upper limit of this range.

The building biology standard also sets limits for static electric fields, static magnetic fields, radioactivity and geological disturbances and the possibility of incorporating these measurements in GPP criteria could be explored further in the next criteria proposals.

Targeted questions to stakeholders about TS4.1 to 4.5:

Q22: How do national and regional methodologies under the Energy Performance of Buildings Directive framework address design estimates for energy consumption due to ventilation, heating, cooling, lighting and/or hot water production?

Q23: Do you think phase-change materials an important role to play in indoor temperature regulation? If yes, then what is the best way to specify this?

Theme 5: Vulnerability and resilience to climate change

The initial proposals here focus on designing against risks of overheating during heatwaves, to improve resilience to flood events and to reduce flood risk downstream. Readers should be aware that there is an ongoing project involving DG CLIMA, DG JRC and Ramboll to develop best practice guidance for assessing and minimising these same climate risks to buildings and potentially others too. The developments of this project may have a direct impact on the next version of proposed criteria in theme 5.

5.1. Future thermal comfort: time out of range

Core criteria				Comprehensive criteria			
TECHNICAL SPECIFICATIONS (TSs)							
<i>Note: TS5.1.1. is effectively the same process as defined for TS4.2.1, but with the difference of using a projected future climate data file (e.g. projections to 2030 or 2050) instead of current climate data.</i>							
Design	Site prep.	Construction	Management	Design	Site prep.	Construction	Management
<p>TS5.1.1: Future thermal comfort: time out of range.</p> <p>For occupancy patterns defined by the contracting authority, the indoor air temperatures shall be dynamically modelled for the detailed building design with hourly climate data projected to 2030 for the following two situations:</p> <ul style="list-style-type: none"> • With no mechanical cooling system installed. • With a mechanical cooling system installed. <p>If no mechanical cooling system is installed, the passive features of the building design and any installed HVAC equipment shall be capable of providing an indoor temperature within the range of 18 to 27 °C for occupied spaces for:</p> <ul style="list-style-type: none"> • 80% of occupied hours for any week, • 88% of occupied hours for any month; • 95% of occupied hours for the year. <p>If a mechanical cooling system is installed, it should be sized to guarantee an upper temperature of less than 27°C during 95% of the occupied hours for any week.</p> <p>The correct construction and installation of the HVAC systems and of any building elements especially relevant to predicted thermal performance shall be ensured by the project manager during the construction and installation stages.</p> <p>Verification:</p> <p>The contracted design team shall provide a design report explaining the calculation methodology, climate data used, any assumptions (e.g. occupation patterns, metabolic factors for activities, clothing factors), the heating system design, any mechanical cooling system design and capacity, thermal properties of the building envelope, interior wall and floor surfaces and any passive design features for</p>				<p>TS5.1.1: Future thermal comfort: time out of range.</p> <p>For occupancy patterns defined by the contracting authority, the indoor air temperatures shall be dynamically modelled for the detailed building design with hourly climate data projected to 2050 for the following two situations:</p> <ul style="list-style-type: none"> • With no mechanical cooling system installed. • With a mechanical cooling system installed. <p>If no mechanical cooling system is installed, the passive features of the building design and any heating system shall be capable of providing a category II (or category I) thermal environment as defined in EN 16798-1, or maintain the temperature within specific ranges defined by the contracting authority, for the building interior during at least:</p> <ul style="list-style-type: none"> • 85% of occupied hours for any week, • 92% of occupied hours for any month; • 97% of occupied hours for the year. <p>If a mechanical cooling system is installed, it should be sized to guarantee a category II thermal environment during 97% of the occupied hours for any week.</p> <p>The correct construction and installation of the HVAC systems and of any building elements especially relevant to predicted thermal performance shall be ensured by the project manager during the construction and installation stages.</p> <p>Verification:</p> <p>The contracted design team shall provide a design report explaining the calculation methodology, climate data used, any assumptions (e.g. occupation patterns, metabolic factors for activities, clothing factors), the heating system design, any mechanical cooling system design and capacity, thermal properties of the building envelope, interior wall and</p>			

Core criteria				Comprehensive criteria			
TECHNICAL SPECIFICATIONS (TSs)							
<i>Note: TS5.1.1. is effectively the same process as defined for TS4.2.1, but with the difference of using a projected future climate data file (e.g. projections to 2030 or 2050) instead of current climate data.</i>							
<p>cooling or solar gain.</p> <p>The results, at hourly scale, will clearly show the time when occupied spaces are out of the defined thermal comfort range and the extent to which they are out of range.</p> <p>In cases where the defined ranges correspond to EN 16798-1 categories, the category II criteria:</p> <ul style="list-style-type: none"> from Annex B2.1 to EN 16798-1 shall be applied if the design includes a mechanical cooling system from Annex B2.2 to EN 16798-1 shall be applied if the design does not include a mechanical system. <p>Design features that are crucial to delivering the design thermal environment should be carefully checked by the project manager during the construction and installation stage.</p>				<p>floor surfaces and any passive design features for cooling or solar gain.</p> <p>The results, at hourly scale, will clearly show the time when occupied spaces are out of the defined thermal comfort range and the extent to which they are out of range.</p> <p>In cases where the defined ranges correspond to EN 16798-1 categories, the category II criteria:</p> <ul style="list-style-type: none"> from Annex B2.1 to EN 16798-1 shall be applied if the design includes a mechanical cooling system from Annex B2.2 to EN 16798-1 shall be applied if the design does not include a mechanical system. <p>Design features that are crucial to delivering the design thermal environment should be carefully checked by the project manager during the construction and installation stage.</p>			
Design	Site prep.	Construction	Management	Design	Site prep.	Construction	Management
<p>TS5.1.2: Passive features to minimise overheating risk.</p> <p>Regardless of whether a mechanical cooling system is installed or not, the building design will incorporate passive features to help regulate internal temperature, such as:</p> <ul style="list-style-type: none"> Adjustable solar shading to maximise solar gain in cold periods and minimise solar gain in hot periods. Cross-ventilation to allow excessively hot air to rise through and exit the building. The use of exposed thermal mass or phase change materials to buffer against overheating. <p>The correct construction and installation of any building elements especially relevant to predicted thermal performance shall be ensured by the project manager during the construction and installation stages.</p> <p>Verification:</p> <p>The design team shall provide a brief description of the building design with the passive thermal aspects clearly highlighted.</p> <p>The project manager shall provide written confirmation that the relevant design features have been appropriately installed.</p>				<p>TS5.1.2: Passive features to minimise overheating risk.</p> <p>Regardless of whether a mechanical cooling system is installed or not, the building design will incorporate passive features to help regulate internal temperature, such as:</p> <ul style="list-style-type: none"> Adjustable solar shading to maximise solar gain in cold periods and minimise solar gain in hot periods. Cross-ventilation to allow excessively hot air to rise through and exit the building. The use of exposed thermal mass or phase change materials to buffer against overheating. The use of heat exchangers to dump excess heat from air into the water heating system. The use of an overhanging green roof, green balconies and/or green facades to provide thermal mass, solar shading and evaporative cooling effects via evapotranspiration (see TS 7.1 and 7.2.). <p>The correct construction and installation of any building elements especially relevant to predicted thermal performance shall be ensured by the project manager during the construction and installation stages.</p> <p>Verification:</p> <p>The design team shall provide a brief description of the building design with the passive thermal aspects</p>			

Core criteria	Comprehensive criteria
TECHNICAL SPECIFICATIONS (TSs)	
<i>Note: TS5.1.1. is effectively the same process as defined for TS4.2.1, but with the difference of using a projected future climate data file (e.g. projections to 2030 or 2050) instead of current climate data.</i>	
	<p>clearly highlighted.</p> <p>The project manager shall provide written confirmation that the relevant design features have been appropriately installed.</p> <p style="background-color: yellow;">For the green roof, balcony or facade design, the growing media, planting plan and irrigation system shall be clearly explained and an operation and maintenance manual provided for the building management team.</p>

Supporting rationale for technical specifications 5.1.1 and 5.1.2:

Why might future thermal comfort be different from thermal comfort today?

Climate data in the built environment and its degree of influence on indoor temperature levels will depend on various factors. The main factors that contribute to an increased risk of overheating inside buildings can be broadly related to external environmental factors, building-related factors and user-related factors.

Environmental factors:

- Increased risk of the urban heat island effect in developed areas as surrounding green spaces and surface water is reduced.
- Increased use of mechanical cooling to cool indoor air in some buildings during hot periods actually increases outdoor temperatures in the surrounding area even more.
- Climate change predictions project that increasing concentrations of CO₂ in the atmosphere could increase global average temperatures by a 1.5 to around 4 °C depending on how much CO₂ concentrations may increase in the future.

Building-related factors that can contribute to overheating risk:

- Increased use of glazing without openable windows in modern building envelopes increasing the risk of passive solar gain. The lack of openable windows predominates in urban environments where environmental noise or ambient air quality would compromise acoustic performance or indoor air quality levels.
- Building envelopes that are designed to keep heat in by decreasing thermal conductivity and air permeability. This will reduce heating energy costs, but increase the risk of overheating if ventilation strategies are inadequate.
- Lower floor to ceiling heights in modern buildings provide less room for hot air to rise. Lower floor heights can be due to the desire to maximise usable floor area for a specific building volume and to accommodate increasing building service infrastructures in false ceilings or under floor coverings.
- Smaller living spaces per person for modern residential buildings, mainly driven by profit margins for property developers.
- Lack of exposed thermal mass or phase change materials inside buildings.

User-related factors that can contribute to overheating risk:

- Inadequate use of openable windows and options for passive cooling in buildings (e.g. opening windows during the night-time or partially or fully lowering shades when sun is directly shining on windows).
- Inadequate clothing for the indoor temperature.

- Inadequate metabolic activities (e.g. working or being outdoors during hottest hours), hygiene habits (e.g. warm showers), hydration (drinking of water) or eating habits (e.g. cooked food) for warm periods in a work or residential environment.

The building-related factors that can contribute to overheating are especially important to building stock in temperate climate zones which have made big advances in improving energy efficiency and whose efforts have mainly focussed on reducing heating demand (Lomas and Porritt, 2017).

Why is increased overheating a problem?

Overheating adversely affects human physiology, which is based on thermoregulation within narrow windows. Natural cooling mechanisms of the human body via radiant heat emission and sweating can be pushed beyond the limit if people do not take care during regular summer temperatures, let alone during heatwaves. From a biological perspective, the members of society most vulnerable to overheating are the elderly and those with health conditions that limit their capacity for thermoregulation. From a social perspective, other vulnerable members of society are those who cannot afford to install or power mechanical cooling systems, those who live in poorly designed buildings, those who have limited mobility and those who need to work outdoors during the hottest hours.

A warmer urban environment will exacerbate heatwave effects which, according to Naumann et al., 2020 who, citing Munich Re's NatCatSERVICE, state that more than 2000 heat-related fatalities per year were reported in the EU (including the UK) during the period from 1980 to 2017.

Projecting to the year 2100 (and accounting for an older demographic and warmer temperature in Europe), Naumann et al., (2020) predicted that European populations exposed to heatwaves and fatalities due to overheating could increase as follows:

Table 4. Potential effects of heatwaves on Europeans in 2100 under different climate scenarios

Scenario for 2100	EU (and UK) citizens exposed to a 1 in 50 year heatwave	Annual fatalities from heatwaves
Baseline	9,600,000	2,800
1.5 °C increase	105,000,000	30,300
2.0 °C increase	172,000,000	52,400
3.0 °C increase	298,000,000	96,000

Clearly the effects of an average increase of temperature by just a few degrees can have a major effect (x10 to x35) increase in heatwave fatalities. Similar increases in the numbers of citizens exposed to 1 in 50 year heatwaves is predicted to occur as well, in line with predicted fatalities. Even when heatwaves do not kill citizens, they create mental stress, can cause adverse health effects that reduce quality of life, reduce worker or student productivity and can lead to health services being overwhelmed.

Potential environmental trade-offs:

The quickest and simplest solution to overheating is to install a mechanical cooling system that can deliver cooled air to the most important occupied spaces in the building. However, this solution comes with some trade-offs, both at the individual building level and on a much broader scale.

For example, mechanical cooling is an energy intensive process and will increase electricity bills for the occupant. Considering that mechanical cooling works by transferring heat from the supply air into the exhaust air, the exhaust air being emitted to the surrounding environment will be even hotter than the ambient air. Considering densely developed urban areas, hundreds or thousands of mechanical cooling systems working at the same time can increase ambient air temperature even further, thus exacerbating the heatwave in dense urban areas. Another problem is that the peak power demand caused by the simultaneous operation of many mechanical cooling devices places a strain on the electrical grid.

The coolant used in mechanical cooling systems is normally a hydrofluorocarbon (HFC), which has a global warming factor that is generally hundreds of times higher than CO₂. The HFC coolant gradually leaks from the system to the atmosphere. When looked at from a life cycle perspective, a study presented by the Concrete Centre (2021) showed that leakage of coolant accounted for around 10% of life cycle Global Warming Potential.

A passive cooling design would deliver many of the benefits of the mechanical cooling system and avoid many of the problems, but passive systems would be more difficult and costly to retrofit into existing buildings, and would require more design effort for new buildings. Passive systems may not be able to fully cope with extreme heatwaves, even though they could greatly reduce the need for mechanical cooling in such periods.

Policy relevance:

Overheating is a central part of the broader policy objective of “adaptation to climate change”. A new EU strategy on adaptation to climate was published in 2021, which actively supports the use of GPP criteria to deliver climate adaptation in building construction and renovation.

The policy goal of climate adaptation is one of the six main environmental objectives of the EU Taxonomy (Annex II) for a wide range of economic activities and the Level(s) framework (macro-objective 5), specifically for buildings.

The increasing problem of overheating in buildings is acknowledged by the EPBD in the recitals, where it is stated: *“Recent years have seen a rise in the number of air-conditioning systems in European countries. This creates considerable problems at peak load times, increasing the cost of electricity and disrupting the energy balance. Priority should be given to strategies which enhance the thermal performance of buildings during the summer period. To that end, there should be focus on measures which avoid overheating, such as shading and sufficient thermal capacity in the building construction, and further development and application of passive cooling techniques, primarily those that improve indoor climatic conditions and the micro-climate around buildings.”* This text clearly encourages passive cooling for buildings wherever possible.

Market considerations:

The same considerations apply here that applied to TS 4.2.1.

What do Green Building Rating Systems or other initiatives say?

The same Green Building Rating System criteria apply here that apply to TS 4.2.1.

5.2. Resilience to flooding

Core criteria				Comprehensive criteria			
TECHNICAL SPECIFICATIONS (TSs)							
<p><i>Note: TSS.2 should be applied for buildings that are considered to be standing in areas of identified flood risk (pluvial, fluvial or coastal flooding). Building in such areas should be avoided unless there is no viable alternative for the contracting authority. In such cases, the potential to reduce flood risk downstream should also be considered by applying TSS.3.</i></p>							
Design	Site prep.	Construction	Management	Design	Site prep.	Construction	Management
<p>TSS.2.1: Design for resilience to flooding.</p> <p>In order to reduce the potential damage caused by flooding:</p> <ul style="list-style-type: none"> The lowest points of ingress to the building shall be elevated to a level equivalent to that of a 1 in 100 year (1% probability) flood event. Or, The building envelope shall be treated to be impermeable to water to a level equivalent to that of a 1 in 100 year (1% probability) flood event plus 1 metre. <p>The correct construction and installation of any building elements especially relevant to flood resilience shall be ensured by the project manager during the construction and installation stages.</p> <p>Verification:</p> <p>The design team shall provide a brief description of the building design with the flood resilience aspects clearly highlighted.</p> <p>The project manager shall provide written confirmation that the relevant design features have been appropriately installed.</p>				<p>TSS.2.1: Design for resilience to flooding.</p> <p>In order to reduce the potential damage caused by flooding:</p> <ul style="list-style-type: none"> The lowest points of ingress to the building shall be elevated to a level equivalent to that of a 1 in 200 year (0.5% probability) flood event. The building envelope shall be treated to be impermeable to water to a level equivalent to that of a 1 in 200 year (0.5% probability) flood event plus 1 metre. The interior surfaces of the ground floor and any subterranean floors will be designed and treated to be resilient to exposure to flood water (e.g. no critical equipment located in these levels, materials are impermeable and/or easy to dry and clean and not be subject to warping or corrosion after flooding). <p>The correct construction and installation of any building elements especially relevant to flood resilience shall be ensured by the project manager during the construction and installation stages.</p> <p>Verification:</p> <p>The design team shall provide a brief description of the building design with flood resilience aspects clearly highlighted.</p> <p>The project manager shall provide written confirmation that the relevant design features have been appropriately installed.</p>			

Supporting rationale for technical specification 5.2.1:

Why is flood risk an increasing concern?

Similar to overheating, the driving forces behind recent increases in the problem of flooding are due both to man-made changes in the surrounding environment and much wider changes in weather patterns.

The local or regional man-made changes that are contributing to increased flood risk are broadly related to increasing urbanisation, both in floodplains and in upstream areas that were previously greenfield sites. The result of the installation of conventional drainage systems in urbanised areas is that rainfall from a storm event landing on an impermeable urban surface is rapidly drained to the natural watercourse and this results in higher and more acute peaks in river flow rates for a given storm event. With all this water draining so quickly to the natural watercourse, the risk of fluvial flooding downstream is increased. If the drainage network becomes blocked, or was not originally designed to accept runoff from such large areas, then the risk of pluvial flooding increases in the immediate area.

Potential environmental and social benefits:

When a developed area floods, the damage to buildings and infrastructure creates not only economic and environmental damage, but also major societal disruption. This damage and disruption can be substantially reduced by constructing buildings that are resilient to flooding, either by being elevated, by being designed to prevent the entry of flood water and/or by being designed to be easy to drain, clean and dry after flood water has entered. Well planned designs may also result in lower premiums for building insurance.

Potential environmental trade-offs:

Elevating a building will require significant more concrete in foundations and additional earthworks. It may also limit the potential usable space for a given structural frame volume and plot area if subterranean floors are not included and mechanical plant and electrical systems need to be installed above ground. This situation could translate to a significantly higher specific embodied carbon (kgCO₂.eq./m²).

Policy relevance:

Flood resilience is a central part of the broader policy objective of “adaptation to climate change”. A new EU strategy on adaptation to climate was published in 2021, which actively supports the use of GPP criteria to deliver climate adaptation in building construction and renovation.

The policy goal of climate adaptation is one of the six main environmental objectives of the EU Taxonomy (Annex II) for a wide range of economic activities and the Level(s) framework (macro-objective 5), specifically for buildings.

What do Green Building Rating Systems or other initiatives say?

To be checked.

5.3. Sustainable drainage

Core criteria				Comprehensive criteria			
TECHNICAL SPECIFICATIONS (TSs)							
<p><i>Note: TS5.3 is focussed on the volumetric or quantitative performance, it does not detail any of the biodiversity aspects that such systems could or should embrace. Consequently, in order to maximise the environmental benefits of sustainable drainage design, this criterion should be applied in tandem with TS3.1.2 and TS7.3.</i></p> <p><i>The design storm data must be relevant to the building site and may be provided by the contracting authority or another public entity specialising in this field. It is up to the contracting authority to decide if a certain modelling software must be used as well.</i></p>							
Design	Site prep.	Construction	Management	Design	Site prep.	Construction	Management
<p>TS5.3. Sustainable drainage</p> <p>For a design storm of 1 in 100 year return period (1% probability) of 4 hour duration, the drainage system for the building and any surrounding plot area will be designed to hold rainwater onsite and deliver runoff rates that are the same or lower than if the plot was an undeveloped greenfield site..</p> <p>The drainage system may be linked only to the building or be part of a larger system that also drains other areas beyond the building plot area. In either case, the design performance should be validated for the whole drainage system.</p> <p>The correct construction and installation of any drainage system components especially relevant to design performance shall be ensured by the project manager during the construction and installation stages.</p> <p>Verification:</p> <p>The design team shall provide a maintenance plan and a detailed description of the drainage system, including all of its components, how they are linked together, any storage capacities, overflow pipes and controlled runoff outlets.</p> <p>A report of the hydraulic simulation showing how the drainage system performs under the design storm condition shall be provided. The report shall include rainfall inputs from drained areas, water levels in storage components and runoff outputs for the design storm period.</p> <p>The target runoff rate shall be clearly stated in the report and this shall be the outcome of a parallel simulation carried out for the same rainfall inputs for the same area but assuming that it was a greenfield site. Any assumptions shall be clearly explained.</p>				<p>TS5.3. Sustainable drainage</p> <p>For a design storm of 1 in 200 year return period (0.5% probability) of 8 hour duration, the drainage system for the building and any surrounding plot area will be designed to hold rainwater onsite and deliver runoff rates that are the same or lower than if the plot was an undeveloped greenfield site..</p> <p>The drainage system may be linked only to the building or be part of a larger system that also drains other areas beyond the building plot area. In either case, the design performance should be validated for the whole drainage system.</p> <p>The correct construction and installation of any drainage system components especially relevant to design performance shall be ensured by the project manager during the construction and installation stages.</p> <p>Verification:</p> <p>The design team shall provide a maintenance plan and a detailed description of the drainage system, including all of its components, how they are linked together, any storage capacities, overflow pipes and controlled runoff outlets.</p> <p>A report of the hydraulic simulation showing how the drainage system performs under the design storm condition shall be provided. The report shall include rainfall inputs from drained areas, water levels in storage components and runoff outputs for the design storm period.</p> <p>The target runoff rate shall be clearly stated in the report and this shall be the outcome of a parallel simulation carried out for the same rainfall inputs for the same area but assuming that it was a greenfield site. Any assumptions shall be clearly explained.</p>			

Supporting rationale for technical specifications 5.1.1 and 5.1.2:

Conventional drainage solutions convey storm water rapidly away from the site to be drained. While this solution has worked well for decades in many places, in areas subjected to major variations in population (e.g. summer tourism) the mains sewerage system has to be sized for peak loads but ends up with very low flow velocities during the winter. A common solution to this problem is to divert storm water drainage into the sewers (creating “combined sewers”), which provide the extra flow needed during the wetter winter months.

However, there are several major problems with rapid storm drainage and combined sewer systems today, which include the following:

- The drainage capacity of storm drains and combined sewers cannot be easily increased, but the impermeable areas that feed these drains have increased substantially in piecemeal fashion in line with urban development. As the margins between actual hydraulic loadings and design capacities of drainage systems continue to reduce, the risk of pluvial flooding in the surrounding area increases for a given storm event.
- A lot of rapidly draining areas upstream will create a large peak flowrate in the river downstream for a given storm event – thus increasing the risk of fluvial flooding downstream.
- Increases in average sea and land temperatures via climate change is being linked to increasing intensities of storm events in many parts of Europe – translating into an increased risk of both pluvial and fluvial flooding.

Potential environmental and social benefits:

By reducing peak stormwater runoff rates, a retentive drainage system reduces the peak flow rates in downstream watercourses, thus reducing the risk of fluvial flooding. Such a drainage system also reduces pressure on drainage networks in the surrounding area, thus reducing the risk of localised pluvial flooding.

Another potential benefit is the collection of rainwater for future use as an alternative to potable water (e.g. consider combining this technical specification with TS3.1.2.). If stored rainwater is used for irrigation, it could be combined with TS7.1 (green roofs), TS7.2 (green walls) or TS7.3 (landscaping and habitat creation). Keeping water onsite can help combat the urban heat island effect via evaporative cooling.

Finally, the deliberate permanent retention of water in above surface retention ponds or below surface reed beds can be used to contribute to green space and habitat creation (e.g. used in

Potential environmental trade-offs:

Retentive drainage systems will always require increased maintenance when compared to direct connections to storm drains or combined sewers. If not designed, installed and managed properly, retentive drainage systems could provide habitats for unwanted insects or vermin and/or generate odours due to stagnant water.

Policy relevance:

Flood risk reduction is a central part of the broader policy objective of “adaptation to climate change”. A new EU strategy on adaptation to climate was published in 2021, which actively supports the use of GPP criteria to deliver climate adaptation in building construction and renovation.

The policy goal of climate adaptation is one of the six main environmental objectives of the EU Taxonomy (Annex II) for a wide range of economic activities and the Level(s) framework (macro-objective 5), specifically for buildings.

In case the drainage system is designed to hold rainwater for human consumption (links to water efficiency objectives) or is designed to hold it in such a way as part of habitat creation (links to biodiversity) then design for flood risk reduction can cut across different policy areas as well.

What do Green Building Rating Systems or other initiatives say?

To be checked.

5.4. Resilience to mains energy and water supply failures

Core criteria				Comprehensive criteria			
TECHNICAL SPECIFICATIONS (TSs)							
<i>Note: TS5.4. is especially important in areas of poorly reliable infrastructure and/or extreme climate risk, where weather events could easily cut grid electricity supplies and/or potable water supplies.</i>							
Design	Site prep.	Construction	Management	Design	Site prep.	Construction	Management
<p>TS5.4: Resilience to mains energy and water supply failures</p> <p>The building shall have an onsite means of generating heat and electricity from onsite energy stores that are sufficient for meeting 3 days of normal demand.</p> <p>The building shall have a store of potable water and/or harvested rainwater that is sufficient for meeting 3 days of normal demand.</p> <p>The building management shall ensure that these contingency systems comply with any relevant national or regional safety standards.</p> <p>Verification:</p> <p>The design team shall provide details of the onsite heat and electricity generating system(s), indicating whether they are principle or backup systems, and details of the harvested rainwater and/or potable water storage systems. Compliance with any national or regional safety standards shall be demonstrated.</p> <p>The building management should determine how much 3 days of normal heat, electricity and water consumption would be, and ensure that sufficient stores of energy and water are held onsite at all times.</p>				<p>TS5.4: Resilience to mains energy and water supply failures</p> <p>The building shall have an onsite means of generating heat and electricity from onsite energy stores that are sufficient for meeting 10 days of normal demand.</p> <p>The building shall have a store of potable water and/or harvested rainwater that is sufficient for meeting 10 days of normal demand.</p> <p>The building management shall ensure that these contingency systems comply with any relevant national or regional safety standards.</p> <p>Verification:</p> <p>The design team shall provide details of the onsite heat and electricity generating system(s), indicating whether they are principle or backup systems, and details of the harvested rainwater and/or potable water storage systems. Compliance with any national or regional safety standards shall be demonstrated.</p> <p>The building management should determine how much 10 days of normal heat, electricity and water consumption would be, and ensure that sufficient stores of energy and water are held onsite at all times.</p>			

Supporting rationale for technical specifications 5.4.1:

There are many reasons that power supply or water supply systems can fail. These could be weather-related (e.g. storms), natural disaster (e.g. earthquake), be due to accidents or be due to deliberate interventions (e.g. vandalism, cyber attacks or acts of war).

The vast majority of buildings in Europe are connected to the electrical grid and are supplied by mains potable water and mains gas. The design and management of buildings to cope without external power or water supply is extremely rare in many areas of Europe due to:

- A well-developed and regulated energy supply and water supply infrastructure and markets.
- Relatively high degree of the EU population living in urbanised areas.
- The relatively mild climates in Europe (i.e. lack of extreme storms and temperatures).
- The relatively low extent of seismic activity in the majority of Europe.

Despite the low probability of occurrence, risk management matrices compare the probability of a risk occurring with the potential harm that the risk would pose if it were to occur.

The immediate and unexpected disruption of power supply to a building results in the immediate cessation of productive activities in that building and could compromise critical systems relating to the security of the building or services it provides to customers or students. In residential buildings, the disruption is potentially

less, but it puts occupants at the risk of extreme heat or cold, greatly complicates visual tasks during the night, prevents the ability to cook food or preserve foodstuffs that need to be chilled or frozen and greatly reduces the mobility of elderly or infirm residents that rely on elevators.

The immediate and unexpected disruption of mains water supply to a building may range from being an inconvenience in offices or educational buildings to creating a public health emergency due to the inability to flush toilets or obtain access to clean drinking water.

Potential environmental and social benefits:

The ability for a building to continue with power supply could provide benefits not only to building occupants but also to neighbouring citizens. This could be critical for saving human lives (e.g. safe heating of building spaces in a snowstorm or the provision of drinking water to prevent dehydration).

For buildings with large vegetated areas, a creative approach could be to harvest rainwater or reuse greywater to cultivate reeds, which could act as a biomass fuel for an onsite combined heat and power unit. For buildings with battery energy storage of sufficient capacity, in normal periods this system could be used to charge up during off-peak hours and to preferentially power the building from battery during peak hours, in order to reduce electricity bills. Such a system would also ensure that any onsite generated renewable energy could be exported during peak hours, again, in order to obtain the maximum economic performance of the building energy system.

Potential environmental trade-offs:

The introduction of any secondary or back-up energy systems or water storage facilities will increase the embodied carbon of the building and occupy space that could otherwise be used by occupants or other building technical systems.

What do Green Building Rating Systems or other initiatives say?

To be checked.

Targeted questions to stakeholders about TS5.1 to 5.4:

Q24: Any suggestions on sources to find the climate files for the EU? If there are different sources, how do they compare in terms of resolution and length of historical data?

Q25: Is there a unified European approach to defining design storm events? And likewise, is there a European method for flood risk assessment?

Q26: Any examples of best practice design or requirements in national or regional building codes for requirements relating to overheating, flood resilience, sustainable drainage or resilience to mains energy or water failures?

Q27: Any examples of design software used for modelling overheating, flood risk mapping or runoff rates from drainage systems?

Theme 6: Life cycle costing

6.1. Life cycle cost assessment

Core criteria				Comprehensive criteria																																																																		
TECHNICAL SPECIFICATIONS (TSs)																																																																						
<p>Note: TS6.1. If life cycle costs are being compared for competing offers from different tenderers, it is important that certain assumptions are fixed, such as the discount rate or default service lives for defined building elements (which could only be altered if supported by a specific supplier guarantee). If a life cycle carbon assessment has been done for TS1.2, then it must be closely related to the data used for TS6.1 here, and vice versa.</p>																																																																						
Design	Site prep.	Construction	Management	Design	Site prep.	Construction	Management																																																															
<p>TS6.1: Life cycle cost assessment</p> <p>Note: The final results should be reported in the format presented in the explanatory note for the sake of transparency and consistency. It is up to the contracting authority to define the scope of the assessment clearly in the call for tender, as well as any more specific national or regional methodology to be followed that is in line with EN 15459-1.</p> <p>At the design stage, the whole life cycle costs of the building shall be estimated in units of €/m²/yr and split for modules A, B and C.</p> <p>Verification:</p> <p>The cost consultant and design team will provide a written report based on the reporting format provided in the explanatory note and in accordance with the EN 15459-1 standard.</p>				<p>TS6.1: Life cycle cost assessment</p> <p>Note: The final results should be reported in the format presented in the explanatory note for the sake of transparency and consistency. It is up to the contracting authority to define the scope of the assessment clearly in the call for tender, as well as any more specific national or regional methodology to be followed that is in line with EN 15459-1.</p> <p>A total of three whole life cycle cost assessments shall be carried out: (i) at the design stage; (ii) after the building has been completed, and (iii) after X years occupation. The whole life cycle costs of the building shall be estimated in units of €/m²/yr and split for modules A, B and C.</p> <p>Verification:</p> <p>The cost consultant and design team will provide a written report based on the reporting format provided in the explanatory note and in accordance with the EN 15459-1 standard.</p>																																																																		
<p><u>Explanatory note for TS6.1:</u></p> <p>The life cycle cost data should be reported in the following format:</p> <table border="1"> <thead> <tr> <th rowspan="2">Type of cost</th> <th colspan="3">Normalised cost by life cycle stage (€/m²/yr)</th> </tr> <tr> <th>A Product and construction stages</th> <th>B Use stage</th> <th>C End of life stage</th> </tr> </thead> <tbody> <tr> <td>Initial costs</td> <td>Construction</td> <td>Refurbishment and adaption</td> <td>Deconstruction and demolition</td> </tr> <tr> <td rowspan="2">Annual costs</td> <td>-</td> <td>Energy</td> <td>Water</td> </tr> <tr> <td>-</td> <td>Maintenance, repair and replacement</td> <td>-</td> </tr> <tr> <td>Periodic costs</td> <td>-</td> <td>Maintenance, repair and replacement</td> <td>-</td> </tr> <tr> <td>Global costs by life cycle stage</td> <td>Sum of stage A costs</td> <td>Sum of stage B costs</td> <td>Sum of stage C costs</td> </tr> </tbody> </table> <p>For transparency, the initial costs and costs for maintenance, repair and replacement should also be reported for at least the following elements and technical systems listed below:</p> <table border="1"> <thead> <tr> <th rowspan="3">Building elements</th> <th colspan="4">Types of data source used for the identified life cycle stages *</th> </tr> <tr> <th rowspan="2">A Product and construction stages</th> <th colspan="3">Basis for future assumptions</th> </tr> <tr> <th>B2 Maintenance</th> <th>B3 Repair</th> <th>B4 Replacement</th> </tr> </thead> <tbody> <tr> <td>Foundations</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Load bearing structural frame</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Non-load bearing elements</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Facades</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Roof</td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table>								Type of cost	Normalised cost by life cycle stage (€/m ² /yr)			A Product and construction stages	B Use stage	C End of life stage	Initial costs	Construction	Refurbishment and adaption	Deconstruction and demolition	Annual costs	-	Energy	Water	-	Maintenance, repair and replacement	-	Periodic costs	-	Maintenance, repair and replacement	-	Global costs by life cycle stage	Sum of stage A costs	Sum of stage B costs	Sum of stage C costs	Building elements	Types of data source used for the identified life cycle stages *				A Product and construction stages	Basis for future assumptions			B2 Maintenance	B3 Repair	B4 Replacement	Foundations					Load bearing structural frame					Non-load bearing elements					Facades					Roof				
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Core criteria		Comprehensive criteria		
TECHNICAL SPECIFICATIONS (TSs)				
<p><i>Note: TS6.1. If life cycle costs are being compared for competing offers from different tenderers, it is important that certain assumptions are fixed, such as the discount rate or default service lives for defined building elements (which could only be altered if supported by a specific supplier guarantee). If a life cycle carbon assessment has been done for TS1.2, then it must be closely related to the data used for TS6.1 here, and vice versa.</i></p>				
Parking facilities				
Fixed lighting system				
Energy system				
Ventilation system				
Sanitary systems				
Miscellaneous systems				
<p><i>* Data sources classification to be used:</i></p> <ol style="list-style-type: none"> 1. Generic or default national or EU data <ol style="list-style-type: none"> 1a. Default data provided at EU or national level 1b. Default data provided by an existing assessment or reporting scheme 2. Older or less geographically specific benchmarked and averaged data <ol style="list-style-type: none"> 2a. Published benchmark data, aggregated and averaged from similar projects 2b. Estimates from published, average cost data obtained from contractors and suppliers 3. Recent tender and market estimates <ol style="list-style-type: none"> 3a. Analysis of the bills of quantities and schedules from other similar projects 4. Current tender and market estimates <ol style="list-style-type: none"> 4a. Direct estimates based on offers from contractors and suppliers 				

Supporting rationale for technical specifications 6.1:

Potential environmental and economic benefits:

Life cycle costing offers the potential to decide if it is worth investing in more expensive building designs or technical systems that are more energy efficient and/or are more durable, but more expensive than less efficient or less durable alternatives.

Extra emphasis can be given to environmentally friendly solutions if a cost for environmental externalities could be assumed. For example, the cost of carbon emissions could be accounted for in calculations, perhaps using the price of carbon emissions in the EU Emissions Trading System as a rule.

Potential limitations of life cycle costing:

Life cycle costing for buildings is an extremely complicated task, in part due to the complexity of buildings and in part due to their extremely long lifetimes. Forecasting trends over a period of 50 years or more, it is quite impossible to predict with any degree of certainty how labour costs, energy prices and material costs will evolve. Even the currency in use could quite easily change.

Life cycle costing will be more important or less important depending on the owner's intention. Some common owner intentions with building investments are:

- To be occupied by the owner long term (life cycle costing is of interest).
- To be part occupied by the owner and part rented out long term (life cycle costing is still of interest).
- To be fully rented out by the owner long term, with water and energy included in rental price (life cycle costing is of interest for building elements, technical systems and energy/water efficiency).
- To be fully rented out by the owner long term, but tenant pays water and energy bills (life cycle costing is of interest only for building elements and building technical system durability, but not their energy/water efficiency).

- As a financial investment to generate rental income short term (or not at all) and then to sell at a profit (life cycle costing is of little interest as the aim will be to keep capital costs to a minimum and sell before elements and technical systems start to need maintenance and repair).

Since this last bullet point is typical of private enterprises, it can be concluded that life cycle costing is generally of interest to public authorities, who invest in and remain owners of buildings for the long term.

Policy relevance:

This criterion is closely related to macro-objective 6 of the Level(s) framework and has some link to those parts of the Public Procurement Directives that allow for the Most Economically Advantageous Tender (MEAT) to be chosen rather than the traditional “lowest price wins” approach.

Market considerations:

Public authorities have a duty to spend public money responsibly but often fail to realise opportunities to achieve a full or partial return on investment costs because of budgeting procedures, financial structures and a lack of reward or incentive to act on such opportunities. While the private real estate sector has been able to find financial gains even just from basic purchasing and leasing models, the public sector is simply not wired to think about potential income streams that could offer a return on initial investment. Instead, public buildings are simply viewed as a capital cost with a long term operational cost element to add on to that.

Some examples of ways public authorities could think differently are:

- Try to maximise real estate value for flagship projects, such as a railway station. This could mean providing office space for rental (or use by other public agencies) or apartments for railway employees, which could be rented at a reduced rate as part an option on their contracts. A similar approach could be taken for schools and with accommodation for school staff.
- The deliberate or unintentional oversizing of office space needs to allow for renting of space to private companies, which would also provide options for accommodating a future expansion of the public department (i.e. simply not renewing leases on the rented space to make room for extra staff).
- Another example is the generally inefficient use of large land areas associated with school buildings outside of school hours. Playgrounds could be used for farmers markets and other events open to the public. Some schools may have great facilities for organising conferences for external parties. In densely developed areas, the land underneath the playground could be developed into underground parking.
- In terms of energy generation, the availability of combined heat and power systems, that could be fed by biomass harvested onsite or in surrounding areas, the potential to install solar panels and the potential to preferentially store electricity onsite, export to the grid during peak hours or import from the grid during off-peak hours, could also result in the additional investment costs in such onsite renewable energy systems paying for themselves in terms of avoided energy costs and income from exported electricity.

All of these investment options and use scenarios could and should be considered before agreeing on the initial planning and building design.

What do Green Building Rating Systems or other initiatives say?

To be checked.

Targeted questions to stakeholders about TS6.1:

Q28: Are life cycle costs for building projects carried out in a standard way across Europe? Please provide examples of methodologies used.

Q29: Should the life cycle costing align with the [International Cost Management Standard \(ICMS-3\)](#)?

Theme 7: Biodiversity

The general philosophy that is applied to biodiversity in EU GPP criteria for buildings is that the construction or renovation of the building should not decrease biodiversity on the building plot compared to before it was built or renovated.

Clearly this will trigger requirements on biodiversity that vary significantly depending on the building site context. For example, much stronger minimum requirements would be expected on a greenfield site compared to building on a previously developed city centre site.

7.1. Site selection and land use impacts

Core criteria				Comprehensive criteria			
TECHNICAL SPECIFICATIONS (TSs)							
<i>Note: TS7.1 only applies to new construction of buildings on greenfield sites. When there is no other choice for the building site, it is recommended to apply the core criteria. When there is a choice, the comprehensive criteria could help in the choice of the site.</i>							
Design	Site prep.	Construction	Management	Design	Site prep.	Construction	Management
<p>TS7.1: Impact of building on biodiversity</p> <p>An environmental Impact Assessment (EIA) or screening* shall be completed in accordance with Directive 2011/92/EU.</p> <p>Where an EIA has been carried out, the required mitigation and compensation measures for protecting the environment are implemented.</p> <p><i>* The procedure through which the competent authority determines whether projects listed in Annex II to Directive 2011/92/EU is to be made subject to an environmental impact assessment (as referred to in Article 4(2) of that Directive).</i></p> <p>Verification:</p> <p>The contracted EIA specialist or team shall provide the results of an EIA screening exercise and, if relevant, a full EIA report, complete with different mitigation and compensation measures to offset impacts caused by the new building.</p>				<p>TS7.1: Impact of building on biodiversity</p> <p>The building shall not be located in:</p> <ul style="list-style-type: none"> biodiversity-sensitive areas such as the Natura 2000 network of protected areas, UNESCO World Heritage sites and Key Biodiversity Areas. arable land and crop land with a moderate to high level of soil fertility and below ground biodiversity as referred to the EU LUCAS survey. greenfield land of recognised high biodiversity value and land that serves as habitat of endangered species (flora and fauna) listed on the European Red List or the IUCN Red List. land matching the definition of forest as set out in national law used in the national greenhouse gas inventory, or where not available, is in accordance with the FAO definition of forest. <p>An environmental Impact Assessment (EIA) or screening* shall be completed in accordance with Directive 2011/92/EU.</p> <p><i>* The procedure through which the competent authority determines whether projects listed in Annex II to Directive 2011/92/EU is to be made subject to an environmental impact assessment (as referred to in Article 4(2) of that Directive).</i></p> <p>Where an EIA has been carried out, the required mitigation and compensation measures for protecting the environment are implemented.</p> <p>Verification:</p> <p>The contracted EIA specialist or team shall provide the results of an EIA screening exercise that confirms that the chosen building site is not located in any of the areas defined above. If relevant, a full EIA report, complete with different mitigation and compensation measures to offset impacts caused by the new building.</p>			

Supporting rationale for technical specification 7.1:

These are grouped together at the end of TS7.4.

7.2. Green roofs

Core criteria				Comprehensive criteria			
TECHNICAL SPECIFICATIONS (TSs)							
<p><i>Note: TS7.2. These criteria generally applicable to new construction only, unless renovation plans are able to ensure that the building structure can handle the extra load (static and dynamic) of a green roof. In major renovation, it is possible that an intensive green roof could also be supported by new columns as part of a structural "exoskeleton".</i></p>							
Design	Site prep.	Construction	Management	Design	Site prep.	Construction	Management
<p>TS7.2: Extensive Green roofs.</p> <p>The roof area of the building and any above ground parking bays shall be covered by an extensive green roof or roofs, seeded with low maintenance sedums, grasses, mosses and wildflower species that are known to support certain bird and invertebrate species.</p> <p>A system for occasional irrigation, as and when needed, shall be included in the design.</p> <p>The correct construction and installation of any green roof system components especially relevant to design performance shall be ensured by the project manager during the construction and installation stages.</p> <p>Verification:</p> <p>The contracted design team shall provide a design report illustrating the specifications for:</p> <ul style="list-style-type: none"> • expected structural loads, including dead loads when dry and irrigated (EN 1991-1-1), with snow loads (EN 1991-1-3) and with wind loads (EN 1991-1-4). • the waterproofing of the building roof, • membranes to protect against root penetration (in line with EN 13948), • moisture retention, other properties and dimensions of the growing media and green roof system, • the irrigation and drainage components, • specifications of the filter layer to retain fines and sediments on the roof, • the type of vegetation to be included and any installation and maintenance instructions. <p>The contractor shall install the green roof(s) as be provided instructions and this shall be checked and verified in writing by the project manager.</p>				<p>TS7.2: Intensive Green roofs.</p> <p>The roof area of the building and any above ground parking bays shall be covered by an intensive green roof or roofs, seeded with a variety of sedums, grasses, mosses, wildflower species, bushes and trees that are known to support certain bird and invertebrate species.</p> <p>The green roof(s) shall be designed to be accessible to building occupants and to provide an amenity area(s).</p> <p>A system for regular irrigation, as and when needed, shall be included in the design.</p> <p>The correct construction and installation of any green roof system components especially relevant to design performance shall be ensured by the project manager during the construction and installation stages.</p> <p>Verification:</p> <p>The contracted design team shall provide a design report illustrating the specifications for:</p> <ul style="list-style-type: none"> • expected structural loads, including dead loads when dry and irrigated (EN 1991-1-1), with snow loads (EN 1991-1-3) and with wind loads (EN 1991-1-4). • the waterproofing of the building roof, • membranes to protect against root penetration (in line with EN 13948), • moisture retention, other properties and dimensions of the growing media and green roof system, • the irrigation and drainage components, • specifications of the filter layer to retain fines and sediments on the roof, • the type of vegetation to be included and any installation and maintenance instructions. <p>The contractor shall install the green roof(s) as be provided instructions and this shall be checked and verified in writing by the project manager.</p>			

Supporting rationale for technical specification 7.2:

These are grouped together at the end of TS7.4.

7.3. Green walls

Core criteria				Comprehensive criteria			
TECHNICAL SPECIFICATIONS (TSs)							
<p><i>Note: TS7.3 should be of particular interest for buildings that are situated in areas subjected to a strong urban heat island effect. The idea for green walls is generally considered for wall surfaces in direct contact with outdoor air, but in theory this could also be applied to interior walls with the idea of maintaining a minimum level of humidity in indoor air and providing surfaces for the filtering of dust in indoor air.</i></p>							
Design	Site prep.	Construction	Management	Design	Site prep.	Construction	Management
<p>TS7.3: Green walls</p> <p><i>Placeholder while it is discussed with stakeholders if these systems are always sustainable, or if there are certain specifications that must be made to optimise sustainability</i></p> <p>Verification:</p>				<p>TS7.3: Green walls</p> <p><i>Placeholder while it is discussed with stakeholders if these systems are always sustainable, or if there are certain specifications that must be made to optimise sustainability</i></p> <p>Verification:</p>			

Supporting rationale for technical specification 7.3:

Not applicable at this stage

Working draft

7.4. Landscaping and habitat creation

Core criteria				Comprehensive criteria			
TECHNICAL SPECIFICATIONS (TSs)							
<i>Note: TS7.4 should be considered especially for schools and any buildings with a significant plot area. Contracting authorities should look for synergies here in combination with TS7.1, TS7.2, especially TS5.3 and possibly TS3.1.2 and TS3.1.3.</i>							
Design	Site prep.	Construction	Management	Design	Site prep.	Construction	Management
<p>TS7.4: Landscaping and habitat creation</p> <p>From a satellite view, at least 50% of the building plot area, including space occupied by the building, shall be landscaped with vegetation and/or water surfaces.</p> <p>In areas that are already covered by the building or by road or walkway access routes for occupants and visitors, this area could potentially be counted as vegetated if a green roof is installed above.</p> <p>Onsite vegetation should include indigenous plant species that are suitable for the local climate and species that are known to support native mammal, bird and insect species.</p> <p>The vegetated area shall provide multiple structural layers (i.e. tree canopy, sub-canopy, groundcover and soil structure).</p> <p>Rock gardens and bird or bat boxes shall be provided onsite to provide habitats for insects and birds to shelter.</p> <p>All excess rainwater drainage shall be routed through the vegetated plot area before leaving site. This may be achieved using nature-based drainage systems, including:</p> <ul style="list-style-type: none"> • Grassed swales. • Infiltration basins. • Retention ponds and artificial wetlands (including reed beds). <p>No use of pesticides or herbicides shall be permitted.</p> <p>The correct construction and installation of any landscaping and drainage components especially relevant to design performance shall be ensured by the project manager during the site preparation, construction and installation stages.</p> <p>The building management shall take responsibility for maintenance of the landscaped areas directly or via sub-contracted to specialised operators.</p> <p>Verification:</p> <p>The contracted design team shall provide a design report explaining the landscaping plan, including growing media specifications, irrigation systems and controls and specification of vegetation and maintenance plans.</p> <p>The contractor shall install the green roof(s) as be provided instructions and this shall be checked and</p>				<p>TS7.4: Landscaping and habitat creation</p> <p>From a satellite view, at least 80% of the building plot area, including space occupied by the building, shall be landscaped with vegetation and/or water surfaces.</p> <p>In areas that are already covered by the building or by road or walkway access routes for occupants and visitors, this area could potentially be counted as vegetated if a green roof is installed above.</p> <p>Onsite vegetation should include indigenous plant species that are suitable for the local climate and species that are known to support native mammal, bird and insect species.</p> <p>The vegetated area shall provide multiple structural layers (i.e. tree canopy, sub-canopy, groundcover and soil structure).</p> <p>Rock gardens and bird or bat boxes shall be provided onsite to provide habitats for insects and birds to shelter.</p> <p>All excess rainwater drainage and greywater shall be routed through the vegetated plot area before leaving site. This may be achieved using nature-based drainage systems, including:</p> <ul style="list-style-type: none"> • Grassed swales. • Infiltration basins. • Retention ponds and artificial wetlands (including reed beds). • Fountains or similar water features that provide drinking water for birds. <p>A preliminary filtering of greywater via limestone and clay reed beds is recommended before it joins any rainwater irrigation and drainage flows.</p> <p>No use of pesticides or herbicides shall be permitted.</p> <p>The correct construction and installation of any landscaping and drainage components especially relevant to design performance shall be ensured by the project manager during the site preparation, construction and installation stages.</p> <p>The building management shall take responsibility for maintenance of the landscaped areas directly or via sub-contracted to specialised operators.</p> <p>Verification:</p> <p>The contracted design team shall provide a design report explaining the landscaping plan, including</p>			

Core criteria	Comprehensive criteria
TECHNICAL SPECIFICATIONS (TSs)	
<i>Note: TS7.4 should be considered especially for schools and any buildings with a significant plot area. Contracting authorities should look for synergies here in combination with TS7.1, TS7.2, especially TSS.3 and possibly TS3.1.2 and TS3.1.3.</i>	
<p>verified in writing by the project manager.</p> <p>The building manager shall provide periodic (e.g. once per year) reports about the maintenance of ecological features or introduction of new ones for the whole site and for any defined sub areas of interest.</p>	<p>growing media specifications, irrigation systems and controls and specification of vegetation and maintenance plans.</p> <p>The contractor shall install the green roof(s) as be provided instructions and this shall be checked and verified in writing by the project manager.</p> <p>The building manager shall provide periodic (e.g. once per year) reports about the maintenance of ecological features or introduction of new ones for the whole site and for any defined sub areas of interest.</p>

Supporting rationale for technical specifications 7.1 to 7.4:

Potential environmental and social benefits:

The ability for a building to continue with power supply could provide benefits not only to building occupants but also to neighbouring citizens. This could be critical for saving human lives (e.g. safe heating of building spaces in a snowstorm or the provision of drinking water to prevent dehydration).

For buildings with large vegetated areas, a creative approach could be to harvest rainwater or reuse greywater to cultivate reeds, which could act as a biomass fuel for an onsite combined heat and power unit. For buildings with battery energy storage of sufficient capacity, in normal periods this system could be used to charge up during off-peak hours and to preferentially power the building from battery during peak hours, in order to reduce electricity bills. Such a system would also ensure that any onsite generated renewable energy could be exported during peak hours, again, in order to obtain the maximum economic performance of the building energy system.

Potential environmental trade-offs:

The introduction of green roofs and green walls will require extra materials that will increase the embodied carbon of the building. Maintenance of the green space, including replacement of growing media and any synthetic fertilisers, may also represent a quite hidden impact that is not normally covered in building LCA analyses.

Policy relevance:

The established Technical Screening Criteria (TSC) for EU Taxonomy indicates that new construction does not present a risk of causing significant harm to the biodiversity if it is not built on one of the following:

- (a) arable land and crop land with a moderate to high level of soil fertility and below ground biodiversity as referred to the [EU LUCAS survey](#).
- (b) greenfield land of recognised high biodiversity value and land that serves as habitat of endangered species (flora and fauna) listed on the [European Red List](#) or the [IUCN Red List](#);
- (c) land matching the definition of forest as set out in national law used in the national greenhouse gas inventory, or where not available, is in accordance with the FAO definition of forest.

These requirements have been directly brought into the comprehensive requirements for TS7.1.

Furthermore, the Platform on Sustainable Finance highlights [preliminary recommendations](#) for Technical Screening Criteria that could determine the conditions under which activities of the construction and real estate sector (see sections 5.1 and 5.2 of [this document](#)), qualify as contributing substantially to objective 6 on Biodiversity.

Land use change and surface sealing are two major drivers of biodiversity loss and construction activities clearly play a key role in both. The EU aims to achieve “no net land take by 2050”. This means avoiding

construction in certain areas. On the other hand, there are many ways that sensitive design of buildings and sites can encourage biodiversity and boost natural habitats.

Market considerations:

The establishment of vegetation in, on and around the building, together with respect for the local fauna, create a positive image of the building, potentially translating into an increased market value of the property. In addition, choosing plants that are suitable for the site can reduce subsequent maintenance costs as these are often hardier, less susceptible to disease etc., and require less care.

New constructions on previously developed land or major renovations can make a substantial contribution by achieving a gain in biodiversity through improving the green infrastructure. There is a diverse range of biodiversity infrastructure features that can be incorporated such as artificial, building integrated nesting boxes for bats and birds and free-standing or building-integrated insect habitats ('insect hotels'). The Platform on Sustainable Finance recommends that at least one feature must be provided per residential unit or per 100m² of site for non-residential development. Compliance may also be demonstrated through the application of a locally applicable Green Space Factor (GSF) method and the appropriate locally defined thresholds for the type of development.

The preliminary recommendations for technical screening criteria for the EU taxonomy proposes thresholds similar to those set in planning requirements of leading cities for urban greening. The Green Space Factor is one way of determining green infrastructure requirements for developments that has grown in popularity in European cities. It is used within the policies of municipalities to set requirements that developers must agree to before planning permission for a site is granted, in this way green infrastructure is planned at the earliest stage.

What do Green Building Rating Systems or other initiatives say?

The **BREEAM** International New Construction (2016) technical manual (SD233 2.0) has 4 criteria related to Biodiversity under its 'Land use and ecology' section:

- LE01 on site selection (3 credits): sets requirements for previously occupied land (as that which is or was occupied by a permanent structure) and contaminated land where remediation works are to be carried out.
- LE02 Ecological value of site and protection of ecological features (2 credits): addresses low ecological value lands and defines the following features of ecological value requiring protection during site clearance and construction:
 1. To protect by barriers trees of over 100mm trunk diameter, stands of trees, and trees of significant ecological value. Barriers must prohibit construction works in the area between itself and the tree trunk. The minimum distance between the tree trunk and barriers must be either the distance of branch spread or half tree height, whichever is the greater. Trees are protected from direct impact and from severance or asphyxiation of the roots;
 2. To protect by cut-off ditches and site drainage the coastal developments, watercourses, wetland areas, areas of freshwater and known groundwater wells in order to prevent run-off to minimise risk of pollution, silting or erosion;
 3. Fenced exclusion zones should be maintained around all mangrove stands (landward side) that are being retained to minimise the risk of workforce machinery damage of these sensitive habitats.
 4. Other ecological features and natural areas requiring protection must either have barriers erected and be protected, or, when remote from site works or storage areas, be protected with a prohibition of construction activity in the vicinity.
- LE03 Minimising impact on existing site ecology: is not applicable to BREEAM International New Construction 2.0 but is addressed under the BREEAM UK New Construction non-domestic buildings technical manual 2014 (SD5076 – Issue: 5.0). The criterion outlines methods to avoid causing changes in the site ecological value or at least help minimise the impact of a building development on existing site ecology (2 credits).

- LE04 Enhancing site ecology (3 credits): contains ecological recommendations for the enhancement of the site's ecology at the Concept Design stage. A percentage of the recommendations within an ecology report for enhancement of site ecology are to be implemented in the final design and build.

Measures may include but are not limited to:

1. The planting of locally appropriate native species or non-native species with a known attraction or benefit to local wildlife;
 2. The adoption of horticultural good practice (e.g. no, or low, use of residual pesticides);
 3. The installation of bird, bat or insect boxes at appropriate locations on the site;
 4. Development of a full biodiversity management plan including avoiding clearance or works at key times of the year (e.g. breeding seasons);
 5. The proper integration, design and maintenance of sustainable drainage systems (SuDS1) (such as rain gardens), green roofs, green walls, community orchards, community allotments etc.
- LE05 Long-term impact on biodiversity (2 credits): provides measures to minimise the long-term impact of the development on the site and the surrounding area's biodiversity.

Additional building-specific measures are provided for the improvement of long-term biodiversity. In the case of educational buildings, meetings are to be scheduled several times a year with staff or pupils or students working party to help them plan conservation and ecological enhancement work, or activities relating to the ecology in or near the school or college grounds.

The **Home Performance Index** (HPI) technical manual version 2.0 (2019) covers Biodiversity matters in the following criteria:

- EN 1.0 Land use: Encourage remediation of contaminated land and restoration and improvement of previously developed lands by proposing compensatory measures (e.g. green roofs or vegetated areas with native and adapted species).
- EN 5.0 Ecology: makes a number of provisions intended to enhance the site's ecological value and biodiversity as follows:
 1. A bird box for every unit.
 2. A habitat for specified insects in the landscaping (e.g. water striders and other aquatic insects in the pond).
 3. Bat boxes in the development.
 4. No surfaces in the landscaping are sealed, and all surfaces are permeable to water.
 5. All non-paved surfaces within the landscaping have sufficient soil depth and quality for growing vegetables.
 6. All walls, where possible, are covered with climbing plants.
 7. There is 1 square metre of pond area for every 5 square metres of hard-surface area in the landscaping.
 8. The vegetation in the landscaping is selected to be nectar rich and provide a variety of food for butterflies (a so-called 'butterfly restaurant').
 9. No more than ten trees or shrubs of the same species per hectare.
 10. All storm water flows for at least 10 metres on the surface of the ground before it is diverted into pipes.
 11. The landscaping is green, but there are no mown lawns.
 12. All rainwater from buildings and hard surfaces in the landscaping is collected and used for irrigation.
 13. All plants have some household use.
 14. There are frog habitats within the landscaping as well as space for frogs to hibernate.

15. In the landscaping, there is at least 2 square metres of conservatory or greenhouse for each apartment.
16. There is food for birds throughout the year within the landscaping.
17. There are at least two different old-crop varieties of fruits and berries for every 100 square metres of landscaping.
18. The facades of the buildings have swallow nesting facilities.
19. The whole landscaping is used for the cultivation of vegetables, fruit and berries.
20. The developers liaise with ecological experts.
21. Greywater is treated in the landscaping and re-used.
22. All biodegradable household and garden waste is composted.
23. Only recycled construction materials are used in the landscaping.
24. Each apartment or house has at least 2 square metres of built-in growing plots or flower boxes;
25. At least half the landscaping area consists of water.
26. All the trees and bushes in the landscaping bear fruit and berries.
27. A section of the landscaping is left for natural succession (that is, to naturally grow and regenerate).
28. There are at least 50 flowering Irish wild herb plants within the landscaping.
29. All the buildings have green roofs.

The **LEED** v4.1 Building Design and Construction (2021) applies to new construction or major renovation of buildings that do not primarily serve residential. The rating system sets out various Sustainable Sites (SS) Credits related to Biodiversity:

- SS Credit “Protect or Restore Habitat” requires to preserve and protect from all development and construction activity 40% of the greenfield area on the site (if such areas exist). It is also required that a portion of the site (including the building footprint) identified as previously disturbed follows vegetation and soil requirements. Vegetated roof surfaces may be included in the habitat area calculations if the plants are native or adapted and provide habitat.

Schools only:

Dedicated athletic fields that are solely for athletic uses are exempted from counting toward the total site area. These areas may not count toward the protected greenfield or restored habitat areas.

- SS Credit “Heat Island Reduction”. Non-roof and Roof measures are presented. On the non-roof side, it can be highlighted the use the existing plant material or install plants that provide shade over paving areas (including playgrounds) on the site within 10 years of planting.

The high-reflectance and vegetated roofs are other strategies. The roof must be vegetated, or be covered by energy generation systems.

- SS Credit “Light Pollution Reduction”. There are upright and light trespass requirements that can be met using the backlight-uplight-glare (BUG) method (Option 1) or the calculation method (Option 2). Internally Illuminated Exterior Signage cannot exceed luminance of 200 cd/m² (nits) during night-time hours and 2000 cd/m² (nits) during daytime hours.

The **VERDE** Evaluation guide for Edificios 2020 (Revised December 2021) has the following Biodiversity criteria:

- PE 06 Habitat management and restoration: The percentage of landscaped area occupied by native or adapted plants should be between 30% and ≥80%. In order to obtain a score in the criterion, the landscaped area must be greater than 20 m².
- PE 07 Use of plants to create shadows: Reduce the effect of radiation on the building's facades through plant elements outside the building itself to reduce the demand for cooling in summer without affecting sunlight in winter.

- PE 08 Heat island effect has two indicators.

Indicator 1: Roof area that avoids the heat island are the ones that:

- i) Landscaped areas with a thickness of topsoil of at least 5 cm.
- ii) Surfaces with a permeable pavement. In the case of open grid flooring permeable, it must be such that it guarantees 50% of its surface covered by soil.
- iii) Surfaces with a light colored finish.
- iv) Shaded surfaces that avoid the heat island. Classification of materials based on color, texture, degree of permeability that could suit best to different degrees of slope.

Indicator 2: Area of East-South-West facades that avoid the heat island are shaded surfaces, with an IRS greater than 40 or covered by vegetation

- PE 09 Light pollution: The evaluation of the building through this criterion is obtained by compliance with measures to reduce pollution caused by outdoor lighting.

Those luminaires located in an area with a higher obstacle that prevents the vertical diffusion of the luminous flux, for example, a covered entrance of a house, will not be taken into account. For each type of luminaire identified, the ULOR (Upper Light Output Ratio) must be indicated through the technical documentation of the luminaire. The ULOR value (in %) is taken from the photometric curves of the luminaires used.

If the photometric curve is not available, the luminaire must indicate the most unfavorable light protection zone in which it can be installed.

DGNB System New Construction Version 2020 International:

- ENV2.3 Land use: addresses brownfield redevelopment including significant improvement of contaminated site and soil sealing factor of the total developed and undeveloped area.
- ENV2.4 Biodiversity at the site: to create, maintain and increase biodiversity both on buildings themselves and in their surroundings.

Indicators:

- i) Biotope area quality
Biodiversity index is the sum of the project area's sub-areas multiplied by the specific factor, as a proportion of the total plot area, which is rated using the site occupancy index.
- ii) Diversity of animal species in the outdoor area: Specific measures for the active introduction of new and native animal species in the outdoor area
- iii) Diversity of animal species on the building itself
- iv) Avoidance of invasive plant species
- v) Measures for habitat connectivity

An evaluation has been carried out with regard to the impact of the project and whether it disrupts or improves links between surrounding biotopes or the movement of animals between areas. Where disruption as a result of the project has been anticipated, measures have been put in place to mitigate the disruption or to interlink areas.

- vi) Development and maintenance care

Targeted questions to stakeholders about TS7.1 to 7.4:

Q30: Are there any examples in the literature assessing the life cycle carbon (or cost) impacts of green roofs and/or green walls?

7.5. Artificial light at night (ALAN)

Core criteria				Comprehensive criteria			
TECHNICAL SPECIFICATIONS (TSs)							
<p><i>Note: TS7.5. is focussed on external lighting within the building plot, and should not be confused with lighting for public roads, for which a dedicated set of EU GPP criteria already exist (see here under "road lighting and traffic signals").</i></p>							
Design	Site prep.	Construction	Management	Design	Site prep.	Construction	Management
<p>TS7.5.1: Ratio of Upward Light Output (R_{ULO}) and obtrusive light.</p> <p>All luminaire models purchased for external lighting of the building and its plot area shall be rated with a 0.0 % RULO.</p> <p>If it is necessary to use a boom angle, either to optimise the pole distribution or due to site constraints in pole positioning, the 0.0 % RULO shall be maintained even when the luminaire is tilted at the required angle.</p> <p>External lighting shall be appropriately shielded so as not to shine directly onto bodies of water.</p> <p>Verification:</p> <p>The lighting system design team shall specify the types, numbers and positioning of external light sources installed on the plot area to illuminate its surface and to illuminate the façade or other elements in a report that is in line with the backlight-uplight-glare (BUG) method or similar methodology.</p> <p>The contractor shall provide invoices for the lighting equipment to be installed, together with product specifications, labels or supplier declarations that confirm compliance with the requirements above.</p> <p>Upon request, the contractor or manufacturer shall provide the photometric file(s) for the light sources. This shall include the photometric intensity table from which the RULO is calculated according to EN 13032-1, EN 13032-2, EN 13032-4, Annex D of IEC 62722-1 or other relevant international standards.</p> <p>In cases where luminaires are not installed horizontally, the photometric file shall demonstrate that either:</p> <ul style="list-style-type: none"> - tilting the data by the same tilt angle to be used with the luminaire still results in a 0.0 % RULO, or - additional shielding has been fitted to the luminaire and the shielded luminaire found to show a 0.0 % RULO when tilted at the design installation angle. 				<p>TS7.5.1: Ratio of Upward Light Output (R_{ULO}) and obtrusive light.</p> <p>All luminaire models purchased for external lighting of the building and its plot area shall be rated with a 0.0 % RULO and with a C3 flux code of ≥ 97 according to photometric data.</p> <p>Internally Illuminated Exterior Signage cannot exceed luminance of 200 cd/m² (nits) during night-time hours.</p> <p>If it is necessary to use a boom angle, either to optimise the pole distribution or due to site constraints in pole positioning, the 0.0 % RULO shall be maintained even when the luminaire is tilted at the required angle.</p> <p>External lighting shall be appropriately shielded so as not to shine directly onto bodies of water.</p> <p>Verification:</p> <p>The lighting system design team shall specify the types, numbers and positioning of external light sources installed on the plot area to illuminate its surface and to illuminate the façade or other elements in a report that is in line with the backlight-uplight-glare (BUG) method or similar methodology.</p> <p>The contractor shall provide invoices for the lighting equipment to be installed, together with product specifications, labels or supplier declarations that confirm compliance with the requirements above.</p> <p>Upon request, the contractor or manufacturer shall provide the photometric file(s) for the light sources. This shall include the photometric intensity table from which the RULO is calculated according to EN 13032-1, EN 13032-2, EN 13032-4, Annex D of IEC 62722-1 or other relevant international standards.</p> <ul style="list-style-type: none"> - tilting the data by the same tilt angle to be used with the luminaire still results in a 0.0 % RULO and a C3 flux code of ≥ 97, or - additional shielding has been fitted to the luminaire and the shielded luminaire found to show a 0.0 % RULO and a C3 flux code of ≥ 97 when tilted at the design installation angle. 			
Design	Site prep.	Construction	Management	Design	Site prep.	Construction	Management
<p>TS7.5.2: Low environmental impact external lighting.</p> <p>All light sources purchased for external lighting of the building and its plot area shall be have a</p>				<p>TS7.5.2: Low environmental impact external lighting.</p> <p>All light sources purchased for external lighting of the building and its plot area shall be have a</p>			

Core criteria	Comprehensive criteria
TECHNICAL SPECIFICATIONS (TSs)	
<p><i>Note: TS7.5. is focussed on external lighting within the building plot, and should not be confused with lighting for public roads, for which a dedicated set of EU GPP criteria already exist (see here under "road lighting and traffic signals").</i></p>	
<p>correlated colour temperature (CCT) of $\leq 3000\text{K}$ and/or a G index* of ≥ 1.5.</p> <p>The external lighting system will be installed with programmable dimming or switch-off controls.</p> <p>Any light sources covered by Regulation (EU) 2019/2015 shall have an energy class rating of C or better.</p> <p><i>*The G-index can be quickly and easily calculated using the same photometric data used to calculate the CCT via an excel spreadsheet available at this website:</i> http://www.juntadeandalucia.es/medioambiente/cieloandaluzindic eg</p> <p>Verification:</p> <p>The contractor shall provide the energy label and declared CCT reported in accordance with CIE 15 and, if requested, the light spectra output for all light sources being procured.</p> <p>Regarding programmable dimming or switch-off controls, the tenderer shall provide details of the proposed dimming/switch-off controls and the range of dimming capabilities, which shall at least permit dimming or switch-off based on an astronomical clock.</p>	<p>correlated colour temperature (CCT) of $\leq 2700\text{K}$ and/or a G index* of ≥ 2.0.</p> <p>The external lighting system will be installed with programmable dimming or switch-off controls.</p> <p>Any light sources covered by Regulation (EU) 2019/2015 shall have an energy class rating of B or better.</p> <p>For LED lighting only: a luminaire lifetime of at least L96 at 6000 hours and L70 at 100000 hours (projected).</p> <p><i>*The G-index can be quickly and easily calculated using the same photometric data used to calculate the CCT via an excel spreadsheet available at this website:</i> http://www.juntadeandalucia.es/medioambiente/cieloandaluzindic eg</p> <p>Verification:</p> <p>The contractor shall provide the energy label and declared CCT reported in accordance with CIE 15 and, if requested, the light spectra output for all light sources being procured.</p> <p>Regarding programmable dimming or switch-off controls, the tenderer shall provide details of the proposed dimming/switch-off controls and the range of dimming capabilities, which shall at least permit dimming or switch-off based on an astronomical clock.</p> <p>Test data regarding the maintained lumen output of the light sources shall be provided by an International Laboratory Accreditation Cooperation-accredited laboratory that meets IES LM-80** for actual data and IES TM-21** for projected data.</p> <p>**To be updated to LM-84 and TM 28 when these versions are published.</p>

Supporting rationale for technical specifications 7.5.1 to 7.5.2:

Potential environmental benefits:

Artificial light at night (ALAN) has a number of different potential environmental impacts, which can be summarised into two physical impacts and one ecological one as follows:

- Skyglow: which, according to CIE 126:1997, is the brightening of the night sky that results from the reflection of radiation (visible and non-visible), scattered from constituents of the atmosphere (gas molecules, aerosols and particulate matter), in the direction of the observation.
- Obtrusive light: which, according to CIE 150:2003, is known as "spill light", which because of quantitative, directional or spectral attributes in a given context, gives rise to annoyance, discomfort, distraction or a reduction in the ability to see essential information.
- Ecological light pollution: causing adverse impacts on the behavioural patterns of insects, birds, mammals, aquatic organisms and plants.

A useful illustration of how skyglow and obtrusive light from external lighting affect the surrounding environment is given below.

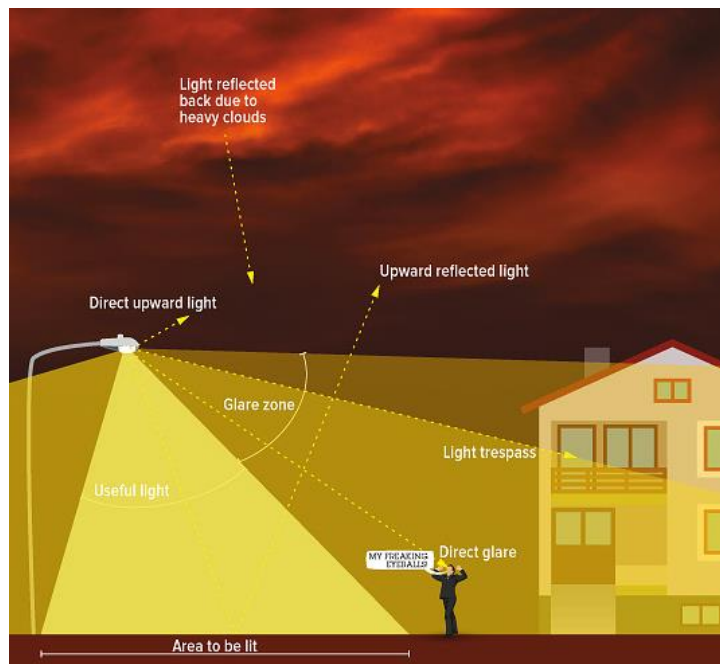


Figure 3. Info-graphic about the different components of light pollution

Source: Anezka Gocova, from <https://astronomynow.com/2015/04/11/international-dark-sky-week-2015/>

Ecological light pollution is a more complex issue, but there is growing evidence of the disruptive impact of ALAN on a number of nocturnal species (UK, 1997; Rich and Langcore, 2006; RC, 2009). These disruptions may be detrimental to some species more than others, or even offer new advantages to species that are best able to adapt.

The most direct solution to reducing light pollution is to reduce lighting levels or to switch off altogether. This would deliver the twin benefit of reduced light pollution and reduced energy consumption. With dimming, further investigation would be merited to understand how dimming affects the electromagnetic fields that are emitted from the lighting infrastructure.

When external light is needed, a given level of light can have a different degree of impact depending on the spectra of its light output. A general relationship between wavelength of light and effect on species was published by Biodiv (2015) as follows.

Table 5. General guide on the effect of different spectral bands of light on different species.

	UV	Violet	Blue	Green	Yellow	Orange	Red	IR
wavelength (nm)	<400	400-420	420-500	500-575	575-585	585-605	605-700	>700
freshwater fish	x	x	x	x	x	x	x	
marine fish	x	x	x	x				
shellfish (zooplankton)	x	(x)	(x)					
amphibia&reptiles	x	x	x	>550	x	x	x	x
birds	x	x	x	x		x	x	x
mammals (excluding bats)	x	x	x	x			x	
bats	x	x	x	x				
insects	x	x	x	x				
note: (x) = assumed possible but not identified in literature								

Source: Biodiv (2015)

It is clear that the lower wavelength (whiter) fractions of light are more disruptive to species than the higher wavelength (warmer) ones. Consequently, in order to reduce the ecological impact of external lighting, it is considered beneficial to specify "warmer" light sources (i.e. lower CCT value or higher G index). While there is a

general correlation between CCT and the fraction of blue, violet and UV light output, it is not always accurate. If contracting authorities want to be sure about controlling the output

Policy relevance:

Biodiversity is one of the six environmental objectives of the EU Taxonomy and has already been addressed in detail during the development of EU GPP criteria for road lighting and traffic signals.

Market considerations:

The massive transition to LED light sources for external lighting is well underway. The LED lighting technology is much more suitable for dimming controls and can today offer significantly higher luminous efficacies than the traditional high pressure sodium (HPS) lamps that were used. However, LED lighting, by its very nature, provides a much “whiter” light output than the yellowy/orange light from HPS. Consequently, the potential impacts on skyglow and ecological light pollution are greater.

However, there are options on the market for “amber LED”, which involves the application of a phosphor coating to convert the blue light to more desirable wavelengths within the visible range.

Light sources are covered by the EU Energy Labelling Regulation (EU) No 2019/2015. Consequently, it is possible to specify products with a minimum energy class.

The European Product Registry for Energy Labelling (EPREL) will be made available to the public in the future, where it will be possible to see the energy labels for light source products covered by the Energy Labelling Regulation. The EPREL database shall permit users to filter data by certain product characteristics. Contracting authorities should consult the EPREL database before setting any energy class requirements for light sources. The “class C” and “class B” requirements set in core and comprehensive criteria for TS 7.5.2 are purely indicative. Depending on real market data, this could easily be “class C” and “class B”, or even “class D” and “class C”.

Since it is not expected that these EU GPP criteria will be published before March 2023, reference is only made to the new energy class scale.

Another important aspect of low environmental impact lighting is actually durability, and for this reason a proposal has been inserted in the comprehensive requirement of TS7.5.2, even though it could be argued that this idea of low environmental impact is more related to theme 1 on life cycle carbon than on theme 7 on biodiversity.

What do Green Building Rating Systems or other initiatives say?

To be checked.

6 Conclusions

This report has presented a brief introduction to the basic tenets of Green Public Procurement and the types of requirements that contracting authorities can use in order to purchase environmentally friendly products and services.

A summary of the main findings from the initial working draft background report on buildings has been provided, which touches upon the scope of definition, market data and environmental impacts of buildings. There is still a lot of background research to be completed, especially with regards to understanding the technical aspects and improvement potential of different building technical systems, building elements and passive design features. In-depth stakeholder engagement will be required to bring this knowledge into the next version of the background report.

A total of 38 initial criteria proposals have been made across 7 central themes, which are largely inspired by the Level(s) common framework and the EU Taxonomy for environmentally sustainable economic activities, these themes are:

1. Energy consumption and greenhouse gas emissions
2. Material circularity
3. Efficient use of water resources
4. Occupant comfort and wellbeing
5. Vulnerability and resilience to climate change
6. Life cycle costing
7. Biodiversity

There are a number of different synergies and trade-offs that can exist for certain requirements. For example, more efficient shower heads and hot water taps not only save water, but also reduce energy consumption and associated CO₂ emissions (both from energy consumption and from CO₂ embodied in delivered water).

Improving daylighting in buildings can improve occupant wellbeing and reduce the energy consumption of lighting systems (with the important caveat that lighting systems are automatically adjustable to a constant luminance level). However, care needs to be taken that extra daylighting does not deliver unwanted glare to occupants or contribute to overheating via excessive solar gain.

The complexity of buildings and the number of specialised disciplines involved underlines the importance of clear communication of information within the design team and between designers, architects and construction contractors (and sub-contractors). Some criteria, like life cycle costing or life cycle carbon, will require some clear specifications to be provided by the contracting authority. To ensure that the contracting authority obtains what it desires from the procurement exercise, it may be necessary to hire external specialists and/or a project manager to ensure that everything goes according to plan.

It is not expected that a contracting authority would attempt to incorporate all of the proposed EU GPP into a call for tender. Priorities should be identified by the contracting authority at an early stage.

In the next draft of criteria proposals, some effort will be made to split criteria into technical specifications, award criteria and to state any contract performance clauses of relevance.

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List of abbreviations and definitions

TBD To be decided (if necessary to keep in future versions of this report)

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