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BIM4Energy Project

Tutorial title: Building Energy and Green Certifications

1 – Aims

The objectives of this building certification tutorial are as follows:

- Learning about the importance of energy efficiency in buildings.
- Knowing about the objectives of the new European directive on energy performance in buildings.
- Knowing about energy performance certificate (EPC) of buildings.
- Knowing about recommended measures for improving the energy performance of buildings
- Knowing what green certificates are and what they are for.

2 - Learning methodology

The teacher will give an explanation about Building Certifications of about 30 minutes.

Students will read this tutorial and follow the steps shown in the tutorial, namely:

- Energy Efficiency in Buildings.
  - What is the energy efficiency of a building?
  - Reforming the EU building stock with the right policy and legislation.
  - Innovating and investing for smarter buildings.
  - Benefiting the environment and citizens.
  - Examples on initiatives and projects in the sector
- Energy Performance of Buildings Directive (2023).
  - Key facts on energy and EU buildings.
  - Revised Energy Performance of Buildings Directive.
  - Advantages of EU building renovation.
- Building Energy Performance Certificate.
  - What is energy performance certification of buildings.
  - Parts of the energy performance certification of buildings.
  - Energy rating of the building.
  - Model of Energy Performance Certificate for Building in Spain.
- Green Building Certificates.
  - What is green building?
  - What is a sustainable building certification?
  - Green Building Councils and building certifications.
  - A list of Green Building Certifications to know.
  - BREAM. How it works and rating.
  - LEED. How it works and rating.

In order to evaluate the success of the application, a questionnaire will be held for the students.

3 - Tutorial duration

The implementation described in this tutorial will be carried out through the BIM-LCA Project website by self-learning.

3 lesson hours are suitable for this training.

4 – Necessary teaching recourses

Computer room with PCs with internet access.

Required software: Microsoft Office.

5 – Contents & tutorial

5.1 – Energy Efficiency in Buildings

5.1.1. What is the energy efficiency of a building?

The energy efficiency of a building [1] is the extent to which the energy consumption per square metre of floor area of the building measures up to established energy consumption benchmarks for that particular type of building under defined climatic conditions.

Building energy consumption benchmarks are representative values for common building types against which a building's actual performance can be compared.

The benchmarks are derived by analysing data on different building types within a given country. The typical benchmark is the median level of performance of all the buildings in a given category and good practice represents the top quartile performance. Comparisons with simple benchmarks of annual energy use per square metre of floor area or treated floor area (kWh/m2/year) allow the standard of energy efficiency to be assessed and priority areas for action to be identified.

Benchmarks are applied mainly to heating, cooling, air-conditioning, ventilation, lighting, fans, pumps and controls, office or other electrical equipment, and electricity

consumption for external lighting. The benchmarks used vary with the country and type of building.

The measure of heat loss through a material, referred to as the U-Value, is also used as a way of describing the energy performance of a building. The U-value refers to how well an element conducts heat from one side to the other by rating how much the heat the component allows to pass through it. They are the standard used in building codes for specifying the minimum energy efficiency values for windows, doors, walls and other exterior building components. U-values also rate the energy efficiency of the combined materials in a building component or section. A low U-value indicates good energy efficiency. Windows, doors, walls and skylights can gain or lose heat, thereby increasing the energy required for cooling or heating. For this reason most building codes have set minimum standards for the energy efficiency of these components.

Buildings are a central part of our daily lives, and we spend a large part of our days in them - at home, at work, or during our spare time.

In its different forms - homes, work places, schools, hospitals, libraries or other public buildings - the built environment is, however, the single largest energy consumer in the EU. And one of the largest carbon dioxide emitters.

Collectively, buildings in the EU [2] are responsible for 40% of our energy consumption and 36% of greenhouse gas emissions, which mainly stem from construction, usage, renovation and demolition.

Improving energy efficiency in buildings therefore has a key role to play in achieving the ambitious goal of carbon-neutrality by 2050, set out in the European Green Deal.

5.1.2. Reforming the EU building stock with the right policy and legislation

Today, roughly 75% of the EU building stock is energy inefficient. This means that a large part of the energy used goes to waste. Such energy loss can be minimised by improving existing buildings and striving for smart solutions and energy efficient materials when constructing new houses.

Renovating existing buildings could reduce the EU's total energy consumption by 5-6% and lower carbon dioxide emissions by about 5%. Yet, on average, less than 1% of the national building stock is renovated each year. (Member State rates vary from 0.4% to 1.2%.) In order to meet our climate and energy objectives, the current rates of renovations should at least double.

The EU recently introduced new ambitious policies to help steer member states towards better energy efficiency in buildings. Knowing that cost is often the major hurdle to renovation, the new rules also ease access to financing for improving the building stock.

The Energy Performance of Buildings Directive (EPBD) 2010/31/EU and the Energy Efficiency Directive (EED) 2012/27/EU were revised in 2018, as part of the Clean energy for all Europeans package, to better reflect the EU's aim of driving the clean energy transition.

Taken together, some of the most important elements in the directives include

- reinforced long-term renovation strategies for EU countries
- nearly zero-energy buildings
- energy performance certificates
- consideration for health and well-being (air pollution), e-mobility (e-charging points) and smart technology (smart meters, self-regulation equipment) in new buildings

After 2018, EU countries needed to write the new and revised provisions of the EPBD into national law by 10 March 2020.

In addition, each EU country needed to present its strategy for tackling energy in buildings for the period 2021-2030 through its integrated national energy and climate plans (NECPs). The cumulative impact of these efforts at national level will feed into the overall goal of reaching a 32.5% energy efficiency target by 2030 for the EU.

But, in 2023 a new EPBD arrived. With new and more ambitious objectives. See section 5.2 in this document.

5.1.3. Innovating and investing for smarter buildings

Through Horizon 2020 and Horizon Europe research and innovation projects, the EU invests in grants or loans that help push technology and best practice in the sector. Appliances like smart meters, better performing materials and digital tools contribute to energy efficiency and can help consumers to better control their energy consumption, and save money.

The EU also supports and finance energy efficiency projects through the European Investment Bank (EIB), which lends money to projects that contribute to reaching the EU's energy and climate goals.

To boost building renovation, the European Commission has announced the intention to launch the new 'renovation wave' initiative, as part of the European Green Deal. The aim is to increase the rate of renovation of existing buildings and bring together the different actors in the sector to develop financing possibilities, promote investments in buildings and pool renovation efforts.

5.1.4. Benefiting the environment and citizens

EU rules on energy efficiency in buildings show a clear and positive impact. Since the first measures were introduced under national building codes, the energy consumption in new buildings of today has halved, relative to typical buildings from the 1980s.

Besides the environmental gains from lower energy use, people across the EU will also benefit from improved energy efficiency in their homes, at work, in schools and other buildings. Energy efficient buildings will result in lower energy bills and reduced energy demand. In some cases they will also benefit from increased renewable energy sources. These changes will also lead to better air quality and improved health.

With certain renovation measures targeting social housing – and new rules for EU countries to measure and monitor figures for those that struggle to pay their energy bills – these building renovation rules will help to combat energy poverty in the EU and ensure that no citizen is left behind in the clean energy transition.

5.1.5. Examples on initiatives and projects in the sector

The EU Building Stock Observatory (BSO) is a tool that keeps track of the characteristics and energy performance of buildings in the EU.

Launched in 2016, the BSO monitors and assesses improvements in energy efficiency for buildings. The results are analysed and shown in a database, a data mapper and in factsheets. The BSO tracks many different aspects pf performance, for example:

- energy efficiency levels in buildings in EU countries, and the EU as a whole
- different certification schemes and how they are implemented
- available investments for renovating buildings
- energy poverty levels across the EU.

BUILD-UP is the European portal for energy efficiency in buildings, and is managed by the Executive Agency for Small and Medium-sized Enterprises (EASME). Through dedicated training sessions, webinars, publications and country factsheets, BUILD-UP

informs and equips stakeholders from the building sector with the skills and knowledge needed to ensure building and renovation projects meet energy efficiency requirements.

The Horizon 2020 energy efficiency data hub offers the possibility to find all existing EU financed projects, with a filter to identify "building" projects.

5.2 – Energy Performance of Buildings Directive

Aiming to achieve a fully decarbonised building stock by 2050, the Energy Performance of Buildings Directive [3] contributes directly to the EU's energy and climate goals.

Buildings are the single largest energy consumer in Europe. The building sector is therefore crucial to achieving the EU's energy and climate goals.

5.2.1. Key facts on energy and EU buildings

85% of EU buildings were built before 2000 and amongst those, 75% have a poor energy performance. Acting on the energy efficiency of buildings is therefore key to saving energy and achieving a zero-emission and fully decarbonised building stock by 2050. These facts and those below come from Eurostat energy balances and EEA Greenhouse Gas Inventory, 2023.

around 40%	over 1/3	+/- 80%
of energy consumed in the EU is used in buildings	of the EU's energy-related GHG emissions come from buildings	of energy used in EU homes is for heating, cooling and hot water

To boost the energy performance of buildings, the EU has established a legislative framework that includes the Energy Performance of Buildings Directive EU/2010/31 and the Energy Efficiency Directive EU/2023/1791, both revised in 2023.

Together, the directives promote policies that will help

- achieve a highly energy efficient and decarbonised building stock by 2050
- create a stable environment for investment decisions
- enable consumers and businesses to make more informed choices to save energy and money.

5.2.2. Revised Energy Performance of Buildings Directive

The revised directive will increase the rate of renovation, particularly for the worst-performing buildings in each country. It will also support better air quality, the digitalisation of energy systems for buildings and the roll-out of infrastructure for sustainable mobility.

Recognising the differences across EU countries in factors such as the existing building stock, geography and climate - the directive allows governments to decide on the renovation measures best-suited to their specific national context.

Countries can also exempt various categories of buildings from the rules including historical buildings and holiday homes.

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Crucially, the revised directive will facilitate more targeted financing to investments in the building sector, complementing other EU instruments and fighting energy poverty by supporting vulnerable consumers. EU countries will also have to ensure that there are safeguards for tenants, such as through rent support or caps on rent increases.

To ensure that buildings are fit for the EU's enhanced climate ambition under the European Green Deal, **the revised directive will contribute to the objective of reaching emission reductions of at least 60% in the building sector by 2030 compared to 2015 and achieving climate neutrality by 2050.**

It will work hand in hand with other policies of the Green Deal package, in particular with the emissions trading system for fuels used in buildings, the revised Energy Efficiency Directive (EU/2023/1791), the revised Renewable Energy Directive (EU/2023/2413), as well as the Alternative Fuels Infrastructure Regulation.

Other measures in the revised EPBD include:

- the gradual introduction of minimum energy performance standards for non-residential buildings to support the renovation of buildings with the lowest energy performance
- national trajectories to reduce the average primary energy use of residential buildings
- an enhanced standard for new buildings, including a more ambitious vision for buildings to be zero-emission
- enhanced long-term renovation strategies, to be renamed national Building Renovation Plans
- increased reliability, quality and digitalisation of Energy Performance Certificates with energy performance classes to be based on common criteria
- a definition of deep renovation and the introduction of building renovation passports
- ensuring new buildings are solar-ready (fit to host solar installations) where technically and economically feasible
- a gradual phase-out of stand-alone boilers powered by fossil fuels, starting with the end of subsidies to such boilers from 1 January 2025
- one-stop-shops for the energy renovations of buildings for home-owners, small and medium-sized enterprises and other stakeholders
- the modernisation of buildings and their systems and better energy system integration (for heating, cooling, ventilation, charging of electric vehicles and renewable energy).

5.2.3. Advantages of EU building renovation

Improving the energy performance of buildings not only saves energy and reduces energy bills, thereby reducing energy poverty and making Europe more energy independent, it also benefits the health and wellbeing of citizens by bringing living standards up to the 21st century for everyone.

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Furthermore, investments in energy efficiency help stimulate the economy and create more green jobs. The EU's construction industry contributes around 9.6% of the EU's value added and employs almost 25 million people in 5.3 million firms. Small and medium-sized enterprises (SMEs) in particular benefit from a boosted renovations market, as they make up 99% of EU construction companies and 90% of the employment in the sector.

5.3 – Building Energy Performance Certificate.

5.3.1. What is energy performance certification of buildings.

An Energy Performance Certificate (EPC) [4] is an official document that shows a home's current and potential energy efficiency. It displays a rating on a scale from A to G, with A being the most efficient and cheapest to heat. It also includes a list of actions that could improve the home's energy efficiency. You'll need an EPC if you're selling, letting or building a home in the UK or Spain, for example.

Energy performance certification provides a means of rating individual buildings – whether they be residential, commercial or public – on how efficient (or inefficient) they are in relation to the amount of energy needed to provide users with expected degrees of comfort and functionality. The degree of efficiency depends on many factors including: local climate; the design of the building; construction methods and materials; systems installed to provide heating, ventilation, air condition or hot sanitary water; and the appliances and equipment needed to support the functions of the building and its users.

Clearly, certification is a complex procedure, requiring in-depth knowledge of building components. It also reflects increasing recognition of the need to think of buildings as "integrated systems", rather than simply the sum of their parts.

Energy certification of buildings typically involves three main steps:

- The **assessment of the energy performance** of a building by a competent assessor using a nominated methodology.
- The **issuance of a certificate** rating the building's energy performance which includes, in some cases, information on possible improvements likely to yield energy savings.
- The **communication of this information** to stakeholders through publication of the certificate.

Certification is often used in connection with the completion of new buildings as a means of demonstrating compliance with building codes. In the case of existing buildings, certification is used to compare similar buildings and to assess the degree to

which an older building falls short of codes that have been introduced since the time of its construction. As much of the existing building stock was built before energy efficiency became a focus of government policy, certification of existing buildings can do more than provide ratings: it can identify measures to improve energy performance (Arkesteijn and van Dijk, 2010).

Energy performance certificates are valuable to all stakeholders in the building sector. They provide a mechanism by which prospective buyers and tenants can compare the energy efficiency of different buildings or the energy rating across a range of similar buildings. Certification also compares existing buildings to recent building codes, providing a way to compare existing and new buildings. In this regard, certificates are often considered a valuable piece of information at the time consumers are making decisions on property purchases or rentals for either new or existing buildings. But certificates can also be valuable to sellers and property owners: buyers/renters might be attracted by the opportunity to save on energy bills by purchasing or renting a more efficient building. Or, they may opt to purchase/rent a less expensive building, knowing in advance that it is less efficient but can be improved through upgrades identified on the certificate.

5.3.2. Parts of the energy performance certification of buildings

Taking as an example an energy performance certificate of a building in Spain [5], this certificate is divided into the following parts:

- Location of the building: address, climate zone, etc.
- Type of the building
- Description of the energy performance of the building
- Energy rating of the building
- Recommendation for energy efficiency improvement
- Test, checks and inspections carried out by the certifying technician.

Perhaps the most useful part of the EPC is the recommendations section. This is a list of measures that could improve the efficiency of the home.

Recommended measures might include:

- Internal or external wall insulation
- Floor insulation (suspended floor)
- Draught proofing
- Low energy lighting
- Double glazed windows

5.3.3. Energy rating of the building

The energy rating is expressed through several indicators that explain the reasons for good or bad energy performance of the building and provide useful information on the aspects to be taken into account when proposing recommendations to improve this performance.

These indicators, on an annual basis and referring to the unit of useful surface area of the building, will be obtained from the energy consumed by the building to satisfy, under certain climatic conditions, the needs associated with normal operating and occupancy conditions, which will include the energy consumed in: heating, cooling, ventilation, production of domestic hot water and, where applicable, lighting; in order to maintain thermal and light comfort conditions as well as indoor air quality.

The main or global indicators of energy efficiency are:

- annual CO2eq emissions;
- the annual consumption of non-renewable primary energy.

These main indicators include the impact of heating, cooling, domestic hot water production and, in uses other than private residential (housing), lighting, as well as the reduction of emissions or consumption of non-renewable primary energy derived from the use of renewable energy sources.

Buildings intended for private residential use (housing) and buildings intended for other uses shall be classified, for each of the energy performance indicators, on a seven-letter scale, ranging from the letter A (most efficient building) to the letter G (least efficient building).

5.3.4. Model of Energy Performance Certificate for Building in Spain

Below is a model of an energy performance certificate for a building in Spain [5].

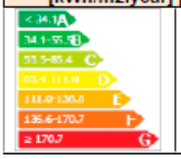
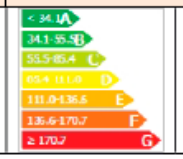
ENERGY PERFORMANCE CERTIFICATE FOR BUILDINGS

Name of the building	RT TO BE CERTIFIED:		
Address			
Municipality		Postcode	
Province		Autonomous Community	
Climate zone		Year of construction	
Current regulations (construction/rehabilitation)			
Cadastral reference(s)			

Type of building or part of the building being certified:	
☐ New building	☐ Existing Building
☐ Housing ☐ Single-family ☐ Block ☐ Complete block ☐ Individual house	☐ Tertiary ☐ Complete building ☐ Local

Name and Surname	NG	NIF/NIE	
Company name		NIF	
Address			
Municipality		Postcode	
Province		Autonomous Community	
e-mail:		Telephone	
Qualifying qualification in accordance with current regulations			
Recognised energy rating procedure used and version:			

ENERGY RATING OB

NON-RENEWABLE PRIMARY ENERGY CONSUMPTION [kWh/m2.year] [kWh/m2.year	CARBON DIOXIDE EMISSIONS [kgCO2/m² -year] [kgCO2/m -year].
	

The undersigned technician declares responsibly that he/she has carried out the energy certification of the building or of the part to be certified in accordance with the procedure established by the regulations in force and that the data contained in this document and its annexes are true:

Date: / / /

Signature of the certifying technician:

Annex I. *Description of the energy performance of the building.*
Annex II. *Energy rating of the building.*
Annex III. *Recommendations for energy efficiency improvements.*
Annex IV. *Tests, checks and inspections carried out by the certifying technician.*

ANNEX I
DESCRIPTION OF THE ENERGY PERFORMANCE OF THE BUILDING

This section describes the energy characteristics of the building, thermal envelope, installations, operating and occupancy conditions and other data used to obtain the energy rating of the building.

1. SURFACE AREA, IMAGE AND LOCATION

Image of the building	Situation map
	

2. THERMAL ENVELOPE

Name	Type	Surface area [m^2]	Transmittance [W/m^2-K]	How to obtain

Name	Type	Surface area [m2]	Transmittance [W/m2-K]	Solar factor	How to obtain. Transmittance	How to obtain. Solar factor

3. THERMAL INSTALLATIONS

Heating generators

Name	Type	Rated power [kW]	Seasonal Performance [%]	Energy Type	How to obtain
TOTALS		-			

Cooling generators

Name	Type	Rated power [kW] [kW] [kW] [kW] [kW] [kW] [kW] [kW] [kW] [kW	Seasonal Performance [%]	Energy Type	How to obtain
TOTALS		-			

Sanitary Hot Water Installations

Name	Type	Rated power kW] [kW] [kW] [kW] [kW] [kW] [kW] [kW] [kW] [kW	Seasonal Performance [%]	Energy Type	How to obtain
-	-	-	-	-	-

Name	-		
Type	-		
Associated area	-		
Heat output [kW]	Cooling capacity [kW]	Seasonal heating performance [%] Seasonal heating performance [%] Seasonal heating performance [%] Seasonal heating performance [%] Seasonal heating performance	Seasonal cold yield [%] Seasonal cold yield [%].
-	-	-	-
Free cooling	Evaporative cooling	Energy recovery	Control
-	-	-	-

Name	Type	Associated service	Energy consumption [kWh/year].
-	-	-	-
TOTALS			

Name	Type	Associated service	Energy consumption [kWh/year].
-	-	-	-
TOTALS			

Space	Installed power [W/m]²	VEEI [W/m² -100lux].	Average illuminance [lux] Average illuminance [lux] Average illuminance [lux] Average illuminance [lux	How to obtain
-	-	-	-	-
TOTALS	-			

Space	Surface area [m]²	Usage profile
-	-	-

Name	Final Energy Consumption, covered as a function of the associated service [%].			Demand for Covered DHW [%] [%].
	Heating	Cooling	ACS	
Solar panels	-	-	-	30
Biomass boiler	-	-	-	
TOTAL	-	-	-	-

Name	Electricity generated and self-consumed [kWh/year].
-	-
TOTAL	-

ENERGY RATING OF THE BUILDING

OVERALL INDICATOR		PARTIAL INDICATORS			
1. ENERGY PERFORMANCE OF THE BUILDING I EMIS		HEATING		ACS	
< 34.1 A 34.1-55.5 B 55.5-85.4 C 85.4-111.0 D 111.0-136.6 E 136.6-170.7 F ≥ 170.7 G	126.89 E	*Heating emissions [kgCO2/m² -year] [kgCO2/m -year].*	*B*	*DHW emissions [kgCO2/m² -year].*	
		50,2			
		REFRIGERATION		LIGHTING	
Global emissions [kgCO2/m² -year].[1]		*Cooling emissions [kgCO2/m² -year] [kgCO2/m -year].*		*Lighting emissions [kgCO2/m² -year] [kgCO2/m -year].*	

The overall rating of the building is expressed in terms of [illegible]osphere as a result of the building's energy consumption.

	kgCO2/m2.year	kgCO2/year
CO2 emissions from electricity consumption	-	-
CO2 emissions from other fuels	-	-

2. ENERGY RATING OF THE BUILDING IN TERMS OF NON-RENEWABLE PRIMARY ENERGY CONSUMPTION

[illegible] any conversion or transformation process.

OVERALL INDICATOR		PARTIAL INDICATORS			
		HEATING		ACS	
< 34.1 A 34.1-55.5 B 55.5-85.4 C 85.4-111.0 D 111.0-136.6 E 136.6-170.7 F ≥ 170.7 G	126.89 E	*Primary energy heating [kWh/m² -year] [kWh/m -year].*	*A*	*Primary energy DHW [kWh/m² -year].*	
		32			
		REFRIGERATION		LIGHTING	
Overall non-renewable primary energy consumption [kWh/m² -year].[1]		*Primary energy cooling [kWh/m² -year] [kWh/m -year].*		*Primary energy lighting [kWh/m² -year] [kWh/m -year].*	

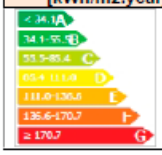
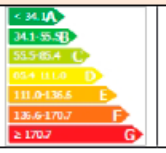
3. PARTIAL QUALIFICATION OF THE HEATING AND COOLING ENERGY DEMAND

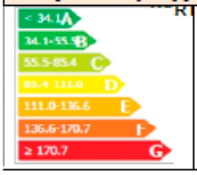
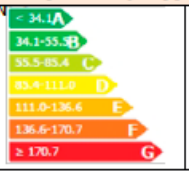
The energy demand for heating and cooling is the energy required to maintain the internal comfort conditions of the building.

HEATING DEMAND		COOLING DEMAND	
< 34.1 A 34.1-55.5 B 55.5-85.4 C 85.4-111.0 D 111.0-136.6 E 136.6-170.7 F ≥ 170.7 G	126.89 E	< 34.1 A 34.1-55.5 B 55.5-85.4 C 85.4-111.0 D 111.0-136.6 E 136.6-170.7 F ≥ 170.7 G	126.89 E
Heating demand [kWh/m² -year].		*Cooling demand [kWh/m² -year].*	

1 The global indicator is the result of the sum of the partial indicators plus the value of the indicator for auxiliary consumption, if any (only tertiary buildings, ventilation, pumping, etc.). Self-consumed electricity is only deducted from the global indicator, not from the partial values. Date (of document generation)

ANNEX III
RECOMMENDATIONS FOR ENERGY EFFICIENCY IMPROVEMENTS

Designation	NON-RENEWABLE PRIMARY ENERGY CONSUMPTION [kWh/m2.year] [kWh/m2.year	CARBON DIOXIDE EMISSIONS [kgCO2/m² -year] [kgCO2/m -year].
		

HEATING DEMAND [kWh/m² -year] [kWh/m -year].	COOLING DEMAND [kWh/m² -year] [kWh/m -year].
	

Indicator	Heating			Cooling		ACS		Lighting		Total	
	Value		savings compared to the situation original	Value	savings compared to the situation original	Value	savings compared to the situation original	Value	savings compared to the situation original	Value	savings compared to the situation original
Final energy consumption [kWh/m² -year].	150,3		12,8%								
Consumption Non-renewable primary energy [kWh/m² -year] [kWh/m -year].	180,4	D	10,2%								
$_{CO2}$ emissions [kgCO2/m² -year].											
Demand [kWh/m² -year] [kWh/m -year].											

Note: The above energy indicators are calculated based on standard coefficients of operation and functioning of the building and are therefore only valid for the purpose of energy rating. For the economic analysis of energy saving and efficiency measures, the certifying technician shall use the actual conditions and historical consumption data of the building.

DESCRIPTION OF IMPROVEMENT MEASURE
Technical characteristics of the measurement (type of equipment, materials, characteristic parameters) *(According to Annex ...)*
Estimated cost of the measure
Other information of interest

5.4 – Green Building Certificates

5.4.1. What is green building?

Sustainability is not a one-time treatment or product [6]. Instead, green building is a process that applies to buildings, their sites, their interiors, their operations, and the communities in which they are situated. The process of green building flows throughout the entire life-cycle of a project, beginning at the inception of a project idea and continuing seamlessly until the project reaches the end of its life and its parts are recycled or reused.

The term green building encompasses planning, design, construction, operations, and ultimately end-of-life recycling or renewal of structures. Green building pursues solutions that represent a healthy and dynamic balance between environmental, social, and economic benefits.

Sustainability and "green," often used interchangeably, are about more than just reducing environmental impacts. Sustainability means creating places that are environmentally responsible, healthful, just, equitable, and profitable. Greening the built environment means looking holistically at natural, human, and economic systems and finding solutions that support quality of life for all.

Triple bottom line is also often used to refer to the concept of sustainability. The term was coined by John Elkington, cofounder of the business consultancy SustainAbility, in his 1998 book *Cannibals with Forks: the Triple Bottom Line of 21st Century Business.* First applied to socially responsible business, the term can characterize all kinds of projects in the built environment. The triple bottom line concept incorporates a long-term view for assessing potential effects and best practices for three kinds of resources:

- **People (social capital).** All the costs and benefits to the people who design, construct, live in, work in, and constitute the local community and are influenced, directly or indirectly, by a project
- **Planet (natural capital).** All the costs and benefits of a project on the natural environment, locally and globally
- **Profit (economic capital).** All the economic costs and benefits of a project for all the stakeholders (not just the project owner)

The goal of the triple bottom line, in terms of the built environment, is to ensure that buildings and communities create value for all stakeholders, not just a restricted few. For example, an energy-efficient building that saves the owners money but makes the occupants sick is not sustainable, nor is a material that has a small carbon footprint but

was made in a sweatshop, nor is an eco-resort that displaces threatened species or local people.

The triple bottom line

A commitment to the triple bottom line means a commitment to look beyond the status quo. It requires consideration of whole communities and whole systems, both at home and around the world. Research is needed to determine the impacts of a given project and find new solutions that are truly sustainable. New tools and processes are required to help projects arrive at integrative, synergistic, sustainable solutions.

The triple bottom line requires a shift in perspective about both the costs and the benefits of our decisions. The term externalities is used by economists to describe costs or benefits incurred by parties who are not part of a transaction. For example, the purchase price of a car does not account for the wear and tear it will have on public roads or the pollution it will put into the environment. To shift the valuation process to account for such negative externalities, building professionals require new metrics. The green building process and rating systems have begun to encourage quantification of externalities. The focus has been first on environmental metrics, but the list is expanding to include indicators of social justice and public health.

5.4.1. What is a sustainable building certification?

Sustainable building certifications – also known as green building rating tools – are used to assess and recognise buildings which meet certain sustainability requirements or standards [7].

Building certifications recognise and reward companies and organisations who build and operate greener buildings, thereby encouraging and incentivising them to push the boundaries on sustainability.

They kick-start the market by setting standards that in turn elevate the ambition of government building codes and regulation, workforce training, and corporate strategies.

Certifications vary in their approach and can be applied to the planning and design, construction, operation, maintenance, renovation, and eventual demolition phases of a building.

Sustainable building certifications can also differ in the type of buildings they are applied to, with specific tools or subsets of tools used for different building types such as homes, commercial buildings, or even whole neighbourhoods.

5.4.2. Green Building Councils and building certifications.

Green Building Councils, which are members of the World Green Building Council (WorldGBC) global network, develop and administer many of the world's building certifications.

By 2021, 4.2 billion square metres of green building space had been certified around the world through member Green Building Councils.

WorldGBC recognises the power that building certifications have had in transforming the sustainability of building practices, and firmly supports their use.

Some of the main green building certifications in Europe are described below.

5.4.3. A list of Green Building Certifications to know

Some of the most well-known green building certificates are as follows:

- LEED (Leadership in Energy and Environmental Design)
- Energy Star
- BREAM (the Building Research Establishment Environmental Assessment Method)
- Green Globes
- Living Building Challenge
- GreenGuard
- WELL Building Standard
- NABERS
- Green Star
- CASBEE
- VERDE

Two of the main green building certifications in Europe are described below.

5.4.4. BREEAM

BREEAM [8] is an international sustainability standard which is met by only a select group of buildings that received the BREEAM label. There are three areas in which a BREEAM certification can be obtained: in-use, building and new construction & renovation. Your score gets higher as you meet more sustainability criteria. A building that has a high BREEAM score benefits from increased value and demonstrates a certain level of sustainability. Furthermore, buildings that are ranked high on BREEAM have positive impact on employee productivity and health of its users.

BREEAM is used in more than 70 countries worldwide, with several of those countries having gone a bit further by developing country-specific BREEAM schemes which are operated by National Scheme Operators (NSOs).

BREEAM is the world-leading sustainability assessment method for the built environment and infrastructure. Project owners around the world rely on BREEAM to achieve their sustainability goals and improve the performance of their assets. The BREEAM framework is used to assess whole life performance, from new build projects to refurbishment and fit-out.

BREEAM supports ESG (environmental social and governance) solutions in:

- Net zero carbon
- Whole life performance
- Health and social impact
- Circularity and resilience
- Biodiversity
- Disclosures and reporting

How BREAM works?

BREEAM is used to specify and measure the sustainability performance of buildings, ensuring that projects meet sustainability goals and continue to perform optimally over time.

A BREEAM assessment uses recognised measures of performance, which are set against established benchmarks, to evaluate a building's specification, design, construction and use. The measures used represent a broad range of categories and criteria from energy to ecology. Each category focuses on the most influential factors.

Integrating sustainability measures at the earliest possible stage of a project using the BREEAM framework enables reduced life cycle costs and increases in asset value, building user experience and health, corporate image and CSR requirements, and risk mitigation.

BREEAM supports solutions to reduce net zero carbon, improve whole life performance, manage health and social impacts, boost circularity, resilience and biodiversity, and support disclosures and reporting.

BREEAM provides a holistic sustainability assessment framework, measuring sustainable value in a series of categories and validating this performance with third-party certification. Each of these categories addresses influential factors, including low impact design and carbon emissions reduction; design durability and resilience; adaption to climate change; and ecological value and biodiversity protection. **BREAM assessment categories** are:

- Management
- Water
- Energy
- Transport
- Health & wellbeing
- Resources
- Resilience
- Land use & ecology
- Pollution
- Materials
- Waste
- Innovation

BREAM rating

A BREEAM certified rating reflects the performance achieved by a project and its stakeholders, as measured against the BREEAM standard and its benchmarks. The rating enables comparability between projects and provides assurance on performance, quality and value of the asset.

The BREEAM ratings range from Acceptable (In-Use scheme only) to Pass, Good, Very Good, Excellent to Outstanding and it is reflected in a series of stars on the BREEAM certificate. Always look for the BREEAM certificate and certification mark to verify an assessment and its BREEAM rating.

BREEAM rating	% score
Outstanding ★★★★★	≥85
Excellent ☆★★★★	≥70
Very good ☆☆★★★	≥55
Good ☆☆☆★★	≥45
Pass ☆☆☆☆★	≥30
Unclassified ☆☆☆☆☆	<30

BREAM rating

5.4.5. LEED

LEED [9](Leadership in Energy and Environmental Design) is the world's most widely used green building rating system. LEED certification provides a framework for healthy, highly efficient, and cost-saving green buildings, which offer environmental, social and governance benefits. LEED certification is a globally recognized symbol of sustainability achievement, and it is backed by an entire industry of committed organizations and individuals paving the way for market transformation.

LEED is for all building types and all building phases including new construction, interior fit outs, operations and maintenance and core and shell.

LEED-certified buildings are critical to addressing climate change and meeting ESG goals, enhancing resilience, and supporting more equitable communities. LEED is a holistic system that doesn't simply focus on one building element, such as energy, water or health. Instead, it looks at the big picture, factoring in all critical elements that work together to create the best building possible. The goal of LEED is to create better buildings that:

- Reduce contribution to global climate change
- Enhance individual human health
- Protect and restore water resources
- Protect and enhance biodiversity and ecosystem services
- Promote sustainable and regenerative material cycles
- Enhance community quality of life

Of all LEED credits, 35% relate to climate change, 20% directly impact human health, 15% impact water resources, 10% affect biodiversity, 10% relate to the green economy, and 5% impact community and natural resources. In LEED, most LEED credits are related to operational and embodied carbon.

How LEED works

To achieve LEED certification, a project earns points by adhering to prerequisites and credits that address carbon, energy, water, waste, transportation, materials, health and indoor environmental quality. Projects go through a verification and review process by US Green Building Council (USGBC) and are awarded points that correspond to a level of LEED certification: Certified (40-49 points), Silver (50-59 points), Gold (60-79 points) and Platinum (80+ points).

LEED is backed by US Green Building Council—the developers of LEED—and an entire industry of committed organizations and individuals who are paving the way for market transformation. USGBC invests more than $30 million annually to maintain, operate and improve LEED and its customer delivery.

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6 - Deliverables

To evaluate the success of the application, students will have to answer an online questionnaire.

7- What we have learned

What is the energy efficiency of a building.

Objectives of the Energy Performance of Buildings Directive (2023).

Key facts about energy and EU buildings.

Advantages of EU building renovation.

What is the energy performance certification of a building and its parts.

The energy rating of the building.

What is green building.

What is a sustainable building certification.

How the BREAM certification works.

What is LEED certification.