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PLUG-AND-USE RENOVATION WITH ADAPTABLE LIGHTWEIGHT SYSTEMS

PLURAL

D1.2
Technical and market codes, national and European certification frameworks

Version: 1.0

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Terms, definitions and abbreviated terms

BIPV	Building Integrated Photovoltaic
CPR	Construction Products Regulation
eAHC	Air handling unit with Heating & Cooling
DHW	Domestic Hot Water
EED	Energy Efficiency Directive
EMC	Electromagnetic Compatibility (EMC)
EPBD	Energy Performance of Buildings Directive
EPC	Energy Performance Certificate
EPD	Environmental Product Declaration
ETA	European Technical Assessment
eWHC	External Wall Heating and Cooling
IAQ	Indoor Air Quality
LCA	Life Cycle Assessment
LVD	Low Voltage Directive
nZEB	Near Zero Energy Building
PCR	Product Category Rules
PnU	Plug and Use
PV	Photovoltaic
RES	Renewable Energy Systems

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Executive summary

PLURAL targets to design, validate and demonstrate a palette of versatile, adaptable, scalable, off-site prefabricated plug and play facades accounting for user needs ("Plug-and-Use" kits). For this purpose, PLURAL focuses on three main pillars:

- Assessing different core systems, which couples heating-cooling, ventilation, heat harvesting systems with smart windows, 3D printing, low carbon footprint coating materials and smart control systems towards NZEB status for different European climates and different residential building typologies (<60 kWh/m^2 per year of buildings' total primary energy consumption and >50 kWh/m^2 per year of on-site renewable energy generation).
- Utilizing BIM based big management platform coupled with Decision Support Tool (DST) in order to optimize the component selection and integration, as well as to optimize the PnU kit design, speed, cost manufacturing and installation (≥ 50% reduction in the time required for deep renovation of e.g. multi-family blocks, 58% reduction in renovation costs through off-site prefabrication lean manufacturing and construction, interactively supported by the BIM based platform and DST)
- Demonstrating the applicability of the PnU kits by implementing the solutions in three real and three virtual residential buildings evaluating the renovation time and cost reduction, the PnU kits performance, carbon saving and users' acceptance.

PLURAL will create best practice renovation examples for the residential sector based on innovation and competitiveness, with benefits for the citizens and the environment. It will develop business cases and models for key stakeholders and improves the life cycle based performance standards applied in the building sector.

In this deliverable, a review of compliance requirements for the PLURAL solutions, i.e. "Smart Wall", "eWHC" and "eAHC" with EU and country specific building regulations and codes is examined. Initially, D1.2 presents all the European regulations that can be related with the PLURAL prefabricated solutions, as well as the national legislation framework of the countries where the PLURAL demo buildings (both real and virtual) are situated. The presented regulations and codes relate to energy performance, structural design, fire safety, hygiene and health, acoustics as well as renewable energy generation in buildings.

At first, D1.2 provides a full picture of the EU and national that relate to the PLURAL systems (Chapter 1 & 2). As the PnU kits are basically construction products, the regulations are presented based on the Construction Products Regulation (CPR) and its seven basic requirements. Next in this report, the components of each PLURAL solution (PnU kit) for prefabricated facades are examined in terms of standardisation (Chapter 3). The final part (Chapter 4) attempts to make a preliminary assessment of the PLURAL renovation plan for each demo building in terms of compliance with each demo country national regulations and codes. This effort cannot be fully completed for any of the demo cases as the technical specifications of the final design of the PnU kits are not all yet defined. The goal is to relate as much as possible the renovation concepts of the demo

buildings with the national regulations in order to identify possible issues of incompliance that need to be handled during design finalization in the next steps of the project.

D1.2 provides input to Task 1.3 that deals with certifications strategies and the related requirements for the innovative PnUs. It also provides supportive documentation for Task 2.6 that delivers the final design of PnU kits.

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Introduction

Deliverable D1.2 “Technical and market codes, national and European certification frameworks” has been prepared in the frame of Task 1.2 “Technical and market codes” (M04-M12). The scope of D1.2 is to review building related European and national regulations and technical codes, to present the standardization framework of the various components of the PLURAL renovation solutions, and to examine the compliance of the PLURAL solutions with them when deployed to the demo buildings of each demo country (real and virtual). More specifically, the main objectives of D1.2. are:

- **Objective 1**: Review the European and all demo countries national legislation framework on all the related aspects of the PLURAL solutions (structural/load bearing and seismic, fire safety, acoustics energy performance, health and safety, renewable energy)
- **Objective 2**: Identify the applicable certification and standardisation framework of PLURAL PnU kits at component level (manufacturing, installation standards, certification and related classifications).
- **Objective 3**: Examine the compliance of the PLURAL renovation concepts with the relevant technical codes and regulations when applied to the specific demo buildings both real and virtual.

After an extended review of the European regulations (chapter 1) regarding all related subjects to buildings, a presentation of national regulations in a common template is given for the three real demo countries and for the three virtual demo ones. The categorisation of the regulations is based on the seven requirements of the Construction Products Regulation (CPR) of EU that are presented in the first chapter while the legal framework for generating on site energy in buildings from renewable sources is also added.

Task 1.2 is using data mostly from Tasks 1.1 and 7.1 where the requirements and the demo buildings survey and preliminary design of the PLURAL renovation with the PnU kits are described. With this input, combined with each country’s building regulations and technical codes, a preliminary compliance review is made. The main purpose of this is to ensure that the intended renovation proposals based on the prefabricated façade elements or plug and use kits are in compliance with the relevant regulations, both in terms of components and processes used in order to installed them at the demo buildings. Early identification of any incompatibilities with the regulations and legal framework will facilitate the overall progress and will provide input to later Tasks of the PLURAL project and especially to WP2, where the final design of the PnU kits and the renovation details will be made. It will also provide some guidance at a later stage at WP7 where the actual renovation process will take place at the three real demo buildings and the virtual renovation at the other three.

1 European technical codes and regulations review

1.1 Introduction - Constructions Products Regulation

In this chapter a review of European regulations about all the possible subjects that can be related with the installation and the use of the PLURAL project PnU kits in buildings, is carried out. Most regulations about buildings constructions refer mostly to new constructions which cannot be directly related with a major renovation using prefabricated elements like the PnU kits of PLURAL project. However, in this report, for the sake of completeness, all relative technical codes and regulations will be presented.

In addition, European technical codes and regulations have already ended or will gradually end up to be transposed to national regulations. This means that they affect the national codes and consequently the minimum requirements of construction products in various categories (structural, fire, energy etc.).

The European Union has put in place a comprehensive legislative and regulatory framework for the construction sector. Health and safety in construction and the free movement of engineering/construction services and products are important policy priorities. Concerning the construction activity itself, the focus is on the competitiveness of the sector, not least in the field of sustainable construction. [1]

European legislation defines the essential requirements that goods must meet when they are placed on the market and the European standardisation bodies have the task of drawing up the corresponding technical specifications. The free movement of products and services is now facilitated by the EU-wide implementation of common European technical standards for structural design: The Eurocodes.

The following Regulations and Directives are related to the EN Eurocodes:

- Construction Products Regulation;
- Public Procurement Directive;
- Services Directive;
- Directive on the provision of information in the field of technical standards and regulations.

In the case of the PLURAL project what is most relevant to focus on from the above is the Construction Products Regulation (CPR) [2].

Construction Products Regulation (CPR)

The Construction Products Directive of 1989 (CPD 89/106/EEC) was one of the first directives from the EU Commission to create a common framework for the regulations on buildings and construction products. It has been replaced by the Construction Products Regulation (CPR) and is legally binding throughout the EU. The objective of the Construction Products Regulation is to achieve the proper functioning of the internal market for construction products by establishing harmonised rules on how to express their performance.

The major key points of the CPR are:

- To set out the conditions for the marketing of construction products.
- To set out methods and criteria for assessing and expressing the performance of construction products, and the conditions for the use of CE marking.

Consequently, the CPR does not set directly any requirements for the construction products but establishes the rules of how and from where the requirements will occur. The aim of the CPR is to make the single market work better and improve the free movement of construction products in the EU, by laying down uniform rules for the marketing of these products and by providing a common technical language to assess the performance of construction products. In this way the regulation also enables EU countries to ensure the safety of construction works.

EU countries, on the other hand, are responsible for fire safety, mechanical resistance and stability, environmental, energy and other requirements applicable to construction works. Most of these requirements come from EU directives and frameworks so their approaches are quite common too.

As it is also stated in the Supporting study for the Review of the Construction Products Regulation: Evaluation [3]:

"The construction works, and consequently also the products used and integrated, are extensively influenced by the design as determined by the designer (architect, engineer, etc). Thus, design rules (building regulations) are set at Member State level (sometimes even at regional/local level) and are generally not related to the performance of an individual product but rather to the performance of the entire works (or a major feature of it) in which it is integrated".

As it is mentioned before and to summarize, the CPR aims to achieve the proper functioning of the internal market for construction products by establishing rules on how to express the performance of construction products in relation to their essential characteristics and on the use of CE marking on those products.

Annex I to the CPR [4] lists 7 basic requirements for construction works. These basic requirements constitute the basis for the preparation of standardisation requests (mandates). Subject to normal maintenance, construction works must be designed and built in such a way as to satisfy the basic requirements for construction works for an economically reasonable working life, in the following areas:

1. Mechanical resistance and stability

The structure and construction products must ensure no collapses, deformations or damages to other structures or people.

2. Safety in case of fire

The structure and construction products must guarantee, in case of fire, the load-bearing capacity of the construction and limited fire propagation. Moreover, occupants and rescue teams' safety must be ensured.

3. Hygiene, health and the environment

Construction products must ensure, during their whole life cycle, the proper hygiene and good health condition to building occupants, as well as not causing emission of dangerous substances in construction, use and demolition phase.

4. Safety and accessibility in use

In general, construction products should guarantee that their use does not create risks of accidents or damages to the users. Moreover, accessibility for disabled persons must be taken into consideration.

5. Protection against noise

Occupants and nearby people should not be disturbed by construction products' noise emissions.

6. Energy economy and heat retention

Construction products must be designed and built in order to require low energy consumptions, both in construction, use and dismantling phases, aiming in general to energy-efficiency principles.

7. Sustainable use of natural resources.

The reuse and recycling of the construction products, as well as their durability must be guaranteed.

It needs to be underlined that the above-mentioned basic works requirements, in spite of the word "requirements", do not impose any obligations on anybody. They rather bring forward a categorization of the requirements Member States have defined or may define for construction works on their territory, and at the same time present the sphere of harmonization for CPR purposes, both these aspects to be taken duly into account when determining essential characteristics of construction products.

When the basic requirements of the CPR and CPD are compared, it may be seen that the CPR has a new requirement (No. 7 Sustainable use of natural resources), and that No. 3 (Hygiene, health and the environment) and No. 4 (Safety and accessibility in use) have been refined. This means that commercialisation of construction materials in Europe beyond 2013 stated to be subject of mandatory environmental assessment [5].

The CPR includes requirements for the sustainable use of natural resources (n7), the reduction of greenhouse gas emissions over the life cycle and the use of EPD for assessing and reporting the impacts of construction products (see section 1.8). If an EU Member State wishes to regulate in these areas of sustainability, it must use European standards where they exist when regulating and must withdraw national standards. This means that in the case of the CPR, a Member State must use the CEN/TC 350 suite of standards [6].

Declaration of Performance and CE marking

The Declaration of Performance is a key part of the Construction Products Regulation. It provides information on the performance of a product. Each construction product covered by a European harmonised standard or

for which a European Technical Assessment has been issued needs this Declaration and has to be CE marked. This helps increase transparency and improves the functioning of the Single Market [7].

Where a manufacturer decides to place a construction product on the market and that product is covered by a harmonised standard or a European Technical Assessment has been issued for it, the manufacturer must draw up a Declaration of Performance which contains, among other things, the following information:

- product reference;
- systems of assessment and verification of consistency of performance of the product;
- reference of the applicable harmonised standard or European Technical Assessment;
- intended use or uses for the product;
- declared performance based on the assessment according to the applicable harmonised standard or European Technical Assessment.

Once the Declaration of Performance has been drawn up, the manufacturer must affix a CE marking to the product. The CE marking indicates that the performance of the product has been assessed and that it remains constant. CE marking enables a construction product to be placed legally on the market in any EU country and then be traded on the EU's single market. EU countries must establish Product Contact Points for Construction to provide information on the requirements for construction products [8].

Based on the seven requirements for construction works and adopted in the CPR, as mentioned above, the regulation review will be continued examining other regulations at European level that are related with both construction products and the building as a whole.

1.2 Mechanical resistance, stability and seismic reaction

Eurocodes

Prior to the CPR, introduced in the previous section, and its predecessor the CPD, the European Commission took the initiative to establish a set of harmonised technical rules for the design of construction works. The goal was these rules to gradually replace the national rules of member states. After the first generation of these European codes in the 1980s, the Commission decided to transfer the preparation and publication of the Eurocodes to the European Committee of Standardization (CEN) in order to be future standards.

By 2002, the Eurocodes have been developed and published as a series of ten European technical standards that provide a common approach to the structural design of buildings and other civil engineering works. They are the recommended reference for technical specifications in public contracts. The EN Eurocodes are expected to contribute to the establishment and functioning of the internal market for construction products and engineering services by eliminating the disparities that hinder their free circulation within the Community. Further, they are meant to lead to more uniform levels of safety in construction in Europe.

They are currently at the stage of maintenance and evolution in order to address the variety of new methods, new materials, new regulatory requirements and new societal needs developing and to extend harmonisation.

The Eurocodes apply to structural design of buildings and other civil engineering works including :

- geotechnical aspects
- structural fire design
- situations including earthquakes, execution and temporary structures

and they cover:

- basis of structural design (EN 1990)
- actions on structures (EN 1991)
- the design of concrete (EN 1992), steel (EN 1993), composite steel and concrete (EN 1994), timber (EN 1995), masonry (EN 1996) and aluminium (EN 1999) structures
- geotechnical design (EN 1997)
- the design, assessment and retrofitting of structures for earthquake resistance (EN 1998).

All of the EN Eurocodes relating to materials have a Part 1-1 which covers the design of buildings and other civil engineering structures and a Part 1-2 for fire design.

The EN Eurocodes are intended to be used as reference documents to determine the performance of construction products. They give a presumption of conformity with the basic requirements for mechanical resistance and stability, resistance to fire and safety in use.

The Member States of the EU and the European Free Trade Association (EFTA) recognise that EN Eurocodes serve as reference documents for the following purposes:

- as a means to prove compliance of building and civil engineering works with the basic requirements of the Construction Products Regulation, particularly Basic Requirement 1 "Mechanical resistance and stability" and Basic Requirement 2 "Safety in case of fire";
- as a basis for specifying contracts for construction works and related engineering services;
- as a framework for drawing up harmonised technical specifications for construction products (ENs and ETAs) [9].

The European Standardisation system relating to construction is a comprehensive system of design standards that comprises the EN Eurocodes, along with material and product standards, as well as execution and test standards.

National Implementation of the EN Eurocodes

Under the Public Procurement Directive, it is mandatory that Member States accept designs to the EN Eurocodes. The EN Eurocodes will become the standard technical specification for all public works contracts.

If proposing an alternative design one must demonstrate that is technically equivalent to an EN Eurocode solution.

The implementation of an EN Eurocode part has three phases, the Translation Period, the National Calibration Period and the Coexistence period. Every country – member state of the EU had to make an implementation plan for the Eurocodes in order to translate every part made available, to set the National Determined Parameters to be applied, to publish the national standard transposing each Eurocode and finally to adapt national provisions that Eurocodes can be used for specifying contracts for the execution of public construction works and related engineering services.

EN Eurocodes recognise the responsibility of regulatory authorities in each Member State and have safeguarded their right to determine values related to regulatory safety matters at a national level where these continue to vary from State to State. EN Eurocodes provide for National Choices full sets of recommended values, classes, symbols and alternative methods to be used as Nationally Determined Parameters (NDPs).

During the Coexistence Period which can last up to a maximum time of three years after the national publication of the last Part of a Package, both the National Standard transposing the EN Eurocode and any existing national standard can be used. At the end of the Coexistence Period of the last EN Eurocode Part of a Package, the National Standardisation Bodies should withdraw all conflicting National Standards [10].

As the National Standardisation Bodies are not expected to maintain the withdrawn National standards in practice, there will be little option but to use the EN Eurocodes. It is generally intended and expected that pressures from international clients and contractors, as well as other stakeholders like the insurance industry, will lead to their more rapid application for private construction [9].

Eurocodes generally deal with structural issues of buildings and infrastructure while PLURAL's suggested and under development solutions are prefabricated external facades or internal "add-ons". This means that structurally there is not much from the PNUs that can affect the buildings structure. However, the timber frame of the external Wall Heating and Cooling that will be deployed in the Czech demo building, may be related for example with Eurocode 5 (Design of timber structures) and the ventilated façade of the Spanish demo building is a metallic structure related to Eurocode 3 (Design of steel structures).

Earthquake resistance

The first European standard for seismic design was first published in 2000 as Eurocode 8 (also denoted by EN 1998): "Design of structures for earthquake resistance". It covers common structures and, although its provisions are of general validity, special structures, such as nuclear power plants, large dams or offshore structures are beyond its scope. Its seismic design should satisfy additional requirements and be subject to complementary verifications. Like all standards it has been replaced and amended since its first publication.

The objectives of seismic design in accordance with Eurocode 8 are explicitly stated. Its purpose is to ensure that in the event of earthquakes:

- *human lives are protected;*
- *damage is limited; and*
- *structures important for civil protection remain operational.*

These objectives are present throughout the code and condition the principles and application rules therein included.
Eurocode 8 is composed by 6 parts dealing with different types of constructions or subjects:

1. General rules, seismic actions and rules for buildings
2. Bridges
3. Assessment and retrofitting of buildings
4. Silos, tanks and pipelines
5. Foundations, retaining structures and geotechnical aspects
6. Towers, masts and chimneys

Although the Eurocodes are the same across the different countries, for matters related to safety and economy or for aspects of geographic or climatic nature national adaptation is allowed if therein explicitly foreseen. These are the Nationally Determined Parameters (NDPs) that are listed at the beginning of each Eurocode. For these parameters, each country, in a National Annex included in the corresponding National Standard, may take a position, either keeping or modifying them.

1.3 Safety in case of fire

Until recently EU countries had different methods for testing and classifying the Reaction to Fire performance of construction materials. This made comparison of the resulting data extremely difficult, with manufacturers required to carry out different tests in order to sell their products in a particular country. The implementation of a single classification system across the EU member states has introduced a common method for comparing the Reaction to Fire performance of construction products. Testing is standardised through the use of EN 13501-1: Fire classification of construction products and building elements. For construction products intended to be used in wall and ceiling assemblies, there are seven Reaction to Fire classification levels available – A1, A2, B, C, D, E and F. Additional criteria provide information on a product's tendency to produce smoke and flaming droplets or particles. For combustible products, smoke release is an important consideration and is measured for Reaction to Fire classes A2 to D. There are three smoke intensity levels: s1, s2 and s3, with s3 being the worst. Burning droplets/particles can inflict skin burns and cause further spread of fire. Burning droplets/particles are measured for Reaction to Fire classes A2 to E. There are three classes of burning droplets: d0, d1 and d2, with d2 being the worst.

The European reaction to fire classification system was introduced in support of the Construction Products Directive (CPD) with the aim of achieving harmonisation and eventually replacing the different national

standard tests and classifications. Some correlations could indeed be drawn between the 7 Euroclasses and elements of the pre-existing standards. Although the CPD is now replaced by the CPR, the European harmonised test methods and classifications remain the same.

Harmonising test standards in the European Union is meaningful whilst aiming for simplification and standardisation. However, the intended use, as described in the CPR, translates into different fields of application. Consequently, the test results have to be interpreted and assessed in order to confirm a fire classification, including the boundary conditions. These currently fall into two categories: the direct field of application (DIAP) and the extended field of application (EXAP).

Essentially, the harmonised tests and standards are in place, but it is still a matter for each Member State to decide for itself what level of classification for fire safety is considered acceptable for each type of application.

Fire regulations historically refer to three basic categories of fire standards: Reaction to fire, resistance to fire and external fire performance of roofs. A fourth category is used in a number of countries and currently research is going on for setting a European approach to “external fire on façades”. This was triggered by the introduction of new façade systems in buildings and their growing importance.

Euro-classification

The European standard that provides classification of products in relation with their performance in fire exposure is the EN 13501 standard with 6 separate parts categorizing different type of products. It was first released in 2002 and various versions followed. The various standard parts provide the fire classification procedure for either fire reaction or fire resistance, depending also on the type of product. The latest versions of the 6 parts of the standard are presented very briefly in the ANNEX I.

Reaction to Fire

A reaction to fire test assesses how easily a product can be ignited and contribute to fire growth. It relates mostly to the early stages of a fire development and is arguably mostly relevant to those products directly exposed to the fire source i.e. wall linings, ceiling linings and external wall surfaces. It is also relevant for assessing the performance of construction products during construction or during building maintenance, e.g. welding of the building elements.

Standard EN 13501 part 1, provides the reaction to fire classification procedure for all construction products, including products incorporated within building elements. Products are considered in relation to their end use application and are divided in three categories:

- construction products, excluding floorings and linear pipe thermal insulation products;
- floorings;
- linear pipe thermal insulation products.

The products are tested with specific test methods and according to their performance they are classified into seven Euroclasses:

- A1 and A2 for non-combustible materials
- B, C, D, E for materials that range from limited to high contribution to fire
- F for materials which fail Euroclass E criteria and are considered flammable.

Further classifications (typically associated with reaction to fire classes D – B) are used to indicate smoke production (from s1 (little or no smoke) to s3 (substantial smoke)) and flaming droplets/particles (from d0 (none) to d2 (quite a lot))

In Annex I (7.1) fire

Alongside the Euroclass system there is now a European test to assess the smouldering or continuous glowing potential of a product (EN 16733). Smouldering or continuous glowing represent slow, internal combustion processes that can lead to fires breaking out some distance and time away from the original source of ignition. This characteristic is considered a risk, regarding hidden spread of fire and persistence of ignition sources after fire brigades have assumed that a fire is completely extinguished.

Resistance to fire

One definition of fire resistance is "the ability of a structural element to sustain the performance of its structural duty, whilst being exposed to the temperatures likely to be encountered in a developed fire for specified periods of time."

As it was described in section 1.2 of this report, the Eurocodes (EN 1991 General Actions and the relating to specific material ones: EN 1992, 1993, 1994, 1995, 1996 1999) have a dedicated part (Part 1-2) for fire design. The fire parts of Structural Eurocodes deal with specific aspects of passive fire protection in terms of designing structures and parts thereof for adequate load bearing resistance and for limiting fire spread as relevant. These parts of the Eurocodes deal only with passive methods of fire protection. Active methods are not covered.

In the EN 1991-1-2 the terms: load bearing function – R, Integrity – E, and Insulation – I, are mentioned. Then they are also defined in the EN 13501-2 where the classifications for resistance to fire are described together with the parts 3 and 4 for other type building components and systems. According to the EN 13501-2:

R - Loadbearing capacity is the ability of the element of construction to withstand fire exposure under specified mechanical actions, on one or more faces, for a period of time, without any loss of structural stability. The criteria which provide for assessment of imminent collapse will vary as a function of the type of loadbearing element (columns, walls, floors, roofs)

E - Integrity is the ability of the element of construction that has a separating function, to withstand fire exposure on one side only, without the transmission of fire to the unexposed side as a result of the passage of flames or hot gases. They may cause ignition either of the unexposed surface or of any material adjacent to that surface.

I - Thermal insulation is the ability of the element of construction to withstand fire exposure on one side only, without the transmission of fire as a result of significant transfer of heat from the exposed side to the unexposed side. Transmission shall be limited so that neither the unexposed surface nor any material in close proximity to that surface is ignited. The element shall also provide a barrier to heat, sufficient to protect people near to it.

Consequently, resistance to fire relates to the structure, which mostly is a combination of products including fixing methods. However, it could consist of a single or composite product. Accreditation is therefore awarded to that particular construction as a whole, and not to the individual products it is made of. With this kind of testing, there are many possible different combinations of products and fixings making up the overall structure, and it is impractical to test every permutation. Because of the huge variations that are possible, harmonised standards are accompanied by direct and extended field of application rules.

The most relevant test standards are EN 1363, EN 1364, EN 1365 and EN 1366.

The results are expressed as the number of minutes that all, all several of these three aspects resist the effects of a fire, so an element fulfilling all of these criteria for 30 minutes would be classified as REI 30. The classifications for resistance to fire are described in EN 13501-2, 3 and 4. Because the test sample has to represent the complete element, roof or wall, etc. determining REI requires testing in large scale and is expensive. For example, a flat roof test would need to include the supporting roof deck, the waterproofing layer as well as the insulation respecting the method of fixing intended in the building. Naturally, the degree to which the insulation has an opportunity to play a role in fire resistance depends on the construction. For instance, if a flat roof with a concrete slab base were being tested, it would give several hours of fire resistance, regardless of what other products were placed on top, and when it does fail, the performance of the effect of the other products would be irrelevant as the structure itself would already be compromised.

Fire tests for Facades

In the past, most countries set requirements for outer façade insulation based on the classifications obtained from the standard "reaction to fire" laboratory tests. Experience has shown that, in some cases, these tests do not give sufficient information about the performance of the complete insulation system in a real fire. So, dedicated full scale "façade fire" tests have been developed in several European countries. Most of these tests are based on the scenario of a fire in a room breaking through a window. In most cases, the parameters measured include the observation of flame spread (visual observation and temperature measurements), the assessment of damage on the outside of and within the insulation

system after the test, and burning droplets and parts or debris falling down. However, there are large differences between the tests depending on the country. The main parameters, which are different, include the following:

- Type of fire source (some tests use wood cribs, others gas burners or liquid fuels)
- Size of fire source
- Specimen configuration (corner or flat wall, additional openings/windows)
- Height of test rig

Various tests are used for different height limitations in different countries.

The European Commission started a new project in 2017 with the aim to develop a European approach to assess the fire performance of facades and the definition of all relevant details and classifications to be used for harmonised products standards (in CEN) and for European Assessment Documents (in EOT A) for the relevant construction products (kits) within the framework of implementation of the Construction Products Regulation (CPR) 305/2011/EU. As a result of this project in 2018, a study (*Development of a European approach to assess the fire performance of facades,* [11]) was published which still does not deliver a final solution. Two possibilities for the future European method were presented, representing two different approaches.

The European Commission decided in autumn 2019 to go forward with the "alternative approach". A study was started with the goal to finalize this assessment method, develop assessment criteria and classifications and verify repeatability and reproducibility of test results. The European Commission could introduce this new method for CE marking with a delegated act. The study is envisaged for a time period of 2 years and started in April 2020. [12]
It is not clear, how in the end member states will adopt this method for façade systems, as the European Commission can only decide how to deal with products and kits which are CE marked [13].

1.4 Hygiene, health and the environment

Apart from the CPR approach regarding hygiene, health and the environment ("Construction products must ensure, during their whole life cycle, the proper hygiene and good health condition to building occupants, as well as not causing emission of dangerous substances in construction, use and demolition phase"), this category applies also to a building scale as indoor environment conditions.

Although the EPBD indicates that indoor climate conditions shall be taken into account when putting minimum energy requirements in place, within the EU legislation there are currently no clear requirements describing how this can be achieved. The European Committee for Standardization has issued the following

non-mandatory standards with regard to IAQ: EN 13779: Ventilation for non-residential buildings. Performance requirements for ventilation, air conditioning and cooling systems 26; and EN 15251: Indoor environmental input parameters for design and assessment of the energy performance of buildings, addressing indoor air quality, thermal environment, lighting and acoustics 27.

1.5 Safety and accessibility in use

Safety and accessibility in buildings on European regulatory level exists only at a strategy level for accessibility issues in public buildings. In March 2021, the European Commission published the EU Strategy for the Rights of Persons with Disabilities 2021-2030. This is the second strategy of this kind, and builds upon the work done on the basis of the European Disability Strategy 2010-2020. In this first strategy a key feature of the commitments made was to ensure ensuring accessibility of the built environment [14].

Accessibility to the physical environment, including buildings, is required by Article 9 of the Convention on the Rights of Persons with Disabilities (CRPD) and was adopted by most European countries. The latest strategy of 2021-2030 underlines the need for cooperation between the EU and the national frameworks. As it refers mostly to public buildings, national regulation concerning this issue will not be reviewed.

1.6 Protection against noise

On European level, the noise policy relates to environmental noise. EU does not have yet a policy on noise in buildings, e.g. neighbour noise is not included in the EU Noise Policy. Concerning national noise policies, they relate typically to the EU policy and thus in general to environmental noise only. Environmental noise is regulated at EU level at the source of the noise, with legislation on issues such as harmonized noise limits for motor vehicles, outdoor equipment and other noise-generating products. [15], [16]

Acoustic regulations for housing, educational buildings and some other building categories now exist in most countries in Europe, but findings from comparative studies show that extent and strictness as well as descriptors vary considerably across Europe. The acoustic performance areas dealt with are e.g. airborne and impact sound insulation, reverberation time, traffic noise, service equipment noise. Comparing countries, there is in general no consistency of contents, structure or enforcement of acoustic regulations [17].

1.7 Energy economy and heat retention – building energy performance

Buildings are responsible for approximately 40 % of energy consumption and 36 % of CO_2 emissions in the EU. Currently, about 35 % of the EU's buildings are over 50 years old and almost 75 % of the building stock is energy inefficient, while only 0.4 % - 1.2 % (depending on the country) of the building stock is renovated each year. Therefore, more renovation of existing buildings has the potential to lead to significant energy savings – potentially reducing the EU's total energy consumption by 5 % - 6 % and lowering CO_2 emissions by about 5 %.

Before reviewing the basic regulations set by the EU it is very relevant to make a reference to the latest strategies set for building renovations. The Green Deal is an EU strategy that aims to make Europe climate – neutral by 2050. By 2030 aims at a 55% reduction of emissions and includes a number of strategic steps to achieve it. In the building sector there was already a strategy published in 2020 as "A renovation wave for Europe" which aims to double the building renovation rates for the next ten years. This will be pursued with a series of actions which are already decided and included in an action plan [18].

The Energy Performance of Buildings Directive (EPBD) (EUR-Lex, 2010) and the Energy Efficiency Directive (EED) (EUR Lex, 2012) are the EU's main legislative frameworks promoting the improvement of the energy performance of buildings within the EU. The Renewable Energy Directive (Directive 2018/2001/EU) can be also added as the 2018 version, upgraded the one of 2009 including articles related to RES in buildings. They provide policies for achieving a highly energy efficient and decarbonised building stock while creating a stable environment for investment decisions to be taken enabling consumers and businesses to make more informed choices to save energy and money. Actually, the EPBD replaced the first directive dedicated on the energy performance of buildings that was published in 2002 (Directive 2002/91/EC) in the interest of clarity and to raise the bar to a higher level by introducing the ambitious concept of nearly-zero energy consuming buildings and including Renewable Energy systems. Both EPBD and EED were amended, as part of the Clean energy for all Europeans package, in 2018 and 2019 respectively.

The Commission has also established a set of standards and accompanying technical reports to support the EPBD called the energy performance of buildings standards (EPB standards). These are managed by the European Committee for Standardisation (CEN). More details about EPBD and EED are presented next.

The Energy Performance of Buildings Directive (EPBD)

The EPBD is the main legal instrument in the European Union for improving energy performance in buildings. It provides for a comprehensive and integrated approach towards improving the efficient use of energy in both new and existing buildings, residential as well as commercial. The EPBD regulates both 'passive' measures for the building design and envelope, as well as the 'active systems', such as for heating, cooling, DHW, ventilation and lighting.

In the EPBD are introduced the energy performance certificate of buildings, which indicate the Energy Performance of the building as a numeric value, allowing for benchmarking. The certificates also include a list of cost-effective energy saving measures.

The EPBD mentions specifically that the energy performance of buildings should be calculated based on a methodology, which may be differentiated at national and regional level. However, that methodology should take into account existing European standards. While no country has directly and fully applied them in their methodology procedures, many countries have adopted an approach, which is broadly compatible with the European standards.

On 30 November 2016, as part of the Clean Energy for All Europeans package, the Commission proposed an update to the Energy Performance of Buildings Directive to help promote the use of smart technology in buildings, to streamline existing rules and accelerate building renovation. The Commission also published a new buildings database − the EU Building Stock Observatory − to track the energy performance of buildings across Europe.

On 19 June 2018, Directive 2018/844/EU was published, amending the EPBD. Under the revised directive the following requirements were established (Buildings, 2018).

- EU countries will have to establish stronger long long-term renovation strategies, aiming at decarbonising the national building stocks by 2050, and with a solid financial component.
- Smart technologies will be further promoted, for instance through requirements on the installation of building automation and control systems and on devices that regulate temperature at room level.
- EU countries will have to express their national energy performance requirements in ways that allow cross-national comparison
- All new buildings must be nearly zero-energy buildings by 31 December 2020 (public buildings by 31 December 2018)
- Energy performance certificates must be issued when a building is sold or rented, and they must also be included in all advertisements for the sale or rental of buildings
- EU countries must establish inspection schemes for heating and air conditioning systems or put in place measures with equivalent effect.
- EU countries must set cost-optimal minimum energy performance requirements for new buildings, for the major renovation of existing buildings, and for the replacement or retrofit of building elements (heating and cooling systems, roofs, walls and so on)
- EU countries must draw up lists of national financial measures to improve the energy efficiency of buildings.

For many countries, the EPBD was the means of introducing new elements in their building codes prior to which there were no energy performance requirements concerning the building as whole or specific elements. Nearly all countries have now adopted a national methodology, which sets performance-based requirements for new buildings. For countries in which prescriptive requirements existed before 2002 there was a shift towards a holistic-based approach whereby existing single element requirements in many cases were tightened.

Finally, EPBD explicitly considers fire safety and indoor quality issues in a building renovation with energy saving purposes. In this way a recommendation is made to take a more holistic approach of a renovation and not focus only on energy performance.

DIRECTIVE (EU) 2018/844: Whereas (8): "…Member States should be able to use their long-term renovation strategies to address fire safety and risks related to intense seismic activity which affect energy efficiency renovations and the lifetime of buildings." Whereas (19): "For new buildings and buildings undergoing major

renovations, Member States should encourage high-efficiency alternative systems, if technically, functionally and economically feasible, while also addressing the issues of healthy indoor climate conditions, fire safety and risks related to intense seismic activity, in accordance with domestic safety regulations." [19]

Energy Efficiency Directive (EED)

The 2012 Energy Efficiency Directive established a set of binding measures to help the EU reach its 20% energy efficiency target by 2020. Under the Directive, all EU countries are required to use energy more efficiently at all stages of the energy chain, from production to final consumption.

Energy efficiency plays a vital role in reducing the impact of energy costs on business and domestic consumers. It lessens carbon emissions and decreases our dependence on fossil fuels, thereby improving our competitiveness and sustaining jobs. Achieving greater efficiency in resource inputs and minimising waste also improves productivity and reduces costs.

In the context of the Energy Efficiency Directive, a number of important measures have been adopted throughout the EU to improve energy efficiency in Europe, including

- policy measures to achieve energy savings equivalent to annual reduction of 1.5% in national energy sales
- EU countries making energy efficient renovations to at least 3% per year of buildings owned and occupied by central governments
- national long-term renovation strategies for the building stock in each EU country
- mandatory energy efficiency certificates accompanying the sale and rental of buildings
- the preparation of national energy efficiency action plans (NEEAPs) every three years
- minimum energy efficiency standards and labelling for a variety of products such as boilers, household appliances, lighting and televisions (energy label and ecodesign)
- the planned rollout of close to 200 million smart meters for electricity and 45 million for gas by 2020
- obligation schemes for energy companies to achieve yearly energy savings of 1.5% of annual sales to final consumers
- large companies conducting energy audits at least every four years
- protecting the rights of consumers to receive easy and free access to data on real-time and historical energy consumption

The Commission also published guidelines on good practice in energy efficiency.

On 30 November 2016 the Commission proposed an update to the Energy Efficiency Directive, including a new 30% energy efficiency target for 2030, and measures to update the Directive to make sure the new target is met (Energy Efficiency Directive, 2018) [20].

The Renewable Energy Directive

The Renewable Energy Directive is in general the legal framework for the development of renewable energy across all sectors of the EU economy. It establishes common principles and rules to remove barriers,

stimulate investments and drive cost reductions in renewable energy technologies, and empowers citizens, consumers and businesses to participate in the clean energy transformation. The first Renewable Energy Directive was released in 2009 setting European (20% by 2020) and national binding targets.

In 2018 the new Renewable Energy Directive (2018/2001/EU) came into force aimed at keeping the EU a global leader in renewables and helping the EU to meet its emissions reduction commitments under the Paris Agreement.

Building on the 20% target for 2020, it established a new binding renewable energy target for the EU for 2030 of at least 32%, with a clause for a possible upwards revision by 2023, and comprises measures for the different sectors to make it happen. This Directive underlined the obligation of the member states to introduce measures in their building regulations and codes in order to increase the share of all kinds of energy from renewable sources in the building sector. This included in particular new provisions to enable citizens to play an active role in the development of renewables - enabling renewable energy communities and self-consumption of renewable energy, an increased 14 % target for the share of renewable fuels in transport by 2030 and strengthened criteria for ensuring bioenergy sustainability.

On 21 July 2021, the Commission presented a proposal for a revised directive, as part of the package to deliver on the European Green Deal. The proposed revision of the directive is now being considered by the Council and the European Parliament. The adoption is expected by end of 2022 [21]

1.8 Sustainable use of natural resources

The basic requirement about the sustainable use of natural resources and described in the CPR has to do with the recyclability of construction works, their materials and parts after demolition, the durability of construction works and the use of environmentally compatible raw and secondary materials in construction works. And continues: For the assessment of the sustainable use of resources and of the impact of construction works on the environment Environmental Product Declarations should be used when available. REGULATION (EU) No 305/2011 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 9 March 2011 lying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC

Environmental Product Declaration (EPD)

An Environmental Product Declaration (EPD) is defined by International Organization for Standardization (ISO) 14025 as a Type III declaration that "quantifies environmental information on the life cycle of a product to enable comparisons between products fulfilling the same function." The EPD methodology is based on the Life Cycle Assessment (LCA) tool that follows ISO series 14040.

An EPD report tells the life cycle story of a product in a single, comprehensive report. The EPD provides information about a product's impact upon the environment, such as global warming potential and impacts to air, soil and water bodies (smog creation, ozone depletion, water pollution etc). EPDs do not rank products,

and the existence of an EPD for a product does not indicate that environmental performance criteria have been met. EPDs are a disclosure tool that helps purchasers to better understand a product's sustainable qualities and environmental repercussions, so they can make more informed product selections. EPDs can be developed after a product life cycle assessment (LCA) is conducted and are based on applicable product category rules (PCRs).

EPDs provide a standard way of declaring the impacts of manufacturing and using products through Life Cycle Assessment (LCA). Construction products are assessed using a single set of Product Category Rules (PCR) ensuring consistent reporting for similar products. EPD for construction products in Europe use the European Standard, EN 15804, as their PCR, to ensure that the information is provided using the same LCA rules, with the same environmental indicators, and in a way that means the information for lots of different products can be brought together to provide the environmental impacts for a building. EPD should always be independently verified by an expert familiar with the product category. [21]

The PCR:

- defines the parameters to be declared and the way in which they are collated and reported,
- describes which stages of a product's life cycle are considered in the EPD and which processes are to be included in the life cycle stages,
- defines rules for the development of scenarios,
- includes the rules for calculating the Life Cycle Inventory and the Life Cycle Impact Assessment underlying the EPD, including the specification of the data quality to be applied,
- includes the rules for reporting predetermined, environmental and health information, that is not covered by LCA for a product, construction process and construction service where necessary,
- defines the conditions under which construction products can be compared based on the information provided by EPD.

For the EPD of construction services the same rules and requirements apply as for the EPD of construction products.

Within the construction industry, EPDs support carbon emission reduction by making it possible to compare the impacts of different materials and products in order to select the most sustainable option. Architects, engineers and designers are able to choose the most sustainable option for their project. Manufacturers are able to optimize the impact of their products and market their carbon transparency. An EPD is usually valid for five years, and is generated according to the relevant standards. [22]

An EPD is just a way of providing environmental information about the product – products with high impacts can have EPD just like products with low impacts – but an EPD does give you the information to assess the product's performance at the building level. It's important to take into account the other products that you will need to product the required functionality at the building level – two insulation products may have different conductivities so you will need less of one to provide the same amount of insulation – you will need

to consider both the quantity of each insulation and the impact provided in the EPD to understand which product will have the better environmental performance.

In order to enhance harmonization, the main Program Operators for EPD verification in the construction sector created the Association ECO Platform, with members from different European countries.

EPDs are not, at least yet, mandatory in all European countries. According to [22] the EPDs are required in the Swedish regulation and in some certifications such as BREEAM and LEED. In Europe EPDs are used in public and private procurement as evidence for the various environmental related characteristics of the various products and services. From a marketing perspective and as EPD program operators and certifiers suggest, EPDs demonstrate a manufacturer's commitment to sustainability and equip them with a valuable tool for differentiation. They also help customers better understand a product's sustainable qualities and environmental repercussions and empower them to make more informed purchasing decisions.

1.9 Electromechanical equipment regulatory framework

The electric storage module is mainly covered by two European regulations:

The **Low Voltage Directive (LVD) 2014/35/EU** (The Low Voltage Directive (LVD), 2014): it is intended to remove all obstacles to the sale of low voltage electrical equipment within the EU, while at the same time ensuring that they offer the highest possible level of safety. Low voltage electrical equipment is defined as any equipment designed for use with a voltage rating between 50 and 1000 V for alternating current and between 75 and 1500 V for direct current. Annex II to the Directive contains a list of equipment not covered, including electrical components of lifts, electricity meters, plugs and socket outlets for domestic use.

The Directive 2014/35/EU specifies that equipment must not endanger the safety of people, animals or property when properly installed and maintained and used in applications for which it was made. The key safety objectives for equipment covered are listed in Annex I.

It applies to a wide range of electrical equipment for both consumer and professional usage, such as:

- household appliances
- cables
- power supply units
- laser equipment

- certain components (e.g. fuses)

EU legislation in the electrical sector is important to ensure that health and safety requirements are the same across Europe for products placed on the market.

The General Product Safety Directive (2001/95/EC) covers consumer goods with a voltage below 50 V for alternating current, or below 75 V for direct current.

The **Electromagnetic Compatibility (EMC) 2014/30/EU** (EMC Directive (2004/108/EC), 2018): it sets the essential protection requirements for electrical and electronic equipment. In particular, it limits electromagnetic emissions of equipment in order to ensure that, when used as intended, such equipment does not disturb radio and telecommunication as well as other equipment. The Directive also governs the immunity of such equipment to interference and seeks to ensure that this equipment is not disturbed by radio emissions when used as intended. In order to market your electrical device within the member states of the European Union, your product must comply with harmonized standards (such as EN 55022 and EN 55024 for Information Technology Equipment).

The European heat pump industry and European certification bodies cooperated to introduce a European heat-pump certificate based on the CEN KEYMARK scheme.

The Heat Pump KEYMARK is an independent European certification mark (ISO type 5 certification) for all heat pumps, combination heat pumps and hot water heaters (as covered by Eco-design, EU Regulation 813/2013 and 814/2013).

The CEN heat pump KEYMARK is a full certificate supporting the quality of heat pumps in the European market. It has been developed by the heat pump industry in 2015 but it is owned by CEN.

The key requirements of the new heat-pump KEYMARK include:

- a set of performance test requirements carried out by third party tests based on EN 14511, EN 15879 and EN 16147
- a robust model range approach
- a product related Factory Production Control (FPC)
- an initial inspection of the FPC
- Regularly surveillance of the certified products and FPC

2 Regulations at national level

2.1 Introduction - Buildings related Regulations in the demo countries

According to the first chapter European Regulations can be either mandatory or not in the EU member states. Sometimes there is a period for transposition of the regulations and the directives while at the same time there can be a degree of freedom when implementing an EU directive which may come at a form of guidelines and not strict rules. For all of the above each of the EU countries have complied with the EU regulations by making the necessary transpositions of directives or by changing, upgrading or amending their national regulations. Some of them may have stricter requirement at some fields than the EU ones or not yet complied with the proposed ones. EU regulations also allow the setting of national parameters which is another case of differentiation between countries national codes.

In this chapter all available national regulations concerning construction products and construction of buildings will be presented. These regulations have either a direct or indirect relation with the PLURALs project PnU kits. For example, regulation requirements on thermal properties of external wall is a direct one because of the extra insulation that a PnU kits will add to the existing wall. On the other hand, regulation relating to building permits needed for a major renovation, or PV connection method possibilities are affecting in an indirect manner the renovation solution as a whole by setting some requirements either in terms of procedure or in terms of allowed systems, equipment connectivity restrictions etc.

The regulations review will be done following a per country structure, starting with the countries where real demonstration of the PnU renovation solutions will be installed to the selected buildings. These countries are Greece, Czech Republic and Spain where the compliance of any building intervention with the national regulations is of high importance. Virtual demo countries which are Switzerland, Germany and Sweden will follow. In the case of the virtual application of the PnUs in the demo buildings, it is still important to stay within each country's regulation framework in order to demonstrate the replicability of the PLURAL concepts in different countries.

As described in chapter one, the regulation review is following the CPR's basic categories structure in order to have a common reference. All available regulations of the six countries are put in a common review template, where the most important information and requirements have been gathered. However, regulations in each country are not issued in the same way meaning that some country may have a separate regulation for a subject and another may include two subjects. In addition, some countries may not cover all CPR categories. The categories of the CPR are summed up again to facilitate the review:

1. Mechanical resistance, stability and seismic behavior
2. Safety in case of fire
3. Hygiene, health and the environment
4. Safety and accessibility in use

5. Protection against noise
6. Energy economy and heat retention
7. Sustainable use of natural resources.

Apart from regulations related to these categories, the review will deal with two more: The first is a general category of construction works/urban planning type of regulation that deals with the process of the building construction as well as with the building permits among others. The second is the legal framework for RES and PV systems connection methods, which are added because it was considered crucial as all of the PLURAL solutions will include a photovoltaic system for electricity generation that will be implemented at the demo buildings. Finally, in the first category seismic behavior is added as very relevant in order not to add more categories.

The regulation review will start with the more general category of construction works/urban planning related regulations then with the CPR based ones and will close with the RES implementation framework.

2.2 National Regulations - Greece

2.2.1 Building construction – urban planning related regulation

Country	GREECE
Category	**Building construction works - urban planning**
Regulation Original Title	ΝΕΟΣ ΟΙΚΟΔΟΜΙΚΟΣ ΚΑΝΟΝΙΣΜΟΣ – ΝΟΚ
English translation of title	NEW BUILDING CONSTRUCTIONS REGULATION
Publication year / amendment year (if any)	2012 – various amendments are made
Document type & Status	Type: Regulations, codes with legal status Status: Approved and in force
Region of enforcement (If differentiated countrywide)	The regulation is applied countrywide
Brief summary / content description	The regulation gives the definitions of building related types of constructions and related processes and sets restrictions regarding their size, location etc. while also defines all types of building quantities and factors related with building areas, dimensions, coverage, heights etc. It defines all the building permits and where they are mandatory. It deals with cases of buildings with special architecture, motivation for buildings that reach high energy performance and with access and functional requirements in all buildings for people with disabilities.
Scope of: (cases that is applied)	The regulation is applied to all urban and non-urban areas for new and existing buildings and infrastructure.
Basic requirements for existing residential buildings related with the PLURAL concepts	**Building envelope:** The regulation does not include any major point concerning the installation of prefabricated walls / facades. It only foresees the procedure of adding external insulation (ETICS) or passive solar systems on the facades of a building. According to the regulation for doing this a “small scale works permit is needed” which is a standard procedure for light construction works at a building. In addition, it includes some clarification regarding the addition of any structure on the outer envelope, in case the building is very close or on the boundaries of its landsite. **Technical systems:** The regulation includes some restrictions regarding the installation of various electromechanical equipment on the building. The most important ones are those concerning the installation of solar panels (either for DHW or PVs). It is allowed to put them on any legal and permanent construction of the building except on the roof of the staircase structure (that is used for access on a flat roof).

2.2.2 Mechanical resistance, stability and seismic behavior related regulations

Country	GREECE
Category	**Mechanical resistance, stability and seismic behaviour**
Regulation Original Title	ΕΛΛΗΝΙΚΟΣ ΑΝΤΙΣΕΙΣΜΙΚΟΣ ΚΑΝΟΝΙΣΜΟΣ – ΕΑΚ
English translation of title	GREEK ANTI-SEISMIC REGULATION
Publication year / amendment year (if any)	2000 – (last corrections 2016)
Document type & Status	Type: Regulations, codes with legal status Status: Approved and in force
Region of enforcement (If differentiated countrywide)	The regulation is applied countrywide
Brief summary / content description	The anti-seismic regulation is the basic tool for design and construction of buildings and infrastructure able to withstand with safety the intense stresses of an earthquake. The 2001 regulation complied with the Eurocode 7 and Eurocode 8.
Scope of: (cases that is applied)	The regulation is applied to all urban and non-urban areas for new and buildings and other civil works, as well as vertical expansions of existing buildings.
Basic requirements for existing residential buildings related with the PLURAL concepts	The regulation consists of basic requirement, design specification, seismic actions and combinations with others as well as ground and support issues. It also describes application rules mostly for buildings. As the regulation refers to new buildings or new parts for existing buildings there are no specifications for checking or strengthening existing buildings. As far as the prefabricated type of walls that are going to be added in the frame of PLURAL project, the regulation includes a section about add-ons that is the closest to the PnU kit that is going to be installed.

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2.2.3 Fire safety regulation

Country	GREECE
Category	Safety in case of fire in buildings
Original Title	ΚΑΝΟΝΙΣΜΟΣ ΠΥΡΟΠΡΟΣΤΑΣΙΑΣ ΚΤΗΡΙΩΝ
English translation of title	BUILDING FIRE PROTECTION REGULATION
Publication year / amendment year (if any)	2018
Document type & Status	Type: Regulations, codes with legal status Status: Approved and in force
Region of enforcement (If differentiated countrywide)	The regulation is applied countrywide
Brief summary / content description	The regulation defines all the measures and requirements that should be taken in buildings in order to protect the life and health of building users in case of fire, to prevent the spread of fire from one space to other spaces of the same building or other buildings and regions and to protect the buildings themselves and their content. Primary target is the human safety in case of fire by appropriate building design, equipment and material selection and by installing appropriate active fire protection systems. More specifically in the regulation are defined: - the measures that protect a building for collapsing at least for as long as it takes for its evacuation, - the minimum requirements regarding the design of the escape routes for fast and safe evacuation of the users protecting them from smoke, heat and other toxic substances, - the maximum allowed sizes for fire compartmentation, - the measures to prevent the spread of fire to adjacent buildings, - the requirements of the materials used depending on their location in the building - and the active measures and fire safety systems that detect fire in time, suppress it and provide enough time for safe evacuation. The measures are based on the following basic parameters: - possible building users, type and population - interaction of various building spaces - the design and structure philosophy of buildings in Greece
Scope of: (cases that is applied) New & Existing Buildings	The regulation applies to all new buildings and as it replaces older regulations, it determines which regulation for various cases of existing buildings should be followed, depending if there are any additions or changes in use of the existing buildings. For existing buildings that are not undergoing any major changes the regulation is not binding but it is recommended to be followed where possible according to "Recommended fire safety measures in existing buildings" published in May 2019 as supplementary to the regulation.
Basic requirements for residential buildings	Escape routes: The escape routes of a building strongly depend on the architectural design and in existing building is very difficult to change it. However, the requirements for maximum lengths of an "unprotected escape route" for residential buildings are not very demanding and in most cases typical multifamily houses comply with them.

Emergency lighting installation with fixtures showing the building exit is mandatory and can be easily applied to existing buildings.

Structural Fire safety: Structural elements (Load bearing and non-load bearing, doors etc.), protected escape routes, staircases and fire compartments of a building should fulfill the fire resistance rating in minutes and category (load bearing capacity, integrity and heat insulation). Eurocodes 1-9 can be applied here for the estimation of the structural elements' resistance to fire.

The total floor area of independent fire compartment of a building shouldn't exceed specific values depending on the use and height of building.

For residential buildings, the minimum requirements of fire resistance are presented below:

TABLE 2.2-1: FIRE RESISTANCE VALUES (GREEK REGULATION)

	Minimum fire resistance in minutes					
	Underground floors		Above the ground floors			
	Height>10m	Height<10m	Up to 2 floors	3 to 6 floors	7 to 10 floors and < 27m	>27
Residential	90	60	30	60	90	120

Depending on the category of the structural elements the fire resistance refers to one, two or all of the categories:

R – load bearing capacity, E – integrity and I – heat insulation

TABLE 2.2-2: CATEGORY REQUIREMENTS OF STRUCTURAL ELEMENTS (GREEK REGULATION)

Structural Elements	Minimum requirements
Load bearing wall (internal/external)	REI
External non load bearing, walls of fire protected escape routes and fire compartments	EI
Load bearing vertical elements	R
Fire resistant Doors, windows	EI
Structure elements between floors (slabs and beams)	REI
Staircases walls	EI
Load bearing elements of staircases	R
Self-bearing roof elements (panels)	REI

Spread of fire in the building: Internal staircases that are also fire protected escape routes should be of permanent structure and have a fire resistance rating of at least 60 min for 4 or less floors. Requirements are stricter for higher buildings with more population.

Piping requirements regarding the maximum allowed diameter when crossing fire compartments and when transferring flammable fluids (e.g. R32). For piping with internal diameter higher than 40mm it is not allowed to pass through fire compartments unless they are made or covered with unburnt material. The same stands for any piping carrying flammable fluids.

High risk spaces: These space are divided into two categories with the first include all typical machinery spaces, boiler rooms with power < 50 kW, storage rooms and rooms with high risk due to their nature. These spaces should be designed as separate fire

compartments with at least the same fire resistance rating as the building's other fire compartments. The second category refers to spaces with higher than 50 kW boilers, transformer rooms, natural or liquid gas storage, electric vehicle charging rooms etc.
Reaction to fire requirements: For internal layers of structural products (finishings, pipe insulation, electric cables) that can be directly exposed to fire, are set by the Euroclasses and the EN 13501. The relevant requirements for residential buildings are presented in Table 2.2-3.

TABLE 2.2-3: FIRE EUROCLASSES OF INTERNAL FINISHING (GREEK REGULATION)

	Walls and Ceilings				Floors	
	Fire protected escape routes – high risk spaces	Non fire protected escape routes	General		Fire protected escape routes– high risk spaces	Non fire protected escape routes
			Spaces > 10 m^2	Spaces < 10 m^2		
Residential buildings	A2-s1,d1	C-s1,d1	C-s2,d2	D-s2,d2	B_{FL}-s2	D_{FL}-s2

Spread of fire outside the building: The relevant requirements refer to fire resistance rating (in min), reaction to fire rating (Euroclass) of the façade system and openings percentage requirements, depending on the distance between two adjacent buildings. Table 2.2-4 is valid for low rise buildings (<23m). For high rise buildings and specific type uses (like medical, social care and educational) the requirements are stricter.

TABLE 2.2-4: FIRE EUROCLASSES OF EXTERNAL FINISHING (GREEK REGULATION)

	Distance from adjacent building or land boundaries			
	< 3 m	3-5 m	5-10 m	>10 m
Fire resistance rating of external wall	Full requirement of table 1	Full requirement of table 1	Half requirement of table 1	No requirement
Fire reaction class of façade	B-s1,d1	B-s1,d2	C-s2,d2	D-s2,d2
Openings percentage	≤15%	≤25%	≤50%	≤80%

Active fire safety measures: The requirements are based on the type and size of buildings. For residential houses specifically the requirements are: Fire extinguishers in common spaces: 1 per floor and per 400m^2. Manual fire alarm system is mandatory for multifamily houses of 3 or more floors.
Automated fire detection system is also mandatory for residential buildings of more than 3 floors, however in existing building of 6 or less floors single autonomous fire detectors can be installed instead in every kitchen and bedroom.

Active & Passive	The regulation deals with both passive and active fire safety measures.

2.2.4 Protection against noise & hygiene, health and the environment related regulation

Country	GREECE
Category	Protection against noise – acoustics / Hygiene, health and the environment
Original Title	ΚΤΗΡΙΟΔΟΜΙΚΟΣ ΚΑΝΟΝΙΣΜΟΣ
English translation of title	BUILDING STRUCTURES REGULATION
Publication year / amendment year (if any)	1989
Document type & Status	Type: Regulations, codes with legal status Status: Approved and in force
Brief summary / content description	The building structures regulation is a more generic regulation that covers all aspects of infrastructure use, including its construction, with a more descriptive approach and in some cases with specific requirements. The building structures regulation aims to regulate the construction of infrastructures in order to serve their intended use and under normal conditions of maintenance and for an acceptable lifetime to satisfy the following: - Comfort, health, wellbeing and safety of residents and users - Quality, safety, durability, aesthetics and functionality of buildings - Protection of the environment - Facilitate and promote scientific research in the construction field - Increase of productivity in the building construction field
Scope of: (cases that is applied)	The regulation has a generic application to all type of buildings and infrastructure. The regulation defines all types of building use.
Basic requirements for residential buildings	The regulation defines the typical population of each type of building use and sets the maximum allowed number of people per area for types of building use where people are gathered or waiting. It refers to safety and durability of buildings by setting precaution measures and referring to other regulations e.g. (fire protection). The regulation defines the clear internal height and volume that the buildings should have. It defines all types of building walls, openings and windows/doors. It makes a reference to prefabricated walls with frames. All types of walls and windows should have stability in case of an earthquake, wind resistance, fire resistance, thermal insulation, sound insulation, waterproofing, resistance to solar radiation, mechanical strength under normal conditions, stability of any layers they are covered with. From the above there is a specific article on sound performance described below: The regulation deals also with **natural daylight and natural ventilation** in buildings. All spaces with a primary use (not auxiliary use) should in general have access to natural daylight and natural ventilation. It is allowed for specific building types not having natural ventilation when there is sufficient mechanical ventilation and there is a full study and approve by the appropriate organization. Natural and direct daylight and natural ventilation is mandatory for main spaces of residential buildings. All residential spaces should have adequate natural ventilation and daylight. A space that is considered to have adequate daylight should have openings to the external environment with an area of at least 10% of the space floor area. Only the glazing area of the opening that is above 1.20m from the floor is taken into account. A space that is considered to have direct natural ventilation should have openings to the external

environment with an area of at least 5% of the space floor area. Natural ventilation is mandatory in residential buildings, even if mechanical ventilation is applied.

A requirement for a quantified ventilation rate is given in the technical guidebook for energy performance of buildings calculation (*T.O.T.E.E 20701-1/2017*) based on some relevant Greek and international standards. According to this, 15 m^3/h per person or 0.75 m^3/h per m^2 of floor area is the minimum rate.

Specific requirements for **noise protection** are set in Article 12 of the regulation and for buildings constructed after the publication of the regulation. The requirements set three categories:

A) High acoustic comfort
B) Normal acoustic comfort
C) Low acoustic comfort

All all new buildings should belong at least to category B. Acoustic comfort of a space is defined by a set of acoustic parameters related to the sound insulation and protection from noise of the space from:

- Airborne noise generated in adjacent spaces
- Impact noise generated in adjacent spaces
- Airborne noise generated in common private spaces of the same building
- Airborne noise generated from external sources

Parameters: R_w, R'_w, $L'_{n,w}$ $L_{Aeg,h}$ L_{pA} are defined in the following table and the maximum values for a space to belong to category A, B or C are presented in the next tables:

TABLE 2.2-5: ACOUSTIC COMFORT PARAMETERS (GREEK REGULATION)

Type of noise	Parameter of acoustic comfort			Measured quantity		
	Name	Symbol	Unit	Name	Symbol	Unit
Protection from airborne noise	*Weighted Sound Reduction Index*	R_w	dB	*Sound Reduction Index*	R	dB
	Weighted apparent Sound Reduction Index	R_w	dB	*Apparent Sound Reduction Index*	R’	dB
Protection from impact noise	weighted, *standardised impact* sound pressure level	$L'_{n,w}$	dB	*standardised impact* sound pressure level	L'_n	dB
Protection from airborne noise – external sources	Soundlevel - A	$L_{Aeg,h}$	dB (A)	Soundlevel - A	L_{pA}	dB (A)
Protection from airborne noise –	Soundlevel - A	L_{pA}	dB (A)	Soundlevel - A	L_{pA}	dB (A)

from facilities						

For category A – High Acoustic comfort for residential use:

TABLE 2.2-6: THRESHOLDS FOR HIGH ACOUSTIC COMFORT (GREEK REGULATION)

		External noises	Noises of building facilities			
R'_w	$L'_{n,w}$	$L_{Aeq,h}$	L_{pA}	R'_w	R'_w	$L'_{n,w}$
54	55	30	25	48	60	45

For category B – Normal Acoustic comfort for residential use:

TABLE 2.2-7: THRESHOLDS FOR NORMAL ACOUSTIC COMFORT (GREEK REGULATION)

Noise protection from adjacent space (of primary, secondary or common use)		Noise protection from		Noise reduction from spaces of the same residence	Noise reduction of a primary space from building facilities spaces	
		External noises	Noises of building facilities			
R'_w	$L'_{n,w}$	$L_{Aeq,h}$	L_{pA}	R'_w	R'_w	$L'_{n,w}$
50	60	35	30	42	55	50

This regulation was never really applied in practice. In 2010 a new regulation was suggested by the Greek Institute of Acoustics that was updating and reforming the previous one. Unfortunately, this new suggested regulation is still not officially active and in practice it is not mandatory to perform an acoustics study when constructing a new residential building.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958218

2.2.5 Energy performance of buildings regulation

Country	GREECE
Category	Energy performance of buildings (EPBD/EED transposition)
Original Title	ΚΑΝΟΝΙΣΜΟΣ ΕΝΕΡΓΕΙΑΚΗΣ ΑΠΟΔΟΣΗΣ ΚΤΗΡΙΩΝ (ΚΕΝΑΚ)
English translation of title	REGULATION of BUILDING ENERGY PERFORMANCE
Publication year / amendment year (if any)	2010, 2017 revision
Document type & Status	Type: Regulations, codes with legal status Status: Approved and in force
Region of enforcement (If differentiated countrywide)	The regulation is applied countrywide
Brief summary / content description	The Greek Regulation of Building Energy Performance aims at reducing energy consumption for heating, cooling, DHW and lighting of buildings ensuring at the same time comfort and quality of the indoor build environment. It defines the methodology for calculating the energy performance of buildings by estimating energy consumption for heating, cooling, DHW and lighting. It sets the minimum requirements and the classification of building energy performance. It also prescribes the type and the content of Energy Performance Study of buildings as well as the procedure of energy inspection of buildings and its systems after which an Energy Performance Certificate (EPC) is issued. The above are facilitated with a series of technical guidebooks published by the technical chamber of Greece and approved by the respective ministry.
Scope of: (cases that is applied)	The regulation applies to all buildings consuming energy for regulating the indoor conditions for ensuring the comforts of their users. The Energy Performance Study is obligatory for all new and all deeply renovated buildings. Issuing an EPC is mandatory, apart from new and deeply renovated buildings, when a building is sold or leased and for all public buildings larger than 250 m^2 of total floor area. In addition, when a building element or system is installed or replaced post initial construction has to satisfy the minimum requirements of the regulation to the extent that its technically, functionally and economically feasible.
Basic requirements for residential buildings	**Basic requirements set by the Regulation:** 1. **Building Envelope:** Individual building elements of the building envelope have to fulfil the following requirements concerning their insulating properties, which are differentiated if it's a new or existing building and they also depend on the climate zone the building belongs (4 climate zones within Greece also defined by the regulation itself). The maximum allowed heat transfer coefficient of every element of **existing buildings** and in every climate zone is presented in the table below:

TABLE 2.2-8: MAXIMUM U-VALUES FOR EXISTING BUILDINGS (GREEK REGULATION)

Building element	Max U – Value [W/m^2K]
	Climate Zone

<table>
<tr>
<td></td>
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<table>
<tr><th></th><th>A</th><th>B</th><th>C</th><th>D</th></tr>
<tr><td>External horizontal or inclined roof</td><td>0.50</td><td>0.45</td><td>0.40</td><td>0.35</td></tr>
<tr><td>External wall</td><td>0.60</td><td>0.50</td><td>0.45</td><td>0.40</td></tr>
<tr><td>Wall adjacent to unheated space or ground</td><td>1.50</td><td>1.00</td><td>0.80</td><td>0.70</td></tr>
<tr><td>External floor</td><td>0.50</td><td>0.45</td><td>0.40</td><td>0.35</td></tr>
<tr><td>Floor adjacent to unheated space or ground</td><td>1.20</td><td>0.90</td><td>0.75</td><td>0.70</td></tr>
<tr><td>External openings (windows/doors)</td><td>3.20</td><td>3.00</td><td>2.80</td><td>2.60</td></tr>
<tr><td>Openings adjacent to unheated space or ground</td><td>5.70</td><td>5.20</td><td>4.80</td><td>4.40</td></tr>
</table>
There is also a maximum allowed average U value for the whole building including thermal bridges which depends on the Total External Area to total volume ratio (A/V) but it is not applied when the case is a building unit (part of a building) like in the VVV demo case which we examine a floor of two apartments.

2. Building (technical) systems:
a) All piping networks (water or other fluid) should be insulated according to the Technical Guidebooks accompanying the regulation. For space heating/cooling the minimum requirements of the insulation of the piping is 19mm and 13mm for DHW with a thermal conductivity of λ=0.040 W/mK. Piping networks should also have a regulation system for a reduced energy consumption under partial load.
b) For new buildings and where feasible for existing, there is a minimum solar fraction for DHW of 60% requirement unless there is another type of RES system, district heating or high efficiency heat pumps.
c) When there is a central heating, cooling or DHW system there should be calorific measurement for cost allocation and at least a thermostat per autonomous space.
d) All technical systems of the building or building unit should comply with the 2012/27/EU directive that was amended with the 2018/2002 directive.
</td>
</tr>
<tr>
<td>New buildings vs Retrofit existing buildings</td>
<td>The requirements of the regulation must be followed for new buildings. They also apply for existing buildings but as long as its technically, functionally or economically feasible.
In addition when a building or a building unit undergoes major renovation, (specifically defined based on the budget of the renovation: If the total renovation budget exceeds the 25% of the value of the building being renovated without taking into account the value of the land) then an energy performance study should be also submitted & a building permit issued.</td>
</tr>
<tr>
<td>nZEB definition and requirements
(if available)</td>
<td>Currently in Greece, nZEB are all the buildings that are class A for new buildings and class B+ for existing in our Energy Performance Certificate scale without any more specific requirements or quantitative limitations in consumption or generation from RES. From the beginning of 2021 any new building should be nZEB (class A) even though an extent was given till May that B+ were also allowed. According to the latest voted Greek law (4819/2021 on 23/07/2021) all new buildings should be nZEB.</td>
</tr>
</table>

2.2.6 RES in buildings legal framework

Country	GREECE
Category	Renewable energy sources in buildings – PV systems & net metering in buildings
Original Title	-
English translation of title	Not a regulation – Legal framework regarding PV systems in buildings and net metering (based on law 4513 of 2018 ministerial decree of Ministry of Energy 15084/382 in 2019)
Publication year / amendment year (if any)	2018, 2019
Region of enforcement (If differentiated countrywide)	The laws are applied countrywide
Document type & Status	Type: Laws, ministerial decrees Status: Approved and in force
Brief summary / content description	The legal framework describes the terms and procedures for power generation with the method of net metering and virtual net metering at buildings or energy communities with all kinds of renewable energy sources (photovoltaics, small wind turbines, biogas, biomass, CHP, small hydroelectric stations)
Scope of: (cases that is applied)	The framework applies for all kind of building owners/users and consumers both physical and legal entities as well as private and public
Basic terms	**Net-metering with no energy storage** In general, when the net-metering connection is applied, a PV system installed in a building is connected with the grid and for a given period the user pays to the energy provider the difference between the energy consumed and generated onsite or else the net electricity consumption. The energy does not have to be necessarily consumed at the same time as generated. The term for a net-metering connection are: • The maximum kWp of the PV system depends on the type and size of the electrical supply from the energy provider and the type of the applicant.

TABLE 2.2-9: MAXIMUM ALLOWED PV SYSTEM POWER (GREEK REGULATION)

Voltage level	No of grid supply	Agreed Power of supply (kVA)	Maximum allowed PV system power (kWp) for interconnected mainland	
			Physical or legal entities	Public entities. Energy communities
Low Single phase	03	8	5	5
	05	12	5	5
Low – 3 phase	1	15	15	15
	2	25	20	25
	3	35	20	35
	4	55	27.5	55
	5	85	42.5	85
	6	135	67.5	100
	7	250	100	100
Medium	-	-	100% of Agreed	100% of Agreed

			Power up to 1MWp	Power up to 1MWp

It also depends if the consumer is on the continental Greece or the non-interconnected islands.

- The PV system should be installed in the same space/building with the consumption facilities or to an adjacent space
- Natural and legal entities are eligible for a net-metering connection as long as they are owners of the building they want to install the PV system or they have legal right of use of the building after the owner's written consent.
- It is possible to install a PV system in a common space of a building (e.g. roof) after the consent of all the related owners.
- Every PV system can be related with only one individual power supply (meter).
- The net-metering PV system can only be installed in a permanent power supply and be registered at the same name of the person also registered in the power supply.
- The calculation of the net consumption is made in 3 years' basis and there is no compensation if the generated electricity is more than the consumed one.
- It can be applied for both single and three-phase systems (max 5 kWp for single phase) and only three phase PV system can be installed in a three phase power supply.
- Both generated and consumed electricity should be measured at a net-metering system. The typical electricity supply meter should measure both directions of power flow between the grid and the consumer and a second meter should measure only the generation of the PV system.
- The net-metering pricing depends always on the timing of the electricity generation and consumption. This means that the higher the concurrency of PV generation and building consumption, the higher the benefit.

Net-metering with energy storage

Since 2019, it is possible for a PV system to be installed with a net-metering connection and with a permanent energy storage system (array of batteries). With the addition of storage in a building the level of generation and consumption concurrency rises and as so does the benefit.

The following additional terms stand when there is energy storage:

- The storage system is considered as part of the internal electrical installation of the building and should comply with all relevant national and international standards and regulations.
- The storage system is connected in parallel with the grid.
- The operation of the storage system ensures that there is no exchange of energy between itself and the grid which means that the energy stored in it, comes exclusively from the PV system as well as the stored energy is provided exclusively to the consumptions of the building.
- The nominal power (in kVA) of the storage system inverter should not exceed the total installed kWp of the PV system with a maximum of 30

	kVA. In addition, the power of the inverter should be such in order for the maximum current that may occur from both the PV system and the storage system not to exceed the maximum load of the electrical supply. **Autonomous PV system** Even if there is no legal framework for a building with an autonomous PV system, it is possible for a building to have one as long as there is no connection to the grid.

2.3 Spain

2.3.1 General building constructions and urban planning related regulations

In Spain, there are different regulation for urban planning depending on the regions (Catalonia) and the municialities (municipality of Terrassa). Consequently, in this first category of regulations three tables are presented for the demo building of Terrassa.

Country	SPAIN
Category	**General on Building Constructions - Introduction**
Original Title	Código Técnico de la Edificación (CTE) – Parte 1: Disposiciones generales
English translation of title	Spanish Technical Building Code (CTE) – Part 1: General provisions
Publication year / amendment year (if any)	2006. Several amendments and current version from December 2019
Document type & Status	Type: Regulation with legal status (Royal Decree 314/2006) Status: Approved and in force
Region of enforcement (If differentiated countrywide)	The regulation is applied countrywide
Brief summary / content description	The Spanish Technical Building Code (CTE) is the regulatory framework that establishes the Basic Quality Demands that buildings, including their installations, must meet in order to satisfy the basic safety and habitability requirements. The CTE establishes the Basic Demands for each of the Basic Requirements, i.e.: Structural safety; Safety in case of fire; Hygiene, health and the environment; Safety and accessibility in use; Protection against noise; Energy economy and thermal insulation. The CTE Part 1 establishes the general legal provisions to meet the requirements given in the relevant Basic Documents of the CTE. In this introduction to the analysis of such Basic Documents in the next pages, the conditions for the compliance with the CTE are detailed below.
General conditions for the compliance with the CTE	The fulfillment of the Basic Demands established in the CTE can be justified in two different ways: - Adopt the technical solutions prescribed in the CTE Basic Documents, whose application in the project, execution of the works or building maintenance, is enough to prove compliance with the Basic Demands. - Alternative solutions, understood as solutions deviating from those described in the Basic Documents, can be adopted by the project manager under his responsibility, provided that a technical justification is documented to prove that the building design meets the CTE Basic Demands because its performances are, at least, equivalent to those obtained with the direct application of the Basic Documents.

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	Regarding the compliance with the CTE of products, equipment and materials: - Construction products that are permanently incorporated into buildings, depending on of their intended use, shall bear the CE marking in accordance with the Regulation (EU) No 305/2011. - Other voluntary certifications that facilitate the compliance with the Basic Demands may be recognised by the competent Public Administrations. - Innovative products, equipment and systems that demonstrate compliance with the CTE Basic Demands by means of a favourable technical evaluation for the intended use, issued by the organisations authorised by the Public Administrations.

Country	**SPAIN**
Category	Urban regulations
Original Title	POUM Terrassa Pla d'ordenació urbanística municipal de Terrassa
English translation of title	Municipal Urban planning plan for Terrassa city
Publication year / amendment year (if any)	2002. Last modification in 2013
Region of enforcement (If differentiated countrywide)	This regulation is applied just in Terrassa municipality (local regulation)
Document type & Status	Type: Plan, that implements the revised text of the urban planning law (Decree 1/2010), Status: Approved and in force
Brief summary / content description	The legal framework defines the Zoning and Land use of the Municipality's territory. As well as the main urban regulation depending on the land use classification.
Scope of: (cases that is applied)	The framework applies to the global municipality territory, although it is more specific for the urban land. Urban parameters regarding façade line, height etc. apply for new buildings or building extensions.
Basic terms	It distinguishes between: - Urban land (already provided with urban services) - Future urban land (could be urban in future growths) - Not urban land (cannot no be urban land) It stablishes zones depending on the activities allowed and urban parameters depending on the specific type qualification of the plot. In the PLURAL plot, the urban parameters restrict the thickness of the new façade (due to the stablished urban line of façade) and the height of the building. The specific urban parameters of the PLURAL plot are: Main use: residential use Position of the building: Aligned with urban line façade Maximum height: 10.70m. (G. Floor + 2floors) Height between floors: 2.70m Maximum height of volume additions: 3.60m

Country	SPAIN
Category	**Habitability**
Original Title	*Requisits mínims d' habitabilitat en els edificis d'habitatges i de la cèdula d'habitabilitat* (D 55/2009)
English translation of title	Minimum habitability requirements in residential buildings and the certificate of habitability (D 141/2012)
Publication year / amendment year (if any)	2012
Region of enforcement (If differentiated countrywide)	This regulation is applied in the Catalan territory (Catalan Autonomy regulation)
Document type & Status	Type: Laws, Catalan government decree Status: Approved and in force
Brief summary / content description	The Decree regulates the minimum living conditions that must to have all the houses in the territory of Catalonia
Scope of: (cases that is applied)	The framework applies to all residential buildings/ dwellings, although it stablishes different requirements attending to the age of the building: a) Newly built homes (Annex 1 applies) b) Pre-existing dwellings, built prior to August 11, 1984, (Annex 2 applies). c) Pre-existing dwellings, built after 11 August 1984, (for which the first transitional provision applies). d) Public endowment housing, (Annex 3 applies)
Basic terms	The regulation defines: • Standard area per person and maximum occupancy for housing: - 1 person per room ≥ 5 m² - 2 people per room ≥ 8 m² - 3 people per room ≥ 12 m² - 2 people in homes without rooms and only with space for common use • Principles to follow during renovation actions in residential buildings: a) Non-worsening principle. The proposed reform cannot worsen pre-existing living conditions and requirements, including when the reform proposed involves the division of existing housing. b) Principle of proportionality. Making balance between the scope of the intervention and the improvement that this entails on the minimum living conditions. It has to be a proportion between the improvement achieved (with the established requirement) and its cost so it does not become economically unviable. c) Principle of non-intervention. The partial intervention on the building or the home must not involve the intervention on the whole. d) Principle of incompatibility, when the established requirement is impossible to comply with because part or all of the building is protected. e) Principle of improvement, by which any criterion of flexibility can only be apply in part and to the extent that it is fully justified that it is not necessary to apply in full the required habitability requirement • Defines the requirements (light, surface, distribution) of different private spaces as well as common areas in order to promote accessibility, security

	and healthiness. i.ex. Minimum light surface - Living room: Min. natural light surf: 0,80m^2 - Bed rooms: Min. natural light surf: 0,40m^2 It also establishes the exceptional cases, where existing dwelling could be exonerated of accomplish the regulation. In PLURAL project this regulation has to be taken into account in order to be sure that the new construction systems applied do not affect some the minimum requirements of the regulation (i. e. regarding natural light minimum surface)

2.3.2 Mechanical resistance, stability and seismic behavior related regulations

Country	**SPAIN**
Category	**Mechanical resistance, stability and seismic behavior**
Original Title	Documento Básico de Seguridad Estructural DB-SE (Código Técnico de la Edificación - CTE)
English translation of title	Basic Document of the Structural Safety DB-SE (Spanish Technical Building Code - CTE)
Publication year / amendment year (if any)	Publication year 2006. Current version from 2019, including reviews of Royal Decree 732/2019
Region of enforcement (If differentiated countrywide)	This regulation is applied countrywide.
Document type & Status	Type: Laws, ministerial decrees Status: Approved and in force
Brief summary / content description	The Spanish Technical Building Code (CTE) establishes the requirements for structural safety, through this basic document “DB SE Structural Safety”. Its objective is to ensure that the building has an appropriate structural behavior regarding of foreseeable actions and influences to which it may be subjected during its construction and its previewed use. This Document is complemented with other 5 Specific documents (also included in the Spanish Technical Building Code - CTE): • DB-SE-AE: Actions in the building • DB-SE-C: Structural safety for Building Foundations • DB-SE-A: Structural safety for Steel solutions • DB-SE-F: Structural safety for Fabric walls • DB-SE-M: Structural safety for Timber solutions While regarding reinforced concrete structural solutions there is a specific regulation. NCSE (Regulation regarding earthquake resistant construction”) - Código estructural (Structural Code) - EFHE

Scope of: (cases that is applied)	The requirements of the regulation must be followed by any project applied to private or public buildings, that needs a constructive license or permit. It applies to new buildings but also to existing ones as long as it is technically, functionally or economically feasible. If it is not accomplished the responsible technician has to justify it under its responsibility.
Basic terms	In DB-SE, the 2 main requirements to the dimensioning/definition of the structural elements. - Last limit state. If the structural element surpassed this status the stability of the element -and the building-is in risk. - Service limit state. It is related with the level of deformation of the structural element due to the actions in the building. If this limit is exceeded, it can cause discomfort or damage elements of the building. Identifies different kind of actions to take into account, as well the security coefficients to be implemented and the main lines to follow for the structural calculations. In addition, DB-SE-EA, stablish "standard" values to quantify the different actions that affect de building, depending on its use, form and constructive solution. Identifying permanent actions and variable. In PLURAL, where the existing building has concrete reinforced structure. The Basic Documents related of Structural security, have to be complemented with the regulation regarding concrete structures; the Structural Code (approved on the 29th of June 2021)

2.3.3 Fire safety regulations

Country	SPAIN
Category	**Safety in case of fire**
Original Title	Documento Básico DB-SI Seguridad en caso de incendios (Código Técnico de la Edificación - CTE)
English translation of title	Basic Document for the Safety in case of fire DB-SI (Spanish Technical Building Code - CTE)
Publication year / amendment year (if any)	2006. Several amendments and current version from December 2019
Document type & Status	Type: Regulation with legal status Status: Approved and in force
Region of enforcement (If differentiated countrywide)	The regulation is applied countrywide
Brief summary / content description	The main purpose of the CTE DB-SI is reducing to acceptable levels the risks for building users to suffer harm in the event of fire. The document establishes the requirements, rules and procedures to fulfill the Basic Demands (see below) and achieve a minimum level of quality that ensures fire safety. 6 Basic Demands (SI) are established as follows: • SI1: Limitation of indoor fire spread. • SI2: Limitation of external fire spread. • SI3: Building occupants' egress. • SI4: Fire protection installations. • SI5: Firefighter's intervention. • SI6: Structural resistance to fire. As for the PLURAL PnU systems, the applying Basic Demand is SI2.
Scope of: (cases that is applied)	The requirements of the regulation must be followed for new buildings. They can also be applicable to existing buildings if it is technically, functionally, or economically feasible. In the case of renovation of an existing building (without change in the building use or occupancy), CTE DB-SI shall apply to the building elements subject to reform, provided that it results in a better alignment of the safety conditions with the provisions in CTE DB-SI. Consideration of the requirements in CTE DB-SI should be based on the principle of proportionality between the renovation scope and the degree of improvement in the safety conditions in case of fire. In no case will the building renovation result in a decrease of the safety conditions of the previously existing building. CTE DB-SI does not apply to industrial buildings (which are ruled by a different Regulatory Document).
Basic requirements for residential buildings	**SI2: Limitation of external fire spread.** **Façades. Resistance to fire requirements.**

1. To avoid horizontal fire spread, the distance to adjacent building elements from parts of the façade which have a resistance to fire less than EI 60 will be in accordance with the next table and figures, depending on the angle between buildings.

TABLE 2.3-1: MINIMUM DISTANCE BETWEEN ELEMENTS WITH EI<60 (SPANISH FIRE SAFETY REGULATION)

α	0°		45°	60°	90°	135°	180°
d (m)	3,00		2,75	2,50	2,00	1,25	0,50

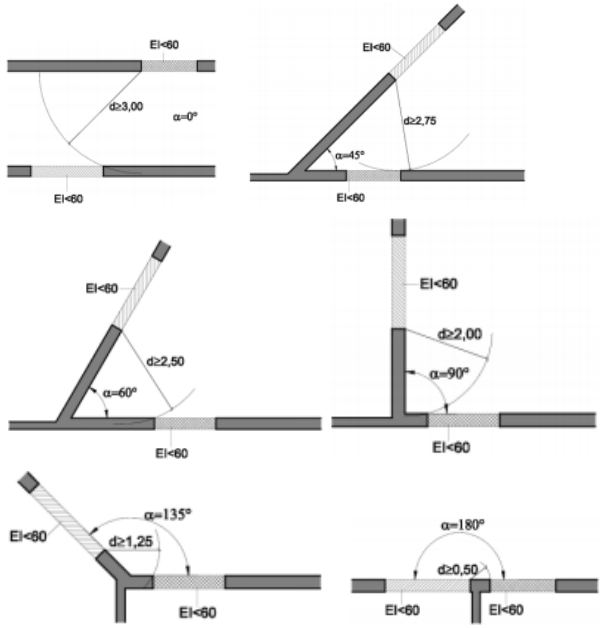


FIGURE 2.3-1: SCHEMATIC OF MINIMUM DISTANCE BETWEEN ELEMENTS WITH EI<60 (SPANISH FIRE SAFETY REGULATION)

2. To avoid vertical fire spread, the façade element (as a whole) will have a minimum resistance to fire EI 60 in a zone of at least 1 m of vertical distance between fire compartments (i.e.: in general, between floors).

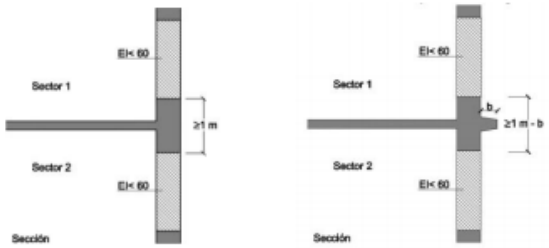


FIGURE 2.3-2: SCHEMATIC OF MINIMUM VERTICAL DISTANCE BETWEEN ELEMENTS WITH EI<60 (SPANISH FIRE SAFETY REGULATION)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958218

Note: the 1 m vertical distance between façade parts less than EI 60 can be proportionally reduced if a horizontal wing is considered (as shown in the figure above, at the right).

Façades. Reaction to fire requirements.

1. The reaction to fire of the façade constructive elements which amount more than 10 % of the total façade area will be:
   - D-s3,d0 in façades with a height up to 10 m.
   - C-s3,d0 in façades with a height up to 18 m.
   - B-s3,d0 in façades higher than 18 m.

   The field of application of the reaction to fire classification shall consider the end-use constructive system including the inner layers of the façade element if not protected by a EI 30 external layer.

2. The insulation layer installed in the gap of ventilated façades will have the following reaction to fire:
   - D-s3,d0 in façades with a height up to 10 m.
   - B-s3,d0 in façades with a height up to 28 m.
   - A2-s3,d0 in façades higher than 28 m.

   Vertical fire spread through the gap in the ventilated façade shall be avoided at the floors level. Fire stopping barriers (at least E30) can be considered to that end.

3. In façades with a height up to 18 m where the lower part is accessible to the general public, the reaction to fire of the façade constructive elements, as well as of the elements in the gap of a ventilated façade, will be at least B-s3,d0 up to a height of 3,5 m from the lower edge.

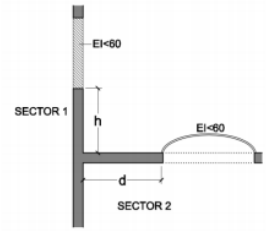
Roofs. Resistance to fire requirements.

1. To avoid horizontal fire spread between adjacent buildings, the roof will have a resistance to fire of at least REI 60 in a zone of minimum 0,5 m from the adjacent building.
   If an internal compartmentation wall joins the roof, the roof will have a resistance to fire of at least REI 60 in a zone of minimum 1,0 m above the wall.
   Alternatively, the wall between adjacent buildings or the internal compartmentation wall can be enlarged 0,60 m over the roof external surface.

2. If a roof joins a façade (of a different fire compartment or a different building), the vertical distance (h) of at least EI 60 in the façade and the horizontal distance (d) of at least EI 60 in the roof will be in accordance with the next table and figure.

TABLE 2.3-2 VERTICAL AND HORIZONTAL DISTANCE BETWEEN ROOF AND FAÇADE OF EI<60 (SPANISH FIRE SAFETY REGULATION)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958218

	<table><tr><td>d (m)</td><td>≥ 2,50</td><td>2,00</td><td>1,75</td><td>1,50</td><td>1,25</td><td>1,00</td><td>0,75</td><td>0,50</td><td>0</td></tr><tr><td>h (m)</td><td>0</td><td>1,00</td><td>1,50</td><td>2,00</td><td>2,50</td><td>3,00</td><td>3,50</td><td>4,00</td><td>5,00</td></tr></table>  **Roofs. Reaction to fire requirements.** Materials that occupy more than 10 % of the external surface of the roof areas located less than 5 m away from the vertical projection of any façade, with a resistance to fire lower than EI 60, will have a class B_{ROOF}(t1).
Observations	If PLURAL PnU Systems eventually include any fire protective installation (e.g.: sprinklers), Spanish Regulation RIPCI will also need to be taken into account. Real Decreto 513/2017 RIPCI: Reglamento de Instalaciones de Protección Contra Incendios *(Regulation on Fire Protective Installations)*. At the moment, fire protective installations are not foreseen in the design of PLURAL PnU Systems-

2.3.4 Hygiene, health and the environment related regulations

Country	**SPAIN**
Category	**Hygiene, health and the environment**
Original Title	Documento Básico DB-HS Salubridad (Código Técnico de la Edificación -CTE)
English translation of title	Basic Document of Hygiene, health and the environment DB-HS (Spanish Technical Building Code - CTE)
Publication year / amendment year (if any)	2006. Several amendments and current version from 2019
Document type & Status	Type: Regulations, codes with legal status Status: Approved and in force
Region of enforcement (If differentiated countrywide)	The regulation is applied countrywide
Brief summary / content description	The Spanish Technical Building Code (CTE) stablishes the requirement of hygiene, health and the environment, which is included in the Basic Document "**DB HS Hygiene, health and the environment",** updated in the Royal Decree 732/2019. Its objective is to reduce to acceptable limits the users' risk of disturbance or developing illnesses inside the buildings and under ordinary

<table>
<tr><td></td><td>conditions of use, as well as the buildings' risk to be deteriorated and to deteriorate their close environment. The document establishes 6 Basic Demands (HS):
• HS1: Protection against moisture.
• HS2: Collection and evacuation of residues.
• HS3: Internal air quality.
• HS4: Water supply.
• HS5: Water evacuation.
• HS6: Protection against radon exposure.
HS2, HS4, HS5 and HS6 are considered out of the scope of this report and won't be further presented.</td></tr>
<tr><td>Scope of: (cases that is applied)</td><td>The requirements of the regulation must be followed for new or existing buildings, and for walls and floors in contact with the terrain and façades and roofs in contact with the environment.</td></tr>
<tr><td>Basic requirements for residential buildings</td><td>Basic Demands set by the Regulation:
HS1: Protection against moisture.
The minimum water tightness degree necessary for the walls is:
TABLE 2.3-3: MINIMUM WATER TIGHTNESS FOR WALLS (SPANISH REGULATIONS)
<table>
<tr><td></td><td colspan="3">Terrain permeability coefficient</td></tr>
<tr><td>Water presence</td><td>$K_s \geq 10^{-2}$ cm/s</td><td>$10^{-5} < K_s < 10^{-2}$ cm/s</td><td>$K_s \leq 10^{-5}$ cm/s</td></tr>
<tr><td>High</td><td>5</td><td>5</td><td>4</td></tr>
<tr><td>Medium</td><td>3</td><td>2</td><td>2</td></tr>
<tr><td>Low</td><td>1</td><td>1</td><td>1</td></tr>
</table>
The constructive solutions must have a drainage well close to the wall, at least every 50 meters. The well must have an internal diameter equal or higher than 0,7 meters. For the ventilation of the chamber, there must be ventilation openings in the top and bottom of the internal sheet, and the area in contact with these openings must be ventilated with at least 0,7 l/s every m^2 flow. The relation between the effective total area of the openings S_S, in cm^2, and the internal sheet surface A_h, in m^2, must comply with: $30 > S_s/A_h > 10$.
The minimum water tightness degree necessary for the floors is:
TABLE 2.3-4: MINIMUM WATER TIGHTNESS FOR FLOORS (SPANISH REGULATIONS)
<table>
<tr><td></td><td colspan="2">Terrain permeability coefficient</td></tr>
<tr><td>Water presence</td><td>$K_s \geq 10^{-5}$ cm/s</td><td>$K_s \leq 10^{-5}$ cm/s</td></tr>
<tr><td>High</td><td>5</td><td>4</td></tr>
<tr><td>Medium</td><td>4</td><td>3</td></tr>
<tr><td>Low</td><td>2</td><td>1</td></tr>
</table>
The constructive solutions must have a drainage well under the floor, at least for each 800 m^2. The relation between the effective total area of the openings S_S, in cm^2, and the elevated floor surface A_s, in m^2, must comply with: $30 > S_s/A_s > 10$.
The minimum water tightness degree required for the façades is:
TABLE 2.3-5: MINIMUM WATER TIGHTNESS FOR FAÇADES (SPANISH REGULATIONS)</td></tr>
</table>

		Average rainfall zone				
		I P > 2000 mm	II 1000 mm < p ≤ 2000 mm	III 500 mm < p ≤ 1000 mm	IV 300 mm < p ≤ 500 mm	V p < 300 mm
Wind exposure degree	V1	5	5	4	3	2
	V2	5	4	3	3	2
	V3	5	4	3	2	1

The wind exposure degree is defined as:

TABLE 2.3-6: WIND EXPOSURE DEGREE (SPANISH REGULATIONS)

		Building surroundings class					
		E1			E0		
		Wind zone			Wind zone		
		A	B	C	A	B	C
Building height [m]	≤ 15	V3	V3	V3	V2	V2	V2
	16-40	V3	V2	V2	V2	V2	V1
	41-100	V2	V2	V2	V1	V1	V1

Flat roofs must have a slope towards the water evacuation elements depending on the use of the roof and the type of protection:

TABLE 2.3-7: FLAT ROOF SLOPE (SPANISH REGULATIONS)

Use		Protection	Slope [%]
Passable	Pedestrians Vehicles	Fixed floor Floating floor Tread layer	1-5 1-5 1-5
Non-passable		Gravel Self-protected sheet	1-5 1-15
Landscaped		Topsoil	1-5

For inclined roofs without impermeabilization, there must be an inclination towards the water evacuation elements depending on the type of roof:

TABLE 2.3-8: INCLINED ROOF SLOPE (SPANISH REGULATIONS)

Type of roof		Minimum slope [%]
Tile		30-40
Slate		60
Plates and profiles	Zinc	10
	Fiber-cement	10-25
	Synthetics	5-15
	Galvanized	5-15
	Light alloys	5-15

The ventilated air chamber must be located on the external side of the thermal insulation. The total effective area, S_S in cm^2, divided by the roof surface A_c in m^2, must comply with: $30 > S_S/A_C > 3$.

Some requirements regarding drainage pipes and HS2 section about residues evacuation were omitted as not relevant to the scope of this report

HS3: Internal air quality.

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In the habitable dwellings, there has to be an adequate supply of external air to have an average annual CO_2 concentration lower than 900 ppm, and an annual accumulated CO_2 lower than 500000 ppm·h when exceeding 1600 ppm. To remove the pollutants, there must be a minimum air flow of 1,5 l/s in non-occupation periods. The minimum constant flow for ventilation in habitable areas is:

TABLE 2.3-9: MINIMUM CONSTANT VENTILATION FLOW RATE (SPANISH REGULATIONS)

Type of area	Minimum flow q_v [l/s]				
	Dry buildings			Wet buildings	
	Main bedroom	Other bedrooms	Living rooms	Total minimum	Minimum per building
0-1 bedrooms	8	-	6	12	6
2 bedrooms	8	4	8	24	7
3 or more bedrooms	8	4	10	33	8

In the kitchen areas there must be an extraction system with a flow equal or greater than 50 l/s.

On the other hand, in non-habitable areas, the minimum ventilation flow must be:

TABLE 2.3-10: MINIMUM CONSTANT VENTILATION FLOW RATE FOR NON-HABITABLE AREAS (SPANISH REGULATIONS)

	Minimum flow q_v [l/s]	
Areas	Per effective m^2	Depending on other parameters
Storage rooms	0,7	
Garages		120/place
Residues storage	10	

The total effective area of the ventilation openings of every space must be at least the highest of the obtained by means of the following formulas:

TABLE 2.3-11: TOTAL EFFECTIVE AREA OF VENTILATIONS (SPANISH REGULATIONS)

Admission openings	$4 \cdot q_v$ $4 \cdot q_{va}$
Extraction openings	$4 \cdot q_v$ $4 \cdot q_{ve}$
Passing openings	70 cm^2 $8 \cdot q_{vp}$
Mixt openings	$8 \cdot q_v$
q_v = minimum ventilation flow required [l/s] q_{va} = ventilation flow corresponding to each admission openings [l/s] q_{ve} = ventilation flow corresponding to each extraction openings [l/s] q_{vp} = ventilation flow corresponding to each passing openings [l/s]	

When it comes to extraction ducts for hybrid ventilation, the section of each length of the extraction ducts in cm^3 must be at least as follows, depending on the air flow in the length of the duct and the shooting class, knowing that q_{vt} [l/s] is the sum of all the flows passing through the extraction openings ending in the length:

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TABLE 2.3-12: DIMENSIONS OF EXTRACTION OPENINGS (SPANISH REGULATIONS)

Air flow in the length of the duct [l/s]	Shooting class			
	T-1	T-2	T-3	T-4
$q_{vt} \leq 100$	1 x 225	1 x 400	1 x 625	1 x 625
$100 < q_{vt} \leq 300$	1 x 400	1 x 625	1 x 625	1 x 900
$300 < q_{vt} \leq 500$	1 x 625	1 x 900	1 x 900	2 x 900
$500 < q_{vt} \leq 750$	1 x 625	1 x 900	1 x 900 + 1 x 625	3 x 900
$750 < q_{vt} \leq 1000$	1 x 900	1 x 900 + 1 x 625	2 x 900	3 x 900 + 1 x 625

When it comes to extraction ducts for mechanical ventilation, the nominal section of each length of the extraction duct must be at least equal than the obtained by the formula $S \geq 2,5\ q_{vt}$ for ducts next to an habitable area, and $S \geq 2,5\ q_{vt}$ for ducts on the roof.

2.3.5 Protection against noise related regulations

Country	SPAIN
Category	**Protection against noise - acoustics**
Original Title	Documento Básico DB-HR Protección frente al ruido (Código Técnico de la Edificación - CTE)
English translation of title	Basic Document of the Protection against noise DB-HR (Spanish Technical Building Code - CTE)
Publication year / amendment year (if any)	2007. Several amendments and current version from 2019
Document type & Status	Type: Regulations, codes with legal status Status: Approved and in force
Region of enforcement (If differentiated countrywide)	The regulation is applied countrywide
Brief summary / content description	The Spanish Technical Building Code (CTE-Codigo Técnico de la Edificación, Royal Decree 1371/2007) stablishes the requirement of protection against noise, which is included in the basic document "**DB HR Protection against noise",** updated in the Royal Decree 732/2019. Its objective is to limit the damages or disturbances that the noise may cause in the users inside the building in ordinary conditions, reducing the air noise transmission, the impact noise and the building's installations noises and vibrations.
Scope of: (cases that is applied)	The requirements of the regulation must be followed for new and existing buildings, but not for the following cases: • Noisy enclosures with their own specific regulation. • Public buildings aimed to hold spectacles. • Conference rooms of less than 350 m^3. • Modification and refurbishment works in existing buildings, unless it is a full refurbishment.

Basic requirements for residential buildings

DB-I «Protection against noise» (Documento Básico DB-HR «Protección frente al ruido») of the Spanish Technical Building Code (CTE - Código Técnico de la Edificación), concerning protection against noise.

Basic demands set by the Regulation:

The building envelope must reach the limit values of the airborne noise insulation and must not exceed the limit values of the impact noise pressure.

TABLE 2.3-13: MINIMUM SOUND INSULATION VALUES (SPANISH REGULATIONS)

AIRBORNE INSULATION			
		Protected enclosures	Habitable enclosures
Noise from the same unit in private residential buildings		≥ 33 dBA	≥ 33 dBA
Noise from different units	Non-shared doors and windows	≥ 50 dBA	≥ 45 dBA
	Shared doors and windows	≥ 30 dBA	≥ 20 dBA
	Envelope	≥ 50 dBA	≥ 50 dBA
Installations and activity enclosures	Non-shared doors and windows	≥ 55 dBA	≥ 45 dBA
	Shared doors and windows		≥ 30 dBA
	Envelope		≥ 50 dBA
External noise		See following table	-
		Habitable and protected enclosures	
Insulation of each enclosure in a partition wall		≥ 40 dBA	
Insulation of both enclosures in a partition wall		≥ 50 dBA	
IMPACT SOUND			
		Protected enclosures	Habitable enclosures
Noise from different units		≤ 65 dBA	-
Installations and activity enclosures		≤ 60 dBA	≤ 60 dBA

Noise index L_d (dBA)	Building use			
	Residential and hospitals		Culture, sanitary*, educational and administrative	
	Bedrooms	Living rooms	Living rooms	Rooms
$L_d \leq 60$	30	30	30	30
$60 < L_d \leq 65$	32	30	32	30
$65 < L_d \leq 70$	37	32	37	32
$70 < L_d \leq 75$	42	37	42	37
$L_d > 75$	47	42	47	42
*Non-hospital buildings.				

The partitions must reach a minimum surface mass value (m) and a global acoustic reduction index (R_A), depending on the type of partition:

TABLE 2.3-14: MINIMUM SOUND REDUCTION INDEX OF ELEMENTS (SPANISH REGULATIONS)

Type	m [kg/m^2]	R_A [dBA]

Masonry or heavy prefabricated panels with direct support	70	35
Masonry or heavy prefabricated panels with elastic bands	65	33
Self-supporting framework	25	43

The acoustic parameters of the vertical partition components depend on the type of partition:

- Type 1 (Single or double masonry sheets with cladding): m = 67-400 kg/m^2, R_A = 33-57 dBA and ΔR_A = 0-16.
- Type 2 (Double masonry sheets with perimetric elastic bands): m = 130-200 kg/m^2, R_A = 54-61 dBA.
- Type 3 (Self-supporting framework): m = 44-60 kg/m^2, R_A = 58-68 dBA.

The acoustic parameters of the horizontal partition components depend on the slab characteristics and the type of floor (floating or suspended): m = 175-500 kg/m^2, R_A = 44-60 dBA:

- Floating floor: ΔL_w = 10-31 dBA and ΔR_A = 0-19 dBA.
- Suspended floor: ΔR_A = 0-15.

Shared walls must have an $R_A \geq$ 45 dBA.

The acoustic parameters of façades, covers and floors in contact with the external environment of protected buildings are:

TABLE 2.3-15: ACOUSTIC PARAMETERS OF EXTERNAL FAÇADES, COVERS AND FLOORS (SPANISH REGULATIONS)

Maximum level demanded $D_{2m,nT,Atr}$ [dBA]	Blind part = 100% $R_{A,tr}$ [dBA]	Blind part ≠ 100% $R_{A,tr}$ [dBA]	% of holes $R_{A,tr}$ [dBA]	
			0-60%	61-100%
30-37	33-39	35-56	25-39	31-39
41-51	43-53	45-60	35-52	42-53

The extraction ducts inside a use unit must be covered with constructive elements of $R_A \geq$ 33 dBA. In the case of ducts for smoke extraction in garages, $R_A \geq$ 45 dBA. On the other hand, elevators without the machinery inside them must have an $R_A \geq$ 50 dBA.

2.3.6 Energy performance of buildings regulation

Country	SPAIN
Category	**Energy performance of buildings (EPBD/EED transposition)**
Original Title	Documento Básico DB-HE Ahorro de energía (Código Técnico de la Edificación - CTE)
English translation of title	Basic Document of the Energy Savings DB-HE (Spanish Technical Building Code - CTE)
Publication year / amendment year (if any)	2006. Several amendments and current version from 2019
Document type & Status	Type: Regulations, codes with legal status Status: Approved and in force

Region of enforcement (If differentiated countrywide)	The regulation is applied countrywide
Brief summary / content description	The Spanish Technical Building Code (CTE) establishes the requirement of energy saving, which is included in the basic document "**DB HE Energy Saving",** updated in the Royal Decree 732/2019. Its objective is to achieve a rational use of the energy necessary for the use of the buildings, reducing consumption and achieving that the origin of part of the same is from renewable sources of energy. The document stablishes 6 basic demands (HE): • HE0: Limitation of the energy demand. • HE1: Conditions to control the energy demand • HE2: Performance of the thermal installations. • HE3: Energy efficiency of the lighting installations. • HE4: Minimum contribution of renewable energy to cover domestic hot water demand • HE5: Minimum electricity generation
Scope of: (cases that is applied)	The requirements of the regulation must be followed for new buildings. They also apply for existing buildings but as long as its technically, functionally or economically feasible. In addition, when a building or a building unit undergoes major renovation and its effective area is bigger than 50m^2: • Increase 10% the effective area. • Change its use reforms in which the thermal generation systems and more than 25% of the total surface of the final thermal envelope of the building are renewed together. For the Terrassa demo case, the retrofit will affect less than 25% of the envelope. Nevertheless, PLURAL detail definition will follow the regulation as guideline.
Basic requirements for residential buildings	DB-I «Energy saving» (Documento Básico DB-HE «Ahorro de Energía») of the Spanish Technical Building Code (CTE - Código Técnico de la Edificación), concerning energy savings, partially transposing the following Directives to the Spanish legal order: Directive 2002/91/EC and Directive 2010/31/EU of the European Parliament and of the Council of 19th May 2010. **Basic demands set by the Regulation:** **HE0: Limitation of the energy demand.** The spaces within the building envelope cannot exceed the thresholds established according to the winter climatic zone where it is located (6 climate zones defined by the regulation itself). The energy consumption is considered to supply energy to heating, cooling, DHW, ventilation and humidity regulation. The regulation establishes two different thresholds depending on whether the renewable energy is considered (total primary) or not (non-renewable primary) which is calculated using the official pass coefficients to convert

final energy to primary energy.

TABLE 2.3-16: ENERGY CONSUMPTION THRESHOLDS (SPANISH ENERGY SAVING REGULATION)

	Value [kWh/m^2·year]					
	Climate Zone					
	α	A	B	**C***	D	E
Non-Renewable Primary Energy Consumption						
New buildings and expansion	20	25	28	**32**	38	43
Change of use to residential private and refurbishment	40	50	55	**65**	70	80
Total Primary Energy Consumption						
New buildings and expansion	40	50	56	**64**	76	86
Change of use to residential private and refurbishment	55	75	80	**90**	105	115
**The demo case is located in Terrassa, Zone C*						

- To justify the compliance with the requirements, a thermal simulation model can be developed or a simplified equivalent method can be used. The simulation has to follow the procedure detailed in this point.
- The buildings that comply with that requirement are considered nZEB according to Spanish regulation.

HE1: Conditions to control the energy demand

Individual building elements of the building envelope have to fulfil the following requirements concerning their insulating properties, which are differentiated on the winter climate zone the building belongs.

In case of refurbishment the limit value of the thermal transmittance shall apply only to elements of the envelope which are affected by the refurbishment, and are presented in the table below:

TABLE 2.3-17: MAX U-VALUES OF BUILDING ELEMENTS (SPANISH ENERGY SAVING REGULATION)

Building element	Max U – Value [W/m^2·K]					
	Climate Zone					
	α	A	B	**C***	D	E
Walls and floors in contact with outside air	0.80	0.70	0.56	**0.49**	0.41	0.37
Roofs in contact with the outside air	0.55	0.55	0.44	**0.4**	0.35	0.33
Walls, floors and roofs in contact with non-habitable areas or with the ground Partition walls or interior partitions belonging to the thermal envelope	0.90	0.80	0.75	**0.70**	0.65	0.59
Openings (frame assembly,	3.2	2.7	2.3	**2.1**	1.8	1.8

glass and, where appropriate, roller shutter box)						
Doors with a semi-transparent surface of 50% or less	5.7					
**The demo case is located in Terrassa, Zone C*						

There is also a maximum allowed global K value for the whole building including thermal bridges which depends on the Total Volume to Total External Area ratio (V/A) and whether the building has underdone and expansion, a change in their use or a renovation >25% of its envelope. The limit values are presented in the table below:

TABLE 2.3-18: MAXIMUM GLOBAL K VALUE (SPANISH ENERGY SAVING REGULATION)

	Compacity	Max K – Value [W/m^2·K]					
	[m^3/m^2]	Climate Zone					
		α	A	B	**C***	D	E
New buildings and expansion	V/A≤1	0.67	0.60	0.58	**0.53**	0.48	0.43
	V/A ≥4	0.86	0.80	0.77	**0.72**	0.67	0.62
Changes of use. Renovations in which more than 25% of the total area of the final thermal envelope of the building is renovated.	V/A≤1	1.00	0.87	0.83	**0.73**	0.63	0.54
	V/A ≥4	1.07	0.94	0.90	**0.81**	0.70	0.62
**The demo case is located in Terrassa, Zone C*							

- Solar gains are also limited. The solar control parameter ($q_{sol:jul}$) is defined as ratio between the solar gains for the month of July and the effective area of the zones included within the thermal envelope. For residential uses this parameter is limited to $q_{sol:jul} \leq 2$ kWh/m^2·month.
- In the case of interstitial condensation on the thermal envelope of the building, this shall be such that they do not significantly impair the thermal performance of the building or pose a risk of degradation or loss of service life.
- Air permeability of openings belonging to the thermal envelope will not exceed the values of the following table.

TABLE 2.3-19: MAXIMUM AIR PERMEABILITY OF OPENINGS (SPANISH ENERGY SAVING REGULATION)

	Q_{100_lim} [m^3/h·m^2]					
	Climate Zone					
	α	A	B	**C***	D	E
Air permeability of openings	≤27	≤27	≤27	**≤9**	≤9	≤9
**The demo case is located in Terrassa, Zone C*						

- For new buildings with a floor area higher than 120 m^2, the air exchange ratio with the outdoor cannot exceed the 6 ren/hour if V/A≤2, and 3 ren/hour if V/A≥4, when submitted to the 50 Pa differential pressure test.

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HE2: Performance of the thermal installations.

The thermal equipment installed in buildings are regulated in Regulation for Thermal Installations in Buildings (RITE Reglamento de Instalaciones Térmicas en los Edificios), stablished in the Royal Decree RD 1027/2007, and its last update is from 2021 in RD 178/2021.

- The document consists of the technical instructions that determine the safety, health, efficiency, renewable energy use requirements.
- The document also establishes the technologies that can be included in thermal installations (also which are excluded due to their low efficiency), and also the minimum efficiency the equipment can have.
- Design conditions for thermal systems in case the metabolic level is 1,2 met, the clothing is 0.5 clo in summer or 1 clo in winter, the air speed is < 0.1 m/s and the comfort is PPD < 10%, the indoor design conditions will be:

TABLE 2.3-20: INDOOR DESIGN CONDITIONS (SPANISH ENERGY SAVING REGULATION)

	Operative T (°C)	Relative Humidity (%)
Summer	23-25	45-60
Winter	21-23	40-50

HE3: Energy efficiency of the lighting installations.

For non-residential buildings, new construction and existing ones where either its lighting installation is renovated or expanded or the use of the building changes, the regulation establishes: lighting efficiency (VEEI), maximum power, efficient lighting control and use of daylight.

HE4: Minimum contribution of renewable energy to cover domestic hot water demand

In case of new buildings, entire renovation or change of thermal installation, if DHW demands are higher than 100 l/day, 70% of the domestic hot water must be provided from renewable sources or from renewable cogeneration processes; either generated in the building itself or from a district heating. This also includes heated pools demand.

Thermal installations dedicated to DHW generation or pool heating based on heat pumps, must have SCOP higher than 2.5 for electrically driven machines and 1.15 for thermally driven machines. This value depends on the supply temperature which can't be lower than 45°C.

HE5: Minimum electricity generation

For non-residential buildings, a renewable electricity system generation will have to be included either in new buildings and enlargement of existing buildings that exceed the 3000 m^2 of effective area, or for buildings entirely renovated or that change their use and have an effective area bigger than 3000 m^2.

This energy can be either for self-consumption or for network injection.

The installed power is proportional to the effective area or to roof surface, and in any case it is limited between 30 and 100 kW.

nZEB definition and requirements (if available)	Which are all the requirements in order for a new or existing building to be considered as nZEB. Currently in Spain, according to Real Decreto 732/2019, the buildings which comply with the energy demand requirements from HE0: Limitation of the energy demand, without any more specific requirements or quantitative limitations in consumption or generation from RES.

2.3.7 RES in buildings legal framework

Country	SPAIN
Category	**Renewable energy sources in buildings – PV systems & net metering in buildings**
Original Title	Real Decreto 244/2019, de 5 de abril, por el que se regulan las condiciones administrativas, técnicas y económicas del autoconsumo de energía eléctrica.
English translation of title	Royal Decree RD 344/2019, of 5th April, which regulates the administrative, technical and economic conditions for the self-consumption of electricity.
Publication year / amendment year (if any)	2019. A first amendment is planned by 2021, which will probably include relevant technical modifications to be considered for the energy and economic balance
Region of enforcement (If differentiated countrywide)	The laws are applied countrywide
Document type & Status	Type: Laws, ministerial decrees Status: Approved and in force
Brief summary / content description	The legal framework defines the technical and economic terms for the modalities of self-consumption of electricity based in law 24/2013 of 26th December, of the Electrical Sector. It establishes: • The two modalities for self-consumption: with and without surplus, and the surplus generation can be with or without compensation. • Individual and collective self-consumption • Compensation mechanisms • Communication procedures for official registering. These procedures have been simplified with respect to previous regulation.
Scope of: (cases that is applied)	The framework applies for all kind of electrical self-consumption installations defined in Law 24/2013 which are connected to the grid (including any kind of use buildings). Isolated and emergency installations are left out of the scope.
Basic terms	**Self-consumption definition** • The consumption of energy by a single or a group of consumers of the electrical energy from a renewable production installation close to the consumption and associated with these. • A renewable production installation close to the consumption can be either: a) connected to the internal network of the associated consumers or are linked to them via direct lines. b) connected to any of the low voltage networks derived from the same transformer substation. c) both generation and consumption are connected at low voltage and at a distance of less than 500 meters from each other. For this purpose, the distance between the metering equipment in its orthogonal projection on the ground plan shall be taken. d) Both generation and consumption are located in the same cadastral reference according to their first 14 digits or, where applicable, according to the provisions of the twentieth additional

provision of Royal Decree 413/2014, of 6th June, which regulates the activity of electricity production from renewable energy sources, cogeneration and waste.

- A renewable production installation for self-consumption, according to law 24/2013, has to comply with the following requirements:
  a) to have less than 100 kW
  b) to be registered under self-consumption regime
  c) have a connection to the power grid
- The decree makes no distinction of which kind of technology is used as long as it is renewable.

Self-consumption modalities

1. **Self-consumption without surplus**
   An anti-surplus energy discharge mechanism must be installed. In that case, no connection license is required.
2. **Self-consumption with surpluses**
   Two sub-categories are distinguished:
   a. Modality of surplus compensation. A net billing is made between the surplus energy generated and the deficit consumed from the network. The installations with power <15 kW are exempted from access and connection permits. In case they are bigger this can be a problem is the supply network does not satisfy the requirements to obtain the permits, and has to be adapted.
   b. Surplus mode without compensation. The energy injected is sold in the electrical market at the price agreed with the supplier.

Individual or Collective

A single consumer associated to one or more renewable production installation. On the other hand, several consumers can be supplied, in an agreed manner, by nearby production installations to those of consumption and associated to these.

Metering requirements

In general, the measuring equipment shall be installed in the corresponding internal networks, at the points as close as possible to the border point that minimize energy losses, and shall have resolution measurement capacity at least hourly.

Sharing coefficients for collective self-consumption

For billing and settlement purposes, the produced energy will be split among the associated beneficiaries in an agreed manner (e.g. according to their power to be billed, according to their economical contribution, etc.).
These coefficients must be constant for all hours of the period, and can only be changed once per each billing period.
It is expected that in 2021 the regulation will be updated to dynamic coefficients which, once per year, will be able to be adjusted individually per each hour of the year.

2.4 Czech Republic

2.4.1 General building constructions and urban planning related regulations

Country	CZECH REPUBLIC
Category	**Building construction works**
Regulation Original Title	Zákon č.183/2006 Sb. - Zákon o územním plánování a stavebním řádu (stavební zákon)
English translation of title	Act No. 183/2006 Coll. - Act on town and country planning and building code (Building Act)
Publication year / amendment year (if any)	2006 – various amendments are made
Document type & Status	Type: Regulations, codes with legal status Status: Approved and in force
Region of enforcement (If differentiated countrywide)	The regulation is applied countrywide
Brief summary / content description	(1) This Act governs, in the matters of town and country planning, particularly the objectives and tasks of town and country planning, the system of authorities of town and country planning, the town and country planning instruments, the assessment of the impacts on area sustainable development, decision-making within the area, possibilities of consolidation of procedures pursuant to this Act with procedures of the environmental impact assessment, conditions for construction, land development and for preparation of the public infrastructure, records of planning activity and qualification requirements for planning activity. (2) This Act governs, in the matters of the building code, particularly the permission of buildings and their alterations, landscaping and facilities, use and removal of structures, supervision and special powers of building offices, position and authorisation of the authorized inspectors, system of building offices, duties and responsibilities of persons within the preparation and realization of structures. (3) Furthermore the Act governs the conditions for the design activity and the structures realizations, general conditions for construction, purpose of expropriation, entry to the grounds and into the structures, protection of public priorities and some other issues related to the subject-matter of this legislation.
Scope of: (cases that is applied)	Part four: BUILDING CODE §103 - §157

Basic requirements for existing residential buildings related with the PLURAL concepts	Building permit is necessary.

2.4.2 Mechanical resistance, stability and seismic behaviour related regulations

Country	**CZECH REPUBLIC**
Category	**Mechanical resistance, stability and seismic behaviour**
Regulation Original Title	Normy pro navrhování konstrukcí (EN, ČSN EN, ČSN)
English translation of title	Standards for design of structures (EN, ČSN EN, ČSN)
Publication year / amendment year (if any)	2006 – various amendments are made
Document type & Status	Type: Regulations, codes with legal status Status: Approved and in force
Region of enforcement (If differentiated countrywide)	The regulation is applied countrywide
Brief summary / content description	These standards apply to the design of mechanical resistance, stability and seismic behaviour of new buildings and structures.
Scope of: (cases that is applied)	ČSN EN 1990 ed.2 - Eurocode: Basis of structural design ČSN EN 1991 – Eurocode 1: Actions on structures ČSN EN 1992 – Eurocode 2: Design of concrete structures ČSN EN 1993 – Eurocode 3: Design of steel structures ČSN EN 1995 – Eurocode 5: Design of timber structures ČSN EN 1996 – Eurocode 6: Design of masonry structures ČSN EN 1998 - Eurocode 8: Design of structures for earthquake resistance ČSN EN 1999 – Eurocode 9: Design of aluminium structures
Basic requirements for existing residential buildings related with the PLURAL concepts	The requirements for mechanical resistance and stability must be met: - existing structures of the building, including foundations - anchoring of panels - panel construction Expected load: - self weight of the panel - wind load - snow load - temperature load - seismic loading is unlikely

2.4.3 Fire safety regulations

Country	CZECH REPUBLIC
Category	**Fire Safety of buildings**
Original Title	Listed for each regulation below.
English translation of title	Listed for each regulation below
Publication year / amendment year (if any)	Listed for each regulation below
Document type & Status	Basic laws (acts), decrees and technical standards (CSN) **Type: Act no. 183/2006 Coll. on urban planning and building code (building act)** / https://www.zakonyprolidi.cz/cs/2006-183 - Status / approach: Mandatory / Prescriptive **Type: Act no. 133/1985 Coll. on fire protection** / https://www.zakonyprolidi.cz/cs/1985-133 - Status / approach: Mandatory / Prescriptive **Type: Decree No. 246/2001 Coll. on determining the conditions of fire safety and performance of state fire supervision (decree on fire prevention)** / https://www.zakonyprolidi.cz/cs/2001-246 - Status / approach: Mandatory / Prescriptive **Type: Decree No. 23/2008 Coll. on technical conditions of fire protection of buildings** / https://www.zakonyprolidi.cz/cs/2008-23 - Status / approach: Mandatory / Prescriptive **Type: technical standard CSN 73 0802 - Fire protection of buildings - Non-industrial buildings (2020, ed.2)** / https://csnonline.agentura-cas.cz/vyhledavani.aspx - Status / approach: Mandatory / Prescriptive (performance based principles only in the Annex I) **Type: technical standard CSN 73 0804 - Fire protection of buildings - Industrial buildings (2020, ed.2)** / https://csnonline.agentura-cas.cz/vyhledavani.aspx - Status / approach: Mandatory / Prescriptive (performance based principles only in the Annex J) **Type: technical standard CSN 73 0810 - Fire protection of buildings - General requirements (2016)** / https://csnonline.agentura-cas.cz/vyhledavani.aspx - Status / approach: Mandatory / Prescriptive
Region of enforcement (If differentiated countrywide)	-
Brief summary / content description	**REGULATORY SYSTEM STRUCTURE** The combination of legislative regulations (laws, decrees) and Czech technical standards creates basic rules for designing fire safety of buildings. Laws and decrees (implementing legislation) are binding. Technical standards are generally not obligatory in the Czech

	Republic (they are recommended), but they can be obligatory if required by a decree (especially in the case of protection of the public interest, such as thermal protection, acoustics or fire safety). Fire design standards (series of standards CSN 73 08xx) and some other associated standards are binding because they are ordered by Decree 23/2008 Coll. The calculation methods and requirements are found exclusively in the technical standards of the ČSN 73 08xx series (fire safety of buildings), in part specific requirements are given in Decree 23/2008 Coll. However, with regard to the age of the Decree, the requirements are translated into the current versions of the standards. **REGULATORY SYSTEM TYPE** The fire safety design system is prescriptive. A different procedure (performance-based design) is allowed by law (133/1985 Coll., § 99) and the framework methodology is then very briefly defined by the fundamental standards CSN 73 0802, resp. CSN 73 0804 (non-production or production objects) in the informative appendix. Acceptance criteria are not defined in national regulations. **EXCEPTIONS AND ALTERNATIVE APPROACH** So far, the different performance-based design process has been applied in exceptional cases. More complicated cases are assessed by the Fire Rescue Service not at district regional workplaces (usually limited knowledge of the issue), but usually at regional directorates or at the highest level (Directorate General of the Fire Rescue Service). **CATEGORISATION** The basic categorization in the field of fire safety designing is created by 2 fundamental standards for non-production buildings (CSN 73 0802, residential and civil buildings) and production buildings (CSN 73 0804). The general content of the master standards is given in the previous section. This categorization is complementary to other project standards (CSN 73 08xx series) for specific constructions and operations (assembly areas, housing, accommodation, alterations to buildings, medical buildings, social care, postal operations, telecommunications links, agricultural buildings, warehouses).
Scope of: (cases that is applied) New & Existing Buildings	**NEW BUILDINGS** set of standards of the ČSN 73 08XX series - Fire safety of buildings **Fundamental** standard; xx (year) = • 02 (2020 ed.2) Non-industrial buildings • 04 (2020 ed.2) Industrial buildings • 10 (2016) General requirements

	Design standard; xx (year) = • 31 (2020 ed.2) Assembly rooms • 33 (2010+2013) Buildings for dwelling and • 35 (2020 ed.2) Buildings for sanitary maters and social care • 42 (2014+2018) Buildings for agricultural production • 43 (2020 ed.2) Communication and postal facilities • 45 (2012) Storage rooms **Value** standard; xx (year) = • 18 (1997+2002) Person/surface rate in buildings • 21 (2007 ed.2) Fire resistance of engineering structures • 22 (1987) Fire-technical properties of materials. Flame spread over the surface of building materials • 24 (1992) Heating value of flammable substances **Special** standard; xx (year) = • 48 (2009+2013+2017) Cable line • 72 (1996) Protection of buildings to extension of fire by air-distributing equipment • 73 (2003) Equipment for fire-water supply • 75 (2011) Setting specification for design of fire detection and fire alarm systems in terms of fire safety solution • 63 (1991+2014) Fire technical properties of materials. Determination of flame propagation along the surface of building materials • 65 (1987) Evaluation of materials drainage of the soffits of ceilings and roofs • 95 (2016) Circuit integrity maintenance of cable systems under fire conditions - Requirements, testing, classification Px-R, PHx-R and application of the test results **EXISTING BUILDINGS** Design standard; xx (year) = 34 (2011+2011+2013) Changes of buildings
Basic requirements for residential buildings	Requirements for residential buildings are defined in the fundamental standard CSN 73 0802 (see above and design logic see diagrams below), more precise requirements are defined in CSN 73 0833 (see above) for 4 categories of residential buildings (family houses, apartment buildings, accommodation facilities with lower and higher capacity). **DESIGN LOGIC FOR FIRE SAFETY ASSESSMENT FOR NON-INDUSTRIAL BUILDINGS (CSN 73 0802)**

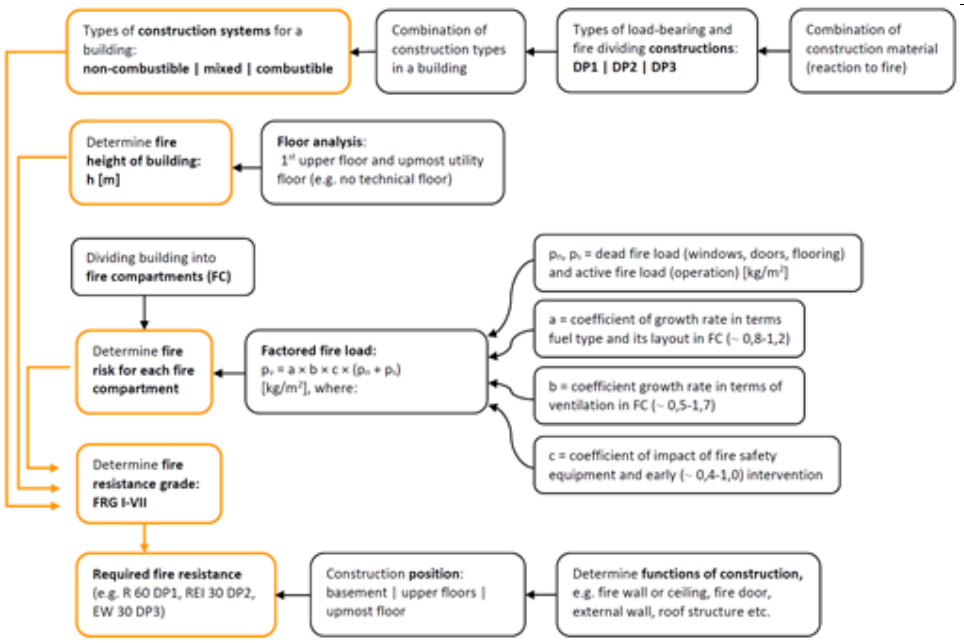

FIGURE 2.4-1: DESIGN LOGIC FOR FIRE SAFETY ASSESSMENT FOR NON-INDUSTRIAL BUILDINGS (CSN 73 0802) (CZECH FIRE SAFETY REGULATION)

CONSTRUCTION TYPES DP1 | DP2 | DP3

Based on reaction to fire classes of building materials constituting the elements and their composition.

TABLE 2.4-1: BUILDING CATEGORY DEPENDING ON COMBUSTIBILITY OF MATERIALS (CZECH FIRE SAFETY REGULATION)

Criteria	DP 1	DP 2	DP 3
Combustible materials in load-bearing parts of construction element	No	Yes	Yes
Combustible materials able to ignite (flame ignition temperature reached) within the required fire resistance period	No	No	Yes

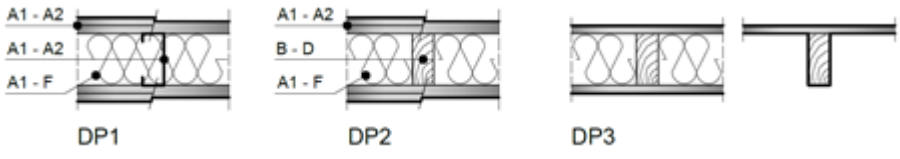

FIGURE 2.4-2: GRAPHICAL REPRESENTATION OF CONSTRUCTION (SANDWICH) ELEMENT TYPES (CZECH FIRE SAFETY REGULATION)

Construction material classification according to the EN 13501-1:

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- A1, A2 = incombustible materials
- B, C, D, E, F = combustible materials

CONSTRUCTION SYSTEM TYPES

Based on the types of fire dividing and load-bearing construction elements constituting the system. Important for building height restrictions (see below the FRG).

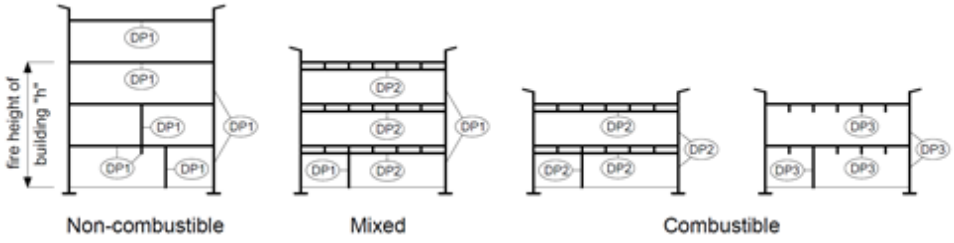

FIGURE 2.4-3: GRAPHICAL REPRESENTATION OF BUILDING CATEGORIZATION (CZECH FIRE SAFETY REGULATION)

Note: Exceptions are defined for the installation of DP3 structures in a non-combustible structural system of a building.

TABLE 2.4-2: FIRE RESISTANCE GRADE (FRG) - METHODOLOGY FOR NON-INDUSTRIAL BUILDING (CSN 73 0802) (CZECH FIRE SAFETY REGULATION)

Construction system (CS) of building	The highest factored fire load (p_v [kg/m²]) in fire compartment (FC)	The lowest fire resistance grade (FRG) in fire compartment						
		I.	II.	III.	IV.	V.	VI.	VII.
		Fire height of building h [m]						
Non-combustible	15	12	30	60	without limit			
	30	O	12	30	without limit			
	45	O	6	22,5	45	without limit		
	60	O	6	12	30	45	without limit	
	90	O_a	O	6	12	30	45	
	120	N_1	O_a	O	6	12	30	45
	above 120[1)]	N_1	N_1	O_a	O	6	12	30
Mixed	10	6	12	12	18	22,5	N_2	N_2
	25	O	6	12	18	22,5	N_2	N_2
	35	O	6	12	18	22,5	N_2	N_2
	50	O_a	O	6	18	22,5	N_2	N_2
	75	N_1	O	6	12	22,5	N_2	N_2
	100	N_1	O	6	9	15	N_2	N_2
	above 100[1)]	N_1	N_1	O	6	12	N_2	N_2
Combustible	10	4	9	12	12	12	N_2	N_2
	20	O	4	9	12	12	N_2	N_2
	30	O	4	9	12	12	N_2	N_2
	40	O_a	O	4	9	12	N_2	N_2
	60	N_1	O	4	4	9	N_2	N_2
	80	N_1	O_a	O	4	9	N_2	N_2
	above 80[1)]	N_1	N_1	O_a	O	4	N_2	N_2

Example:
- block of flats
- h = 21 m
- non-combustible CS
- FC = flat
- p_v = 45 kg/m²

► III. FRG

Table legend:
- N = FRG must not be applied
- O = FC in one-storey buildings only

TABLE 2.4-3: FIRE RESISTANCE GRADE (FRG) - METHODOLOGY FOR NON-INDUSTRIAL BUILDING (CSN 73 0802) (CZECH FIRE SAFETY REGULATION)

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Ref.	Construction	Fire Resistance Grade (FRG) of Fire Compartment (FC)						
		I.	II.	III.	IV.	V.	VI.	VII.
		Fire Resistance of construction and required type						
1	Fire walls and ceilings:							
	a) in basement	30 DP1	45 DP1	60 DP1	90 DP1	120 DP1	180 DP1	180 DP1
	b) in upper floors	15	30	45	60	90	120 DP1	180 DP1
	c) in upmost floor	15	15	30	30	45	60 DP1	90 DP1
	d) between buildings	30 DP1	45 DP1	60 DP1	90 DP1	120 DP1	180 DP1	180 DP1
2	Fire openings:							
	a) in basement	15 DP1	30 DP1	30 DP1	45 DP1	60 DP1	90 DP1	90 DP1
	b) in upper floors	15	15	30	30	45 DP2	60 DP1	90 DP1
	c) in upmost floor	15	15	15	30	30	45 DP2	60 DP1
3a	External walls load-bearing:							
	a) in basement	30 DP1	45 DP1	60 DP1	90 DP1	120 DP1	180 DP1	180 DP1
	b) in upper floors	15	30	45	60	90	120 DP1	180 DP1
	c) in upmost floor	15	15	30	30	45	60 DP1	90 DP1
3b	External walls non-load-bearing:	15	15	30	30	45	60 DP1	90 DP1
4	Load-bearing elements of roof	15	15	30	30	45	60 DP1	90 DP1
5	Load-bearing elements inside Fire Compartment							
	a) in basement	30 DP1	45 DP1	60 DP1	90 DP1	120 DP1	180 DP1	180 DP1
	b) in upper floors	15	30	45	60	90	120 DP1	180 DP1
	c) in upmost floor	15	15	30	30	45	60 DP1	90 DP1
6	Load-bearing elements outside building	15	15	15	30	30 DP1	45 DP1	60 DP1
7	Load-bearing elements of independent building part inside Fire Compartment	15	15	30	30	45	45 DP1	60 DP1
8	Non-loadbearing elements inside Fire Compartment	-	-	-	DP3	DP3	DP2	DP1
9	Stairways, excl. PEW	-	15 DP3	15 DP3	15 DP1	30 DP1	45 DP1	45 DP1
10a	Evacuation and fire elevator shafts and shafts in buildings higher h > 45 m:							
	1. fire separation elements	According to line 1						
	2. fire openings	According to line 2						
10b	Other shafts:							
	1. fire separation elements	30 DP2	30 DP2	30 DP1	30 DP1	45 DP1	60 DP1	90 DP1
	2. fire openings	15 DP2	15 DP2	15 DP1	15 DP1	30 DP1	30 DP1	45 DP1
11	Roof facing	-	-	15	15	30	30 DP1	45 DP1
12	One-storey building:							
	a) fire walls	30 DP1	45 DP1	60 DP1	90 DP1	-	-	-
	b) fire openings	15 DP1	30 DP1	30 DP1	45 DP1	-	-	-
	c) vertical fire barriers in external walls between buildings	15 DP1	30 DP1	30 DP1	45 DP1	-	-	-

REACTION TO FIRE REQUIREMENTS FOR SURFACE TREATMENTS OF BUILDING STRUCTURES

- building exterior: facade systems, roof cladding, requirements especially in CSN 73 0810, specification in CSN 73 0833
- building interior: common requirements in CSN 73 0802 (escape routes, spaces with a larger number of persons, collective garages, etc.), specifying the requirements in CSN 73 0833 (especially for hotels)

Active & Passive	The above-mentioned technical standards / CSN 73 08xx / type: design / define the requirements for equipping the building with active and passive fire protection.

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2.4.4 Hygiene, health and the environment

Country	CZECH REPUBLIC
Category	**Hygiene, health and the environment**
Regulation Original Title	Vyhláška č. 268/2009 Sb. o technických požadavcích na stavby se změnami:20/2012 Sb., 323/2017 Sb.
English translation of title	Decree on technical requirements for constructions
Publication year / amendment year (if any)	2012, 2017 – various amendments are made
Document type & Status	Type: Regulations, codes with legal status Status: Approved and in force
Region of enforcement (If differentiated countrywide)	The regulation is applied countrywide except the locality of Prague, where there is special regulation: Prague building regulations.
Brief summary / content description	• Technical requirements for buildings and building systems • Requirements for building safety • Specific requirements for particular buildings
Scope of: (cases that is applied)	The regulation has a generic application to all type of residential buildings.
Basic requirements for existing residential buildings related with the PLURAL concepts	**Daylight** (§ 11) (1) For newly designed buildings, the lighting design must address daylight, artificial and possible combined lighting in accordance with standard values, and assess them together with heating, cooling, ventilation, noise protection, sun exposure, including the influence of surrounding buildings and the impact of the proposed construction on existing buildings. (2) Living rooms must be provided with daylight in accordance with standard values. **Ventilation** (§ 11) Residential rooms must be provided with sufficient ventilation by outside air. For ventilation of non-residential rooms, a minimum amount of outdoor air 25 m^3/h per person or a minimum ACH of 0.5 1/h must be ensured during the stay of persons. Carbon dioxide CO_2 shall be used as an indicator of the quality of the indoor environment and shall not exceed a concentration of 1500 ppm in the indoor air. According to the standard CSN EN 15665 - Living rooms must be ventilated permanently and exclusively with fresh outside air. - Communication rooms (corridors, anterooms, etc.) may be ventilated by transfer air from the living rooms.

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- Sanitary facilities (toilets, bathrooms) must be maintained at a slight negative pressure in relation to adjacent rooms; ventilation air may be supplied from outside or from adjacent rooms.
- Cloakrooms, pantries and storerooms, which may be a source of odours, are also recommended to be kept at a slight negative pressure.

This will create a clear direction of airflow through the house, which will ensure good air quality in living rooms and prevent the transfer of odours and pollutants from other rooms, especially bathrooms and toilets.

The minimum and recommended values for ventilation are shown in the next table:

TABLE 2.4-4: MINIMUM VENTILATION RATE (CZECH REGULATIONS)

	Permanent ventilation (outside air supply)		Occasional ventilation (exhaust air)		
Requirement	ACH [h^{-1}]	Amount of fresh air per person [m^3/(h.person)]	Kitchen [m^3/h]	Bathroom [m^3/h]	Toilet [m^3/h]
Minimum value	0,3	15	100	50	25
Recommended value	0,5	25	150	90	50

Sunshine (§13)

(1) All flats and their living rooms (that require it by their nature and method of use) must be sunny. At the same time, visual comfort and protection against glare must be ensured, especially in living rooms intended for visually demanding activities.

(2) An apartment is sunny if the sum of the floor areas of its sunny living rooms is equal to at least one third of the sum of the floor areas of all its living rooms. The assessment of sun exposure is based on standard values.

Standard values for daylight and sunshine are defined in ČSN EN 17037 Daylighting in buildings. Based on this standard, the main parameter to be assessed is the following:

Direct sunlight has to fall into the space on the designated day between 1 February and 21 March for the period at least 90 min.

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2.4.5 Protection against noise related regulations

Country	CZECH REPUBLIC
Category	**Protection against noise – acoustics**
Regulation Original Title	Nařízení vlády č.272/2011 Sb. - o ochraně zdraví před nepříznivými účinku hluku a vibrací. Nařízení vlády č. 241/2018 Sb. Kterým se mění NV 272/2011 Sb. - o ochraně zdraví před nepříznivými účinky hluku a vibrací, ve znění nařízení vlády č. 217/2016 Sb.
English translation of title	Government Regulation No. 272/2011 Coll. - on the protection of health against the adverse effects of noise and vibration. Government Regulation No. 241/2018 Coll. Amending NV 272/2011 Coll. - on the protection of health against the adverse effects of noise and vibration, as amended by Government Decree No. 217/2016 Coll.
Publication year / amendment year (if any)	2018
Document type & Status	Type: Regulations, codes with legal status Status: Approved and in force
Region of enforcement (If differentiated countrywide)	The regulation is applied countrywide
Brief summary / content description	This Government Regulation defines hygienic limits for noise (and vibration) in the protected outdoor area of buildings, in the protected outdoor area and in the protected indoor area of buildings.
Scope of: (cases that is applied)	It is used for Residential buildings, surgeries, hospitals, workplaces and schools and functionally similar.
Basic requirements for existing residential buildings related with the PLURAL concepts	Hygienic noise limits for residential building (LAeq,T = equivalent sound pressure level, LAMAX = maximal sound pressure level, night = 22-6, day = 6-22 hours): **Protected indoor spaces** (living room, kitchen, bedroom): **Traffic noise** LAeq,8h = 30 dB / 8 hours of night; LAeq,16h = 40 dB / 16 hours of day **Traffic noise is assessed when providing ventilation or heating a given room.** **HVAC sources** (**ventilation**, **heating**, it could be applied also for cooling, but it is not standard equipment for a residential building in Czech Republic) LAMAX = 30 dB / night; LAMAX = 40 dB / day If the spectrum of the sound source includes a tonal component the correction –5 dB must be applied for the limit... LAMAX = 25 dB / night; LAMAX = 35 dB / day Comfortable sound pressure level in the room from steady sources such as ventilation is LAeq,8h = 22 dB / 8 hours of night with LAMAX ≤ 25 dB with uncertainty of the calculation or measurement.

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2.4.6 Energy performance of buildings regulation

Country	CZECH REPUBLIC
Category	**Energy performance, energy economy (1)**
Regulation Original Title	Zákon č. 406/2000 Sb. Zákon o hospodaření energií
English translation of title	Law of energy management
Publication year / amendment year (if any)	2000 – various amendments are made
Document type & Status	Type: Regulations with legal status Status: Approved and in force
Region of enforcement (If differentiated countrywide)	The regulation is applied countrywide
Brief summary / content description	(a) certain measures to improve the efficiency of energy use and the obligations of natural and legal persons in the management of energy, (b) rules for the development of the State Energy Concept, the Territorial Energy Concept and the State Programme for the Promotion of Energy Saving, (c) the requirements for the ecodesign of products related to energy consumption, (d) requirements for the indication of energy consumption and other main resources on energy labels of energy-related products, (e) requirements for information and education on energy saving and the use of renewable and secondary sources, (f) certain rules for the provision of energy services.
Scope of: (cases that is applied)	General law for most cases in energy use context
Basic requirements for existing residential buildings related with the PLURAL concepts	New buildings must simultaneously meet the requirements for three EN indicators. These are to meet the indicator: • non-renewable primary energy per year Q_{nPE}, • total energy delivered per year Q_{fuel}, • the average heat transfer coefficient of the building envelope U_{em} For renovated buildings, or for major alterations to a completed building and for non-major alterations to a completed building, there is a choice of a combination of indicators to be met. The energy performance requirements for major alteration of a completed building and for a non-major alteration of a completed building, determined by calculation at the cost-optimal level, are met if: • the values of the energy performance indicators U_{em} and Q_{fuel} of the building under assessment are not higher than the reference values of these energy performance indicators for the reference building,

	• the values of the energy performance indicators U_{em} and Q_{nPE} of the building under assessment are not higher than the reference values of these energy performance indicators for the reference building, or • the value of the heat transfer coefficient U for all new and modified building envelope elements is not higher than the reference value of this energy performance indicator, which is set at the level of recommended values according to ČSN 730540-2:2011 (national technical standard for thermal-technical requirements of buildings). • the value of the energy performance indicator of the assessed building for all the changed technical systems of the building listed is not lower than the reference value of this energy performance indicator listed in Table 3 of Annex 1 to Decree 264/2020 Coll.
Definition of nZEB	From 1 January 2020, all new buildings must meet a standard called "Nearly Zero Energy Building (NZEB)". The general definition of a nearly zero energy building is set out in Act 406/2000 Coll., as amended: a building with very low energy performance whose energy consumption should be largely covered by renewable energy sources. The technical parametric requirements are then specified in Decree 264/2020 Coll. The parametric definition is detailed for the individual case studies of apartment and family houses.

Country	**CZECH REPUBLIC**
Category	**Energy performance, energy economy (2)**
Regulation Original Title	Vyhláška č. 264/2020 Sb. Vyhláška o energetické náročnosti budov
English translation of title	Decree on the energy performance of buildings
Publication year / amendment year (if any)	2020
Document type & Status	Type: Regulations, codes with legal status Status: Approved and in force
Region of enforcement (If differentiated countrywide)	The regulation is applied countrywide
Brief summary / content description	Definition of nZEB under conditions of Czech Republic.
Scope of: (cases that is applied)	Building energy performance indicators and their determination Calculation of primary energy from non-renewable energy sources Calculation of delivered energy Building energy performance requirements set at the cost-optimal level

Basic requirements for existing residential buildings related with the PLURAL concepts	**Defines parameters for evaluation of nZEB for renovated buildings**. This new version reflects the new directive EPBD III. It presents that meeting the main criterion of the amount of non-renewable primary energy will depend on the simple shape of the building (lowest A/V ratio), on the use of renewable energies, on the orientation of the building towards the cardinal points and on the thermal engineering properties of the building envelope and the designed technical systems. Strong emphasis is made for application of RES and ventilation with heat recovery (especially for residential buildings). Given the verbal definition of a nearly zero energy building in Act 406/2000, a building that is expected to be outside the current standard of construction. The parametric form of this standard is regulated by Decree 264/2020 Coll. The qualitative assessment of the energy performance of a building in relation to the specified energy performance indicators of the building is in principle determined by: ▪ the level of qualitative design of the building envelope, which directly influences the energy performance indicator average heat transfer coefficient U_{em}, ▪ the technical systems used for heating, cooling, ventilation, humidification, hot water and lighting, which directly affect the energy performance indicator total energy delivered Q_{fuel} ▪ the type of energy carriers consumed in the building, or the energy production within the system boundary of the building, which directly affect the energy performance indicator non-renewable primary energy Q_{nPE}. These criteria also predetermine the requirements for NZEBs. Simply put, an NZEB is a building that has qualitatively more stringent requirements for the building envelope, the technical systems cover the energy demand with high efficiency and the building uses energy carriers with a higher share of renewable primary energy or produces energy (electricity, heat). A nearly zero energy building must then meet the requirement of a 25% reduction in non-renewable primary energy for single-family houses, 20% for apartment buildings and 10% for other buildings. At the same time, the requirement for the average building envelope heat transfer coefficient Uem is also modified through the reference building requirement. The requirement is set to $0,7*U_{em,R}$, where the $U_{em,R}$ value is determined from the required values of the national standard ČSN 730540-2:2011. In other words, the overall quality of the building envelope shall be 30% better than the standard requirement for the building structure.

Country	**CZECH REPUBLIC**
Category	**Energy performance, energy economy (3)**

Regulation Original Title	ČSN 73 0540 (73 0540) Tepelná ochrana budov, části 1 až 4
English translation of title	Thermal protection of buildings, parts 1-4
Publication year / amendment year (if any)	2005 - 2011
Document type & Status	National standard with legal status Status: Approved and in force
Region of enforcement (If differentiated countrywide)	The regulation is applied countrywide
Brief summary / content description	This standard specifies the thermal technical requirements for the design and verification of buildings with the required state of the indoor environment during their use. The provisions of the standard shall be used as far as possible to avoid failures and defects in the use of these buildings.
Scope of: (cases that is applied)	Terminology, requirements, design values and calculation methods for heat and moisture transfer through building structures. Summer thermal stability (non air-conditioned rooms)
Basic requirements for existing residential buildings related with the PLURAL concepts	Heat transfer coefficients defined by CSN 73 0540-2:2011 (selected values) – U (W/(m^{2}K))

TABLE 2.4-5: HEAT TRANSFER COEFFICIENTS DEFINED BY CSN 73 0540-2:2011 (SELECTED VALUES) – U (W/(M^{2}K)) (CZECH ENERGY PERFORMANCE REGULATIONS)

	Required	Recommended	Recommended for passive buildings
Outside wall	0.3	0.2 lightweight 0.25 heavyweight	0.12 to 0.18
Roof (over 45°)	0.3	0.2	0.12 to 0.18
Roof (up to 45°)	0.24	0.16	0.1 to 0.15
Floor on terrain	0.45	0.3	0.15 to 0.22
Window	1.5	1.2	0.6 to 0.8
Door	1.7	1.2	0.9

2.4.7 RES in buildings legal framework

Country	**CZECH REPUBLIC**
Category	**Reneable energy sources legal framework**
Regulation Original Title	Vyhláška č. 16/2016 Sb. - Vyhláška o podmínkách připojení k elektrizační soustavě
English translation of title	Decree No. 16/2016 Coll. - Decree on the conditions of connection to the electricity system
Publication year / amendment year (if any)	2016

Document type* & Status**	Type: Regulations, codes with legal status Status: Approved and in force
Region of enforcement (If differentiated countrywide)	The regulation is applied countrywide
Brief summary / content description	This decree stipulates a) conditions for connection of electricity generation, distribution systems and customer offtake points to the electricity system, (b) the method of determining the proportion of costs associated with the connection and provision of the required power input or output; and (c) rules for the assessment of concurrent connection requirements.
Scope of: (cases that is applied)	The regulation has a generic application to all type of buildings and infrastructure that use micro source, like photovoltaic.
Basic requirements for existing residential buildings related with the PLURAL concepts	For the purposes of this Decree, **micro-source** is a source of electrical energy and all related equipment for electricity generation, intended for parallel operation with a low-voltage distribution system with a nominal alternating phase current of up to 16 A per phase inclusive and a total maximum installed power of up to and including **10 kW**. §16 Conditions for simplified connection of a micro source to the distribution system (1) A simplified connection can be used to connect a micro source to a low voltage level. (2) The conditions for the connection of the applicant's micro-source to the distribution system are a) the measured value of the impedance at the point of connection to the distribution system, which is not greater than the value of the limit impedance according to point (3), b) a technical solution of the micro-source which prevents the supply of electricity to the distribution system at the connection point, except for short-term overflows of electricity to the distribution system, which serves for the response of the limiting device but which does not increase the voltage at the connection point, c) the submission of a connection agreement or for the amendment of an existing connection agreement ; and d) the conclusion of a connection contract between the applicant for the connection of the micro-source and the distribution system operator or the amendment of the existing connection contract, whereby the reserved power is equal to zero. (3) The applicant shall ensure the measurement of the impedance of the current loop at the point of connection to the distribution system according to the Czech technical standard by a person with professional competence. The value of the limit impedance is 0.47 Ω for sources up to 16 A and 0.75 Ω for sources up to 10 A. If the measured value of impedance is higher or equal to the value of the limit impedance, the applicant cannot connect the micro source at the point of connection under simplified connection.

2.5 Germany

2.5.1 General building constructions and urban planning related regulations

Country	GERMANY
Category	**Urban Planning regulations**
Regulation Original Title	Bauordnung für Berlin, Baugesetz
English translation of title	Building regulations Berlin, Building Code
Publication year / amendment year (if any)	2005 – various amendments are made
Document type & Status	Type: Regulations, codes with legal status Status: Approved and in force
Region of enforcement (If differentiated countrywide)	Berlin
Brief summary / content description	
Scope of: (cases that is applied)	The regulation is applied to all urban and non-urban areas for new and existing buildings and infrastructure.
Basic requirements for existing residential buildings related with the PLURAL concepts	Any change to structural facilities generally requires a building permit. For smaller redevelopment measures that are within the framework of the development plan and do not significantly change the appearance, there is the possibility of a permit exemption. Daylight regulations: the windows must have a rough dimension of the window openings of at least one eighth of the net floor area of the room (12.5%)

2.5.2 Fire safety regulations

Country	GERMANY
Category	**Safety in case of fire in buildings**
Original Title	Bauordnung für Berlin
English translation of title	Building regulations for Berlin
Publication year / amendment year (if any)	2005 - various amendments are made
Document type & Status	Type: Regulations, codes with legal status Status: Approved and in force

Region of enforcement (If differentiated countrywide)	Berlin
Brief summary / content description	The regulation defines measures and requirements that should be taken in buildings in order to protect the life and health of building users in case of fire, to prevent the spread of fire from one space to other spaces of the same building or other buildings and regions and to protect the buildings themselves and their content. Primary target is the human safety in case of fire by appropriate building design, equipment and material selection and by installing appropriate active fire protection systems. More specifically in the regulation are defined: - the measures that protect a building for collapsing at least for as long as it takes for its evacuation, - the minimum requirements regarding the design of the escape routes for fast and safe evacuation of the users protecting them from smoke, heat and other toxic substances, - the maximum allowed sizes for fire compartmentation, - the measures to prevent the spread of fire to adjacent buildings, - the requirements of the materials used depending on their location in the building - and the active measures and fire safety systems that detect fire in time, suppress it and provide enough time for safe evacuation.
Scope of: (cases that is applied) New & Existing Buildings	New & existing buildings
Basic requirements for residential buildings	<u>Materials:</u> You are only allowed to use Materials that are at least normally inflammable (normalentflammbar) (category B2). Depending on the building class, the construction must meet requirements for fire resistance class. In our demo case we have building class 1a – so we only have requirements for the basement ceiling, which must be fire-retardant (F30). Fire-retardant components may consist of combustible materials. <u>External Walls:</u> The spread of fire on and in these components must be limited for a sufficiently long period of time. There are no further requirements in GK1 and GK2. From extra Comments: Not-load bearing externals walls must not consist of combustible materials - unless they are fire-retardant (F30). This is invalid for building classes 1-3 (buldings untill a height of 7m) So therefore you can only use materials which are „nicht brennbar“ (A1/A2 in DIN 4102 ans A1/A2-s1,00 in DIN EN 13501) Windows, which are used as an escape route, need a clear opening of 0.9m width and 1.2m height. The bottom of the window must not be higher than 1.2m from the ground.

TABLE 2.5-1: MINIMUM FIRE RESISTANCE OF RESIDENTIAL BUILDINGS (BERLIN FIRE SAFETY REGULATION)

<table>
<tr><td></td><td>
<table>
<tr><td></td><td colspan="5">Minimum fire resistance in minutes</td></tr>
<tr><td></td><td colspan="2">Underground floors</td><td colspan="3">Above the ground floors</td></tr>
<tr><td></td><td>Height<7m</td><td>Height>7m</td><td>Height<7m</td><td>Height<13m</td><td>7 to 10 floors and < 22m, >27</td></tr>
<tr><td>Residential</td><td>30</td><td>90</td><td>30</td><td>60</td><td>90</td></tr>
</table>

<u>Escape Routes:</u>
At least two independent escape routes for each floor, which may lead via the same necessary corridor. In higher floors the first escape route leads trough a necessary staircase. The second escape route may lead through a second necessary staircase or another accessible location in the unit of use.
The maximum distance to a necessary staircase or to the open air must not be longer than 35m.

<u>Active fire safety measures:</u> In apartments, common rooms must each have at least one smoke alarm. The smoke alarms must be installed or mounted and operated in such a way that fire smoke is detected and reported at an early stage.
</td></tr>
<tr><td>Active & Passive</td><td>The regulation deals with both passive and active fire safety measures.</td></tr>
</table>

2.5.3 Protection against noise related regulations

Country	GERMANY
Category	**Protection against noise – acoustics**
Original Title	DIN 4109 Schallschutz im Hochbau
English translation of title	Sound insulation in building construction
Publication year / amendment year (if any)	2016
Document type & Status	Type: professional standard Status: Approved and in force
Brief summary / content description	This standard specifies requirements for the sound insulation of building components of rooms requiring protection and for the permissible sound levels in rooms requiring protection in residential and non-residential buildings to achieve the described sound insulation objectives. The requirements of this standard apply to the protection against noise from other rooms (e.g. neighbouring dwellings), which arises during their intended use, against noise from technical building equipment systems as well as from commercial and industrial operations present in the same building or in buildings structurally connected to it, against external noise, e.g. traffic noise and noise from commercial and industrial operations that are not structurally connected to the rooms requiring protection and form the basis for required building constructions for new buildings as

<table>
<tr><td></td><td>well as for structural changes to existing buildings.</td></tr>
<tr><td>Scope of: (cases that is applied)</td><td>Protection requiring rooms in residential and non-residential buildings</td></tr>
<tr><td>Basic requirements for residential buildings</td><td>
Requirements for insulation in multi-family blocks (indoor components):

TABLE 2.5-2: R'_W & $L'_{N,W}$ VALUE REQUIREMENTS FOR BUILDING ELEMENTS (GERMAN ACOUSTICS STANDARD)
<table>
<tr><th>Component</th><th>Requirement R'_W</th><th>Requirement $L'_{n,W}$</th></tr>
<tr><td>ceilings</td><td>≥ 53</td><td>≤ 50</td></tr>
<tr><td>balconies</td><td>-</td><td>≤ 58</td></tr>
<tr><td>stair platform</td><td>-</td><td>≤ 53</td></tr>
<tr><td>walls between apartments</td><td>≥ 53</td><td>-</td></tr>
<tr><td>shaft wall</td><td>≥ 57</td><td></td></tr>
</table>

The requirements for external components depend on the external noise level and the type of room. For living rooms, the required sound insulation value is between 25 and 50 dB (the higher the external noise level, the higher the required value)

Parameters: R_w, R'_w, $L'_{n,w}$ $L_{Aeg,h}$ L_{pA} are defined in the following table

TABLE 2.5-3: ACOUSTIC COMFORT PARAMETERS REQUIREMENTS (GERMAN ACOUSTICS STANDARD)
<table>
<tr><th rowspan="2">Type of noise</th><th colspan="3">Parameter of acoustic comfort</th><th colspan="3">Measured quantity</th></tr>
<tr><th>Name</th><th>Symbol</th><th>Unit</th><th>Name</th><th>Symbol</th><th>Unit</th></tr>
<tr><td rowspan="2">Protection from airborne noise</td><td>Weighted Sound Reduction Index</td><td>R_w</td><td>dB</td><td>Sound Reduction Index</td><td>R</td><td>dB</td></tr>
<tr><td>Weighted apparent Sound Reduction Index</td><td>R_w</td><td>dB</td><td>Apparent Sound Reduction Index</td><td>R’</td><td>dB</td></tr>
<tr><td>Protection from impact noise</td><td>weighted, standardised impact sound pressure level</td><td>$L'_{n,w}$</td><td>dB</td><td>standardised impact sound pressure level</td><td>L'_n</td><td>dB</td></tr>
<tr><td>Protection from airborne noise – external sources</td><td>Soundlevel - A</td><td>$L_{Aeg,h}$</td><td>dB (A)</td><td>Soundlevel - A</td><td>L_{pA}</td><td>dB (A)</td></tr>
<tr><td>Protection from airborne noise – from facilities</td><td>Soundlevel - A</td><td>L_{pA}</td><td>dB (A)</td><td>Soundlevel - A</td><td>L_{pA}</td><td>dB (A)</td></tr>
</table>
</td></tr>
</table>

2.5.4 Energy performance of buildings regulation

Country	GERMANY
Category	**Energy performance of buildings & renewable energy**
Original Title	Gebäudeenergiegesetz (GEG)
English translation of title	Building Energy Act
Publication year / amendment year (if any)	2020
Document type & Status	Type: Regulations, codes with legal status Status: Aproved and in force
Region of enforcement (If differentiated countrywide)	The regulation is applied countrywide
Brief summary / content description	The Building Energy Act contains requirements for the energy quality of buildings, the preparation and use of energy certificates, and the use of renewable energies in buildings. It is a uniform, coordinated set of regulations for the energy requirements for new buildings, for existing buildings and for the use of renewable energies to supply heating and cooling to buildings. It also includes regulations for ultra-low-energy buildings.
Scope of: (cases that is applied)	New & existing buildings which are heated or cooled
Basic requirements for residential buildings	New buildings must be constructed as ultra-low energy buildings. The energy demand and energy losses must not exceed the maximum permissible values and part of the heating and cooling, energy demand must be covered by renewable energies. The building components must meet the minimum thermal insulation requirements and the influence of thermal bridges must be minimised. In addition, the enveloping surface must be permanently impermeable to air and the solar gain must be reduced in terms of summer heat protection. The limit values to be complied with are regulated in DIN standard 4108. The permissible primary energy demand is determined using a reference building with the same geometry, floor space and orientation. The primary energy demand must not be greater than 75% of the reference building, to be established on the basis of the design. The transmission heat loss must not be greater than that of the reference building. The following U-values are used for the reference building:

TABLE 2.5-4: MAX U-VALUES OF BUILDING ELEMENTS (GERMAN BUILDING ENERGY ACT)

Building element	Max U – Value [W/m^{2}K]
External horizontal or inclined roof	0.2
External wall	0.28
Wall adjacent to unheated space or ground	0.35

<table>
<tr>
<td></td>
<td>
<table>
<tr><td>External floor</td><td>0.35</td></tr>
<tr><td>Floor adjacent to unheated space or ground</td><td>0.35</td></tr>
<tr><td>External openings (windows/doors)</td><td>1.3 (1.8 for doors)</td></tr>
<tr><td>Openings adjacent to unheated space or ground</td><td>1.8</td></tr>
</table>

Maximum values of the heat transfer coefficients
of external building elements in the case of alterations to existing buildings
<table>
<tr><th>Building element</th><th>Max U – Value [W/m^{2}K]</th></tr>
<tr><td>External wall (attaching claddings)</td><td>0.24</td></tr>
<tr><td>External openings (windows/doors)</td><td>1.3</td></tr>
</table>

To meet the requirements for the use of renewable energy, various measures can be combined. In total, a degree of fulfilment of 100% must be achieved (e.g. one measure 100% fulfilled or 2 measures at 50% each etc.)
One measure involves covering 15% of the heating and cooling energy demand from solar thermal systems, and another involves covering 15% of the energy demand from electricity generated from renewable energy sources. Other measures concern the use of biomass, geothermal energy, waste heat, district heating or combined heat and power.
Self-generated electricity from renewable energy sources may be deducted from the primary energy demand if it is primarily intended for own use (maximum 30% or 45% with electrochemical storage).

Building (technical) systems:
Changes to the building technology must not worsen the energy quality of the building.
There are also Requirements for thermal insulation of pipelines and fittings, depending on their diameter 6-100mm
</td>
</tr>
<tr><td>New buildings vs Retrofit existing buildings</td><td>Existing residential buildings may exceed the primary energy barf and the transmission heat loss of the reference building by 40%.</td></tr>
<tr><td>nZEB definition and requirements
(if available)</td><td>Energy efficiency class A+ can be achieved by a final energy demand of less than 30 kWh/m2a</td></tr>
</table>

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958218

2.5.5 RES in buildings legal framework

The legal framework for RES installations in buildings and more specifically for PV systems is included in the Renewable Energy Act (EEG), started in 2000 and last amended in December 2020. It allows both the connection of autonomous with storage and grid connected methods. A grid connected PV system may also have storage. From an output of 10 kW, a control option is required that enables both the measurement of the electricity fed into the grid and the regulation of the feed-in so as not to overload the grid. Self-consumption of the energy is allowed while at the same time surplus is sold to the grid. Feed in tariff however is being decreased due to the increase of the PV systems so the storage becomes more and more attractive.

2.6 Switzerland

Switzerland does not belong to the EU and has no obligation of following EU regulations and standards. However, the country has its own national regulation framework and respective building and technical codes.

2.6.1 General building constructions and urban planning related regulations

Country	SWITZERLAND
Category	Construction regulation
Original Title	Baugesetzt (BauG), Bauordnung der Stadt Bern (BO)
English translation of title	CONSTRUCTION LAW (BauG)
Publication year / amendment year (if any)	(BauG): From June 9, 1985 (Current for the January 1, 2021) (SG): From June 4, 2017 (Current for the January 1, 2021)
Region of enforcement (If differentiated countrywide)	In Switzerland, each canton has its own construction laws that relate to municipal laws.In this case we are referring to the laws of the canton and the municipality of Bern. (Bau G end BO)
Document type & Status	Type: Swiss federal law and ordinance Status: Approved and in force
Brief summary / content description	The regulation is applied to all urban and non-urban areas for new and existing buildings and infrastructure.
Scope of: (cases that is applied)	This Act applies to all planning activities that require a building permit and to all activities that do not require a building permit and that have an impact on the land use and are not conclusively regulated by other legislation.
Basic requirements for existing residential buildings	A building permit is required for all man-made and permanent structures, installations and facilities (building projects) that have a fixed relationship to the ground and are capable of influencing the land use regulations, for example by significantly altering the appearance of the area, burdening the development or affecting the environment. The change of purpose and the demolition of buildings, installations and facilities as well as significant changes to the terrain also require a building permit. Construction projects requiring a building permit may not be commenced until the building permit and the necessary further permits or the overall permit have been granted with legal effect. The provisions on precautionary measures, in particular the early start of construction, remain reserved.
Site and landscape protection, preservation of historical monuments	Historical monuments are outstanding objects and ensembles of cultural, historical or aesthetic value. These include in particular sites, groups of buildings, buildings, gardens, facilities, internal components, spatial structures and fixed furnishings. Architectural monuments are worthy of protection if they are to be preserved undiminished because of their significant architectural quality or distinctive characteristics.

	Monuments worthy of protection may not be demolished as a matter of principle. Interior components, spatial structures and fixed furnishings must be preserved in accordance with their significance, insofar as this is necessary for the purpose of protection and is reasonable for the owner. Buildings, installations, advertisements, signs and paintings must not interfere with landscapes, townscape and streetscape. In order to prevent disturbing building design (disturbing choice of colors or materials, non-local building or roof form and the like), conditions and requirements may be imposed or project changes may be demanded in the building permit procedure. It is the municipalities that regulate the appearance of the building, which can vary from area to area.
Building distances	Construction projects may not cross national, cantonal or municipal boundaries. The regulations of the municipalities are authoritative for the border and building distances to be maintained from neighbouring properties and from other buildings and facilities. The tables with the distances to be respected for each category of building are contained in the regulations of the municipalities (e.g. Bau ordnung der Stadt Bern).

2.6.2 Mechanical resistance, stability and seismic behaviour related regulations

Country	**Switzerland**
Category	**Mechanical resistance, stability and seismic behaviour**
Regulation Original Title	SIA 269/8 ERHALTUNG VON TRAGWERKEN-ERDBEBEN
English translation of title	SIA 269/8 EXISTING STRUCTURES-ERTHQUAKES
Publication year / amendment year (if any)	2017
Document type & Status	Type: SIA Norms (Swiss Society of Engineers and Architects) Status: Approved and in force
Region of enforcement (If differentiated countrywide)	The regulation is applied countrywide
Brief summary / content description	This norm SIA 269/8 provides information and procedures for the verification of existing structures with regard to earthquakes and is addressed to experts in the maintenance of structures as well as to owners of structures. The norm SIA 269/8 is part of the SIA norms in the field of the preservation of structures and is supplemented by the following norms: - SIA 269 Fundamentals of the preservation of structures. - SIA 269/1 Maintenance of structures - actions - SIA 269/2 Maintenance of structures - concrete structures

	- SIA 269/3 Maintenance of structures - steel structures - SIA 269/4 Maintenance of structures - steel-concrete composite structures - SIA 269/5 Maintenance of structures - timber construction - SIA 269/6-1 Preservation of structures - masonry, part 1: natural stone masonry - SIA 269/6-2 Preservation of structures - masonry construction, part 2: masonry made of artificial stones - SIA 269/7 Preservation of structures - Geotechnics.
Scope of: (cases that is applied)	The regulation is applied only for existing buildings and infrastructure.
Basic requirements for existing residential buildings related with the PLURAL concepts	When inspecting existing structures, it may be necessary to record the earthquake behavior more realistically than for new buildings, where simplifying assumptions are often sufficient. The regulation does not include any major point concerning the installation of prefabricated walls / facades. The norm only considers parts of the existing building.

2.6.3 Fire safety regulations

Country	Switzerland
Category	Safety in case of fire in buildings
Original Title	Brandschutzvorschriften VKF
English translation of title	FIRE SAFETY REGULATION
Publication year / amendment year (if any)	2015
Document type & Status	The fire safety regulations consist of: a) the fire protection norm b) the fire safety regulations c) fire protection work aid All norms are published on the following site and are open source: https://www.vkg.ch/ Approved and in force
Region of enforcement (If differentiated countrywide)	The regulation is applied countrywide
Brief summary / content description	The purpose of the fire protection regulations is to protect persons, animals and property from the hazards and effects of fires and explosions. They regulate the legal obligations required for this objective. The regulation defines all the measures and requirements that should be taken in buildings in order to protect the life and health of building users in case of fire, to prevent the spread of fire from one space to other spaces of the same building or other buildings and regions and to protect the buildings themselves and their content. Primary target is the human safety in case of fire by appropriate building design, equipment and material selection and by installing appropriate active fire

<table>
<tr><td></td><td>protection systems. More specifically in the regulation are defined:
○ Correct use of construction materials
○ Safety distances to protect adjacent buildings
○ Supporting structures and fire protection sections
○ Escape routes
○ Technical fire protection
○ Building technical system
○ Special requirement for special rooms and use

Fire regulations in Switzerland are very detailed and must be interpreted with the help of an expert. Each project is supervised by a fire protection expert.</td></tr>
<tr><td>Scope of: (cases that is applied)
New & Existing Buildings</td><td>Fire protection requirements apply to all new buildings and installations.
Existing buildings and facilities must be adapted in accordance with fire safety requirements if:
a) major structural or operational changes are made, extensions are added or the designated use is changed
b) there is a significant danger, especially to persons. (Determined by a fire protection specialist)</td></tr>
<tr><td>Basic requirements for residential buildings</td><td>Escape routes: The escape routes of a building strongly depend on the architectural design and in existing building they are very difficult to be changed.
Escape routes have to be marked with emergency lights if the building is above 30 m.
Fire extinguishing devices
At the request of the fire protection authorities, residential buildings are to be equipped with sufficiently large fire extinguishing equipment suitable for fire fighting (e.g. fixed fire extinguishing stations, portable fire extinguishers).
Structural Fire safety: Structural elements (Load bearing) protected escape routes (Horizontal escape routes), staircases (Vertical escape routes) and fire compartments of a building should fulfill the fire resistance rating in minutes and category (load bearing capacity, integrity and heat insulation).
For residential buildings the minimum requirements are presented below:

TABLE 2.6-1: MINIMUM REQUIREMENTS OF FIRE RESISTANCE RATING FOR RESIDENTIAL BUILDINGS (SWISS FIRE SAFETY REGULATION)
<table><tr><td>MFB Building height category</td><td>Concept</td><td>Supporting structure</td><td>Floor ceilings forming fire cut-offs</td><td>Fire cut-off walls and horizontal escape routes</td><td>Escape route vertical</td></tr><tr><td rowspan="2">Building lower height (<11 m))</td><td>Structural [2]</td><td>R 30 [2]</td><td>REI 30</td><td>EI 30</td><td>REI 30</td></tr><tr><td>Extinguishing system</td><td>N.R</td><td>EI 30</td><td>EI30</td><td>REI 30</td></tr><tr><td rowspan="2">Building middle height (Until 30 m)</td><td>Structural</td><td>R 60</td><td>REI 60</td><td>EI 30</td><td>REI 60</td></tr><tr><td>Extinguishing system</td><td>R 30</td><td>REI 30</td><td>EI 30</td><td>REI 60</td></tr></table>R – load bearing capacity, E – integrity and I – heat insulation

N.R There are no requirements for the fire resistance of load-bearing components.
[1] In the case of single-storey buildings and on the top floor of multi-storey buildings,</td></tr>
</table>

no requirements are imposed on the fire resistance of load-bearing components.
[2] In the case of two-storey buildings with a total floor area above ground level not exceeding 2,400 m^2 , the following applies
- the fire resistance can be reduced by 30 minutes. For floor slabs with fire resistance REI 30, the fire resistance can only be reduced to EI 30.
[3] In the case of two-storey buildings with a total height of more than 11 m and a first floor height of no more than 8 m, the requirements for low-rise buildings apply to the load-bearing components and those forming fire compartments.

High risk spaces: Firing aggregates shall be installed in separate heating rooms. For nominal heat output up to 70 kW, heating rooms shall be designed with the same fire resistance as the use-related fire compartmentation, but at least with fire resistance EI 30, for nominal heat output above 70 kW at least with fire resistance EI 60. Doors shall be designed with fire resistance EI 30 and shall be hinged to open in the direction of escape for nominal heat output over 70 kW.

Building Materials: The building materials are classified by standardized tests or other VKF approved procedures on the basis of fire and smoke behavior, dripping while burning and corrosivity. Due to their fire behavior, they are classified into one of the following categories [abbr. = RF (from French reaction au feu)]:
• RF1 (no fire contribution)
• RF2 (low fire contribution)
• RF3 (permitted fire contribution)
• RF4 (improper fire contribution)
Building materials whose smoke development and/or dripping while burning and/or corrosiveness in the event of a fire can lead to unacceptable fire effects are referred to as critical building materials [abbr. = cr (from French comportement critique)].

Spread of fire outside the building: The distances are to be measured between the facades. If roof projections or structural elements project more than 1 m, the distance shall be increased by the dimension exceeding 1 m.

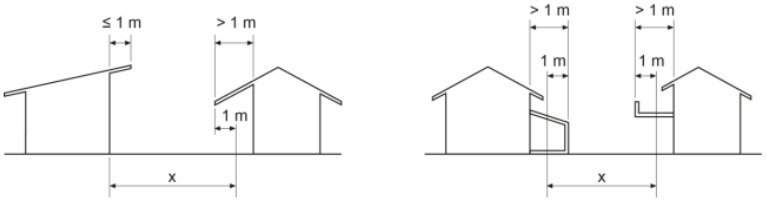

FIGURE 2.6-1: MINIMUM DISTANCE BETWEEN BUILDINGS (SWISS FIRE SAFETY REGULATION)
Source: https://services.vkg.ch/rest/public/georg/bs/publikation/documents/BSPUB-1394520214-81.pdf/content#page=5
The following fire protection distances between neighboring buildings and facilities must be maintained:
a) 5 m, if the outermost layer of both exterior wall constructions consists of building materials RF1.
b) 7.5 m, if the outermost layer of one of the two exterior wall constructions consists of combustible building materials.
c) 10 m, if the outermost layer of both external wall constructions consists of combustible building materials.

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2.6.4 Protection against noise related regulations

Country	Switzerland
Category	Protection against noise – acoustics
Original Title	SIA 181 Schallschutz im Hochbau
English translation of title	SIA 181 PROTECTION AGAINST NOISE IN BUILDING CONSTRUCTION
Publication year / amendment year (if any)	2006
Document type & Status	Type: SIA Norms (Swiss Society of Engineers and Architects) Status: Approved and in force
Brief summary / content description	The SIA 181 standard applies to structural protection against external and internal noise sources as well as structure-borne noise radiated by external and internal sources, in relation to units of use in new buildings and renovations for external building components, partitioning components, staircases, building services equipment and fixed installations in the building. This also applies to renovations and changes of use relevant to building acoustics. Questions of the proportionality of building acoustical requirements for renovations (statics, preservation of historical monuments, technical and operational feasibility and economic viability) are to be settled on a case-by-case basis between the parties involved and, if necessary, with the enforcement authorities.
Scope of: (cases that is applied)	The norm defines the requirements for sound protection in rooms and groups of rooms in which people live and work or spend a long time. It does not apply to specially used rooms such as concert halls, sound and audio studios, etc.
Basic requirements for residential buildings	The Norm defines the calculation methods and limit values to be met for the following noise sources: External sources (Airborne sound and Structure-borne sound) Internal sources (Airborne sound and Impact sound) For each noise source, the measurement methodology is also presented in order to control the quality of the building. The sensitivity level of the various rooms is defined according to the following table.

TABLE 2.6-2: SENSITIVITY LEVEL OF THE VARIOUS ROOMS (PROTECTION AGAINST NOISE – SWISS NORM)

Noise sensitivity	*Description of the type of room and room use on the emission side*
low	*Rooms for predominantly manual activity; rooms which are used by many people or only for a short time.* *Examples: Workshop, manual work room, reception room, waiting room, open-plan office.* *(excluding later subdivision into several units or individual offices), canteen, restaurant, kitchen without schedule planned residential use, bathroom, WC, sales room, laboratory, corridor.*
medium	*Rooms for living, sleeping and for intellectual work.* *Examples: Living room, bedroom, studio, school room, music practice room, kitchen, office room, hotel room, hospital room without a special rest room function.*
high	*Rooms for users with a particularly high need for rest.*

	Examples: special rest rooms in hospitals and sanatoriums, special therapy rooms with a high therapy rooms with high rest requirements, reading and study rooms.

Evaluation parameters: D_e,L_r, D_i L', L_H are defined in the following table and the

TABLE 2.6-3: EVALUATION PARAMETERS: DE,LR, DI L', LH (PROTECTION AGAINST NOISE – SWISS NORM)

Type of noise		*Evaluation parameter*	*symbol*	*Unit*
External sources	*Airborne sound*	*Requirement value*	D_e	*dB*
External sources	*Airborne sound*	*Measure for the evaluation of the outdoor noise emission according to the Federal Noise Abatement Ordinance (LSV).*	L_r	*dB*
External sources		*Requirement value for noise from building services equipment and fixed installations in the building*	L_H	*dB*
Internal sources	*Airborne sound*	*Requirement value*	D_i	*dB*
Internal sources	*Impact sound*	*Requirement value*	*L'*	*dB*

In the following tables are defined the limit values to be respected

TABLE 2.6-4: PROTECTION AGAINST AIRBORNE SOUND FROM OUTSIDE L', LH (PROTECTION AGAINST NOISE – SWISS NORM)

Noise pollution	*small*		*moderate to very strong*	
Location of the reception site	*away from the traffic carriers no disturbing activities*		*in the vicinity of traffic carriers or disruptive activities*	
Evaluation period	*Day*	*Night*	*Day*	*Night*
Rating level dB(A)	$L_r \geq 64$	$L_r \leq 56$	$L_r > 64$	$L_r > 56$
Noise sensitivity	*Requirement values* D_e			
low	*26 dB*	*26 dB*	$L_r - 38$ *dB*	$L_r - 30$ *dB*
medium	*31 dB*	*31 dB*	$L_r - 33$ *dB*	$L_r - 25$ *dB*
high	*36 dB*	*36 dB*	$L_r - 28$*dB*	$L_r - 20$ *dB*

TABLE 2.6-5: MINIMUM REQUIREMENTS FOR PROTECTION AGAINST AIRBORNE SOUND FROM THE INSIDE (PROTECTION AGAINST NOISE – SWISS NORM)

Noise pollution	*small*	*moderate*	*high*	*very high*
Examples of room type and use on the emission side (transmitter room)	*Low-noise use: reading room, waiting room, patient sanitary room, archive*	*Normal use: living room, bedroom, kitchen, bathroom, toilet, corridor, elevator shaft, staircase, office room, conference room, laboratory, sales room without sound system.*	*Loud use: hobby room, meeting room, school room, kindergarten, heating, garage, machine room, restaurant without sound system, sales room with sound system and associated access rooms.*	*Noise intensive use: commercial enterprise, workshop, music practice room, gymnasium, restaurant with sound system and associated access rooms.*
Noise sensitivity	*Requirement value* D_i			

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low	*42 dB*	*47 dB*	*52 dB*	*57 dB*
medium	*47 dB*	*52 dB*	*57 dB*	*62 dB*
high	*52 dB*	*57 dB*	*62 dB*	*67 dB*

TABLE 2.6-6: MINIMUM REQUIREMENTS FOR PROTECTION AGAINST IMPACT SOUND (PROTECTION AGAINST NOISE – SWISS NORM)

Noise pollution	*low*	*medium*	*high*	*very high*
Examples of room type and use on the emission side (transmitter room)	*Archive, waiting room, reading room*	*Living room, bedroom, kitchen, bathroom, toilet, office, heating and air-conditioning room, corridor, stairs, arcade, passage, terrace, garage.*	*Restaurant, hall, schoolroom, nursery, kindergarten, gymnasium, workshop, music practice room and associated development rooms.*	*The uses recorded in the "high" level, if they also occur in the night from 19:00 h to 07:00 h.*
Noise sensitivity	*Requirement value L'*			
low	*63 dB*	*58 dB*	*53 dB*	*48 dB*
medium	*58 dB*	*53 dB*	*48 dB*	*43 dB*
high	*53 dB*	*48 dB*	*43 dB*	*38 dB*

TABLE 2.6-7: MINIMUM REQUIREMENTS FOR PROTECTION AGAINST NOISE FROM TECHNICAL BUILDING INSTALLATIONS AND FIXED INSTALLATIONS IN THE BUILDING (PROTECTION AGAINST NOISE – SWISS NORM)

Emission-side noise type (transmitter room)	*individual sounds*		*Continuous noises Functional or user noises*
	Functional noise	*Noise of use*	
Noise sensitivity	*Requirement value L_H*		
low	*38 dB (A)*	*38 dB (A)*	*38 dB (A)*
medium	*33 dB (A)*	*38 dB (A)*	*38 dB (A)*
high	*28 dB (A)*	*38 dB (A)*	*38 dB (A)*

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2.6.5 Energy performance of buildings regulation

Country	Switzerland
Category	**Energy performance of buildings**
Original Title	Mustervorschriften der Kantone im Energiebereich (MuKEn)
English translation of title	Model of cantons energy regulations
Publication year / amendment year (if any)	2014, 2018 revision
Document type & Status	Type: Regulations, codes with legal status Status: Approved and in force
Region of enforcement (If differentiated countrywide)	In Switzerland, the energy performance regulations for buildings are set federally by the cantons. With a collection of template regulations (the so called MuKEn) the cantons try to harmonize the building related energy regulations. The regulations of the actual MuKEN (of year 2014) are divided into two parts. The basic module with the minimum consensus is implemented by nearly all cantons. A smaller number of cantons applies the additional module with advanced legal regulations.
Brief summary / content description	MuKEn has the main goal to describe procedures and objectives in order to build very energy efficient buildings that have a lower energy demand (for heating, cooling and domestic hot water) and electricity demand. MuKEn regards as well all the procedures that has to be applied in order to reduce the energy demand of old buildings (especially for heating and domestic hot water). MuKEn refers to the buildings (old and new), as well to the new systems (for heating, cooling, ventilation and domestic hot water production) that will be installed in the new buildings or will replace the existing one. MuKEn contains all the requirements that have to be satisfied in case of construction of new building or in case of renovation of an existing building (or existing system). All the requirements regard not only the building envelope, but especially the systems for heating and cooling, DHW preparation, ventilation and lighting. MuKEn contains as well an introduction to the GEAK (Energetic cantonal certification of buildings), a voluntary tool that can be used by owners to categorise energetically their building, plan renovations and receive state subsidies. In case the owner want to receive subsidies for energy renovation of the building, a GEAK Plus certification has to be prepared and sent to the authorities.
Scope of: (cases that is applied)	MuKEn 2014 has to be applied in case of new buildings and for the renovation of existing buildings. The energy regulation tries from one side to pursue goals rather than procedures and from the other side lets to the different cantons a certain freedom in order to consider the differences on the energy plan. In particular starting from 2020 the new buildings have to cover autonomously energy demand for heating (if possible) and a high part of the electricity demand.

<table>
<tr><td></td><td>The public buildings by 2050 will have to cover their energy demands with renewable energies and will reduce their electricity demand by 20% or will cover at least 20% of their electricity demand with renewable energies.
Starting from 2020 the main part of energy demand for domestic hot water in the old buildings has to be produced through renewable energies.
Large incentives will be given to large energy consumers and owners of old buildings for energy requalification.</td></tr>
<tr><td>Basic requirements for residential buildings</td><td>
Basic requirements set by the Regulation:
1. Building envelope
Basically two procedures (defined in the national norm SIA 380/1) must be applied regarding the verification of the thermal insulation:
a) adherence to specific requirements for the thermal insulation of individual parts of the building (Table 2.6-8 in case of new buildings and new construction elements in case of changes of use, Table 2.6-9 for all the construction elements interested by a change of use/transformation);
b) adherence to global requirements regarding the calculation of the heating demand ($Q_{H,li}$) and heating load ($P_{H,li}$, see Table 2.6-10). The calculation of the heating demand limit ($Q_{H,li}$) is defined in the norm SIA 380/1 through the following equation:
$Q_{H,li} = Q_{H,li0} + \triangle Q_{H,li} * (A_{th}/A_E)$
where:
- $Q_{H,li0}$ and $\triangle Q_{H,li}$ are defined in Table 3;
- A_{th} depends on the geometry of the building;
- A_E is the energy reference area defined in the SIA 380/1.

TABLE 2.6-8: U VALUE LIMITS – NEW BUILDINGS (SWISS CANTONS ENERGY REGULATION)
<table>
<tr><td></td><td>U values limit [W/m2K]</td><td></td></tr>
<tr><td>Construction element</td><td>External (or less than 2m under floor)</td><td>non heated rooms or deeper than 2m under floor</td></tr>
<tr><td>Opaque construction</td><td>0.17</td><td>0.25</td></tr>
<tr><td>Window, Door window</td><td>1.0</td><td>1.3</td></tr>
<tr><td>Door</td><td>1.2</td><td>1.5</td></tr>
<tr><td>Shutter box</td><td>0.5</td><td>0.5</td></tr>
</table>
TABLE 2.6-9: U VALUE LIMITS FOR REPLACE OF ELEMENTS (SWISS CANTONS ENERGY REGULATION)
<table>
<tr><td></td><td>U values limit [W/m^{2}K]</td><td></td></tr>
<tr><td>Construction element</td><td>External (or less than 2m under floor)</td><td>non heated rooms or deeper than 2m under floor</td></tr>
<tr><td>Opaque construction</td><td>0.25</td><td>0.28</td></tr>
<tr><td>Window, Door window</td><td>1.0</td><td>1.3</td></tr>
<tr><td>Door</td><td>1.2</td><td>1.5</td></tr>
<tr><td>Shutter box</td><td>0.5</td><td>0.5</td></tr>
</table>
TABLE 2.6-10: HEATING DEMAND AND HEATING LOAD LIMIT VALUES (SWISS CANTONS ENERGY REGULATION)
<table>
<tr><td></td><td>Limit values for new buildings</td><td>Limit values for</td></tr>
</table>
</td></tr>
</table>

				changes of use
Building category	*Heating demand QH,li0 [kWh/m²K]**	*Heating demand ΔQH,li [kWh/m²K]**	*Heating load PH,li [W/m²]***	*Heating demand [kWh/m²K]*
SFH	*13*	*15*	*20*	*1.5*QH,li*
MFH	*16*	*15*	*25*	
Office	*13*	*15*	*25*	
School	*14*	*15*	*20*	
Shop	*7*	*14*	-	
Restaurant	*16*	*15*	-	
Public building	*18*	*15*	-	
Hospital	*18*	*17*	-	
Industry	*10*	*14*	-	
Warehouse	*14*	*14*	-	
sport facility	*16*	*14*	-	
Pool	*15*	*18*	-	
** with an annual average temperature of 9.4 °C*				
*** with an external temperature of -8.0 °C*				

2. Building technical systems

a) new buildings and the extensions of existing building should be built in a way that the total energy demand for heating, cooling, ventilation, domestic hot water production is almost zero. In particular, the global final weighted energy demand (calculation following the national norm defined in the EnDK) for heating, cooling, ventilation and DHW preparation must not exceed the limit values of Table 2.6-11

b) direct use of electricity (electric heater or post heater) is not allowed in the new buildings. All the electric heaters used for heating and domestic hot water preparation and with water heat distribution, has to be replaced with new and more efficient systems within the next 15 years. The use of electric heaters is allowed just in special cases when the building is too isolated or when another kind of heating system is not feasible. Electric heater for domestic hot water preparation is allowed but under certain conditions (maximum temperature of 60 °C, preheating of domestic hot water through heating system, 50% of energy demand covered with renewable energies or waste heat)

c) Oil or gas boilers in new buildings are allowed just in case heat condensation is used. If in an existing building the heat boiler has to be changed, the non renewable energy must not exceed the 90% of the total energy demand (for heating and domestic hot water). In general the replacement of a gas/oil boiler with a more energy efficient solution is encouraged (solar thermal systems, heat pump, wood boiler, district heating, ventilation systems with heat recovery)

d) In the new (or renovated) heating systems, pipe losses should be reduced as much as possible through a minimum thickness

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insulation of pipes (Table 2.6-12) and components. In addition, supply water temperature should not exceed 50 °C (35° in case of floor heating systems)

e) The ventilation systems must be equipped with a high heat recovery system. In addition, the air velocity in the systems cannot exceed 2 m/s and in the ducts cannot exceed values defined in the norm (3 m/s until 1000 m^3/h, 7 m/s in case of 10000 m^3/h). As for the heating systems, the air ducts must be well insulated in order to reduces thermal losses/gains

f) Cooling systems can be installed in renovated buildings just under certain conditions (e.g. total electricity demand for cooling below 12 W/m^2)

g) The building has to produce a part of its electricity demand through system installed in/on or around the building (e.g. PV systems). The minimum power is 10 W/m^2_{ERA} (a power higher than 30 kW is not required). If no PV (or others) system is installed, a compensation fee has to be paid.

h) In the new buildings and in the change of use / transformation of existing buildings, the electricity demand for lighting should not exceed the value defined in the national norm SIA 387/4 (this norm does not apply for residential buildings)

i) New buildings with more than five units and with centralized preparation of DHW must be equipped with individual energy meters. In case centralized heating systems serve more buildings, an energy meter for each building has to be installed. Generally the same requirements regard the renovation of more than 75% of an existing building or in case of renovation of heating/DHW system. These requirements are not valid in case the total power for heating and DHW is lower than 20 W/m^2_{ERA}

TABLE 2.6-11: THRESHOLDS OF GLOBAL WEIGHTED ENERGY FOR BUILDING USES (SWISS CANTONS ENERGY REGULATION)

Category	*Limit value of global final weighted energy [kWh/m^2a]*
Single family house	*35*
Multi family house	*35*
Office	*40*
School	*35*
Shop	*40*
Restaurant	*45*
Public building	*40*
Hospital	*70*
Industry	*20*
Warehouse	*20*
sport facility	*25*
Pool	-

TABLE 2.6-12:MINIMUM PIPE INSULATION THICKNESS (SWISS CANTONS ENERGY REGULATION)

	min. thickness insulation [mm]

<table>
<tr><td></td><td>
<table>
<tr><td>Diameter pipe</td><td>0.03 < l < 0.05 W/mK</td><td>l < 0.03 W/mK</td></tr>
<tr><td>10-15</td><td>40</td><td>30</td></tr>
<tr><td>20-32</td><td>50</td><td>40</td></tr>
<tr><td>40-50</td><td>60</td><td>50</td></tr>
<tr><td>65-80</td><td>80</td><td>60</td></tr>
<tr><td>100-150</td><td>100</td><td>80</td></tr>
<tr><td>175-200</td><td>120</td><td>80</td></tr>
</table>
</td></tr>
<tr><td>New buildings vs Retrofit existing buildings</td><td>The requirements of the regulation apply for new buildings, for existing buildings that have to be renovated or in case of extension of existing buildings. In particular in each article of the norm is explained what apply for new buildings and what for renovation of existing buildings. In addition the norm specify as well if a specific requirement regard just a certain category of buildings.</td></tr>
<tr><td>nZEB definition and requirements
(if available)</td><td>In Switzerland a first definition of nZEB has been introduced with MuKEn 2014, where it is written that: " by 2020 all the new buildings has to cover autonomously the global energy demand for heating (if possible) and an important part of the electricity demand". As other countries, Switzerland in the last 20 years developed a national energy label for buildings called MINERGIE (https://www.minergie.ch/?l) that can be considered equivalent to other european energy labels (as Passivhaus for example). There are different MINERGIE standards (MINERGIE, MINERGIE-P, MINERGIE-A and MINERGIE-ECO) with different restrictions requirements (final weighted energy demand, electricity production, etc.). In particular the requirements of the standard MINERGIE-A are similar to nZEB definition. In the MINERGIE-A the global electricity production of a PV system has to cover the total energy demand of the building (weighted final energy).</td></tr>
</table>

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2.6.6 RES in buildings legal framework

Country	SWITZERLAND
Category	Renewable energy sources in buildings – PV systems
Original Title	Energiegesetz (EnG), Energieverordung (EnV)
English translation of title	ENERGIE LAW (EnG) ENERGIE ORDINANCE (EnV) According to Swiss federal law
Publication year / amendment year (if any)	(EnG): From September 30, 2016 (Current for the January 1, 2021) (EnV): From November 1, 2017 (Current for the January 1, 2021)
Region of enforcement (If differentiated countrywide)	The laws are applied countrywide
Document type & Status	Type: Swiss federal law and ordinance Status: Approved and in force
Brief summary / content description	The purpose of this law is to contribute to an adequate, diversified, secure, economical and environmentally friendly energy supply. Its purpose is to: a. ensure the economical and environmentally compatible provision and distribution of energy b. the economical and efficient use of energy c. the transition to an energy supply that is more strongly based on the use of renewable energies, in particular indigenous renewable energies
Scope of: (cases that is applied)	The framework applies for all kind of building owners/users and consumers both physical and legal entities as well as private and public
Basic legal requirements for photovoltaics	<u>Acceptance and remuneration obligation</u> Grid operators are obliged to take back and appropriately remunerate electricity generated from renewable energies. The selling price of the fed-in energy sold to the grid operator varies from municipality to municipality and is defined by the operator itself. The purchase price of electricity fed into the grid can be found under the following website for each municipality. (www.pv-tarif.ch). Net metering is not allowed in Switzerland. Energy must be consumed at the time of production or must be sold to the grid operator. <u>Self-consumption</u> Plant operators are allowed to consume all or part of the energy they produce themselves at the place of production. They may also sell all or part of the energy they produce for consumption at the place of production. Both are deemed to be own consumption. The Federal Council issues provisions to define and delimit the place of production. <u>Aggregation for own consumption purposes</u> If there are several landowners who are final consumers at a place of production they may group together for the purpose of common own consumption,

	provided that the total production power is significant in relation to the power connected at the metering point. They conclude an agreement with each other and with the plant operator. Subventions for photovoltaic plants Photovoltaics are promoted in Switzerland at the federal level by Pronovo. (www.pronovo.ch). In addition, there are subsidy programs of individual cantons, municipalities and energy suppliers. Photovoltaic systems of all sizes are subsidized throughout Switzerland by the one-time payment (EIV). This covers a maximum of 30 % of the investment costs of reference systems at the time of commissioning. Specifically, a basic contribution and a performance contribution per installed kW are paid. The total contribution can be calculated through the following web page: https://pronovo.ch/de/services/tarifrechner/ One-time payment for small plants (KLEIV) • PV systems < 100 kWp • Application after successful commissioning at Pronovo • Waiting time for new registrations approx. 1 year One-time payment for large installations (GREIV) • PV systems > 100 kWp • Application before construction of the PV system at Pronovo • Waiting time for new registration approx. 1 year Obligation to register the photovoltaic plant Producers of electricity must register the production plant and have the electricity produced recorded by the enforcement agency by means of a guarantee of origin. Exempt from these obligations are producers whose plants: a) operated for a maximum of 50 hours per year b) are neither directly nor indirectly connected to the electricity grid (stand-alone systems) c) have a rated AC power of 30 kVA or less

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2.7 Sweden

2.7.1 General building constructions and urban planning related regulations

Country	SWEDEN
Category	**Building construction works**
Regulation Original Title	Boverkets byggregler
English translation of title	Boverket's Building Regulations
Publication year / amendment year (if any)	2011 – various amendments are made
Document type & Status	Type: Regulations, codes with legal status Status: Approved and in force
Region of enforcement (If differentiated countrywide)	The regulation is applied countrywide
Brief summary / content description	BBR consists of mandatory provisions that you have to fulfil and general recommendations that state how you may fulfil the mandatory provisions. You can choose other solutions then the ones stated in the general recommendations but the verification that you need to do to make sure that the mandatory provisions are fulfilled will be more extensive. It is divided in 9 Chapters: Introduction; general rules for buildings; accessibility, dwelling design, room height, and utility rooms; mechanical resistance and stability; safety in case of fire; hygiene, health and environment; protection against noise; safety in use; energy management
Scope of: (cases that is applied)	The regulation is applied to all urban and non-urban areas for new and existing buildings and infrastructure.
Basic requirements for existing residential buildings related with the PLURAL concepts	**Technical Installation:** "Structural elements and installations with a shorter working life than the building's intended service life should be readily accessible and easy to replace and otherwise be easy to maintain, operate and inspect. " **Light** When used, a general figure for the window glazing area in the room should be at least 10 % of the floor area.

Country	SWEDEN
Category	**Urban Planning regulations**
Regulation Original Title	Plan och bygglagen PBL
English translation of title	Planning and Building Act

Publication year / amendment year (if any)	2010 – various amendments are made
Document type & Status	Type: Regulations, codes with legal status Status: Approved and in force
Region of enforcement (If differentiated countrywide)	The regulation is applied countrywide
Brief summary / content description	n/a
Scope of: (cases that is applied)	The regulation is applied to all urban and non-urban areas for new and existing buildings and infrastructure.
Basic requirements for existing residential buildings related with the PLURAL concepts	- A building must demonstrate a good effect of design, colour and material - In a detailed development plan, the municipality may determine the placing, design, and construction of construction works and lots - Building permits are required for alterations to a building other than extensions, if the alteration entails changing the colour, facing, or roofing material of the building or the buildings' external appearance is substantially changed in any other way. - buildings that do not require permits in accordance with this Act, built environment and construction works must be designed in a manner that is suitable, with regard to the townscape and landscape, natural and cultural values on the site, and in the interest of ensuring a favourable overall impression

2.7.2 Fire safety regulations

Country	**SWEDEN**
Category	**Safety in case of fire in buildings**
Original Title	Boverkets byggregler
English translation of title	Boverket's Building Regulations
Publication year / amendment year (if any)	2011 – various amendments are made
Document type & Status	Type: Regulations, codes with legal status Status: Approved and in force

Region of enforcement (If differentiated countrywide)	The regulation is applied countrywide
Brief summary / content description	Boverket's building regulations, BBR, contains the different fire resistance classes and regulations about safety in case of fire. The classes are differentiated in occupancy classes (1-6, whereas dwelling use is occupancy class 3) and building classes depending on the amount of users and the building height (Br0 for the highest need for protection and Br3 for a low need for protection) You have two ways of designing a building's fire protection: pre-accepted solutions or deviate from the pre-accepted solutions and use fire safety engineering here called analytical design to verify that the solutions fulfil the mandatory provisions in BBR. You will find the pre-accepted solutions in the general recommendations in BBR, and you will find how to use and verify analytical design in Boverket's general recommendations on the analytical design of a building's fire protection, BBRAD.
Scope of: (cases that is applied) New & Existing Buildings	New & existing buildings
Basic requirements for residential buildings	Escape routes: Windows designed for escape should have a clear opening of at least 0.5 meters width and at least 0.6 meters height. The bottom of the window opening should be no more than 1.2m above the floor. Distance to the nearest escape route less than 45m. (Occupancy class 3 – dwelling) Minimum width for escape routes 0.9m (1.2m for more than 150 occupants) Materials: In buildings of class Br1, ceilings should have surface finishes of fire resistance class B-s1,d0, attached to material of A2-s1,d0 or clad in fire resistance class K210/B-s1,d0. Wall surfaces should have surface finishes of at least fire resistance class C-s2,d0. In buildings of class Br1 and Br2, ceiling surfaces and internal wall surfaces in escape routes should have a surface finish of at least fire resistance class B-s1,d0. The surface finish should be attached to the material in fire resistance class A2-s1,d0 or on cladding of at least fire resistance class K210/B-s1,d0. Structural Fire safety: Separating structures in buildings in class Br1 should be designed for at least the fire resistance class EI 60/120/240 (depends on fire load). Dwellings should be designed as separate fire compartments and the separating structure between dwellings should be designed in at least class EI 60. Depending on the category of the structural elements the fire resistance refers to one, two or all of the categories: R – load bearing capacity, E – integrity and I – heat insulation

TABLE 2.7-1 FIRE RESISTANCE CATEGORIES OF STRUCTURAL ELEMENTS (SWEDISH BUILDING REGULATION)

Structural Elements	Minimum requirements
Load bearing wall (internal/external)	REI
External non load bearing, walls of fire protected escape routes and fire compartments	EI
Load bearing vertical elements	R
Fire resistant Doors, windows	EI1 bzw. EI2

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958218

Structure elements between floors (slabs and beams)	REI
Staircases walls	EI
Load bearing elements of staircases	R
Self-bearing roof elements (panels)	REI

Exterior walls:

Exterior walls in buildings of class Br1 shall be designed to ensure

1. the separation function is maintained between fire compartments,

Exterior wall constructions that, when tested in accordance with SS-EN 13501-2 with fire affect as specified in Chapter 4.2 (standard fire curve) comply with applicable parts of the requirements for separating structures, meet the provision's requirements in point 1

2. fire spread inside the wall is limited,

containing only material of at least class A2-s1,d0 or separated in such a way that a fire inside the wall is prevented from spreading past the separating structure

3. the risk of fire spread along the façade surface is limited,

designed with at least class A2- s1,d0. As an alternative, the requirements can be met with a cladding in at least class D-s2,d2 and one other condition: e.g. the building has a maximum of eight storeys and is fitted with automatic fire suppression systems and the façade surface in the ground floor is designed in materials of at least A2-s1,d0

4. the risk of injury due to parts falling from the exterior wall is limited.

ensure the risk of falling structural elements, such as broken glass, small bits of plaster and the like is limited

For exterior walls to buildings with up to eight storeys if the test shows that

a) no major parts of the façade fall down, for example, large pieces of plaster, panels or glass panes, which could cause danger to people evacuating or to rescue personnel,

b) fire spread on the surface finish and inside the wall is limited to the bottom edge of the window two floors above the fire room,

c) no exterior flames occur which could ignite the eaves located above the window two floors above the fire room. As an equivalent criterion, the gas temperature just below the eaves must not exceed 500 °C for a continuous period longer than 2 minutes or 450 °C for longer than 10 minutes.

For exterior walls in buildings with more than eight storeys, in addition to criteria a–c in the test, the exterior wall must not increase the risk of fire spreading to another fire compartment in a floor above the fire room. As an equivalent criterion when testing according to SP FIRE 105, the total heat flow into the façade in the centre of the window in the storey above the fire room must not exceed 80 kW/m

If there are exceptional reasons for not meeting the requirements for protection against fire spread along the façade surface as specified above, the material should at least meet class D-s2,d2.

When the distance between windows above each other is smaller than 1.2 meters, one window has to be in class E30 or both in E15.

Active & Passive	The regulation deals with both passive and active fire safety measures.

2.7.3 Protection against noise related regulations

Country	SWEDEN
Category	Noise
Original Title	Boverkets byggregler
English translation of title	Boverket's Building Regulations
Publication year / amendment year (if any)	2011 – various amendments are made
Document type & Status	Type: Regulations, codes with legal status Status: Approved and in force
Brief summary / content description	BBR consists of mandatory provisions that you have to fulfil and general recommendations that state how you may fulfil the mandatory provisions. You can choose other solutions then the ones stated in the general recommendations but the verification that you need to do to make sure that the mandatory provisions are fulfilled will be more extensive. It is divided in 9 Chapters: Introduction; general rules for buildings; accessibility, dwelling design, room height, and utility rooms; mechanical resistance and stability; safety in case of fire; hygiene, health and environment; **protection against noise**; safety in use; energy management
Scope of: (cases that is applied)	new & existing buildings
Basic requirements for residential buildings	The regulation issues general guidelines on noise emissions in residential areas. These guidelines are merely recommendations and are not legally binding when planning or constructing dwellings. The different guidelines are discrepant and overlap in part. • For residential use there are the following noise levels that may not be exceeded: 30 A-weighted decibels (dB(A)) equivalent sound level indoors; • 45 dB(A) maximum sound level indoors at night; • 55 dB(A) equivalent sound level outdoors

2.7.4 Energy performance and energy economy related regulations

Country	SWEDEN
Category	**Energy performance of buildings**
Original Title	Boverkets byggregler
English translation of title	Boverket's Building Regulations
Publication year / amendment year (if any)	2011 – various amendments are made
Document type & Status	Type: Regulations, codes with legal status Status: Approved and in force

Region of enforcement (If differentiated countrywide)	BBR consists of mandatory provisions that you have to fulfil and general recommendations that state how you may fulfil the mandatory provisions. You can choose other solutions then the ones stated in the general recommendations but the verification that you need to do to make sure that the mandatory provisions are fulfilled will be more extensive. It is devided in 9 Chapters: Introduction; general rules for buildings; accessibility, dwelling design, room height, and utility rooms; mechanical resistance and stability; safety in case of fire; hygiene, health and environment; protection against noise; safety in use; **energy management**
Brief summary / content description	new & existing buildings
Scope of: (cases that is applied)	new & existing
Basic requirements for residential buildings	Dwellings shall be designed to ensure a primary energy number (EP_{pet}), the installed electric input for heating, the average air leakage of the building envelope and the average thermal transmittance (U_m) of the building envelope. The requirements for apartment buildings for energy performance are between 5-15 kWh/m^2 depending on the climatic zone. The maximum permitted energy number for multi-dwelling blocks is 85 kWh/m^{2}a. The installed electric input for heating is different for various locations in Sweden. For Uppsala and surrounding areas it is 4.5 kW. The average heat transfer coefficient should be less than 0.4 W/m^{2}K. The building's climate envelope shall be so air tight that the requirements of the building's primary energy number and installed electric input for space heating are met. If the building does not meet the requirements for the primary energy number in Section 9:2 after changes have been made, the following U-values shall be pursued in changes to the building envelope.

TABLE 2.7-2: MAX U-VALUES (SWEDISH BUILDING REGULATION)

Building element	U
External horizontal or inclined roof	0.13
External wall	0.18
External floor	0.15
External openings (windows/doors)	1.2

Exterior wall: Reasons to allow a higher U-value could for example be when
– only apportion of an exterior wall is affected or
– it means that the usability of a balcony is significantly reduced

	For technical reasons it may be inappropriate to add insulation to certain wall constructions. When applying external supplementary insulation, the effects on the building's character, details such as door and window coverage, and the relationship between the façade and eaves and plinth are to be considered. Handling of energy from the sun, wind, ground, air or water is regulated in Boverket's mandatory provisions and general recommendations (2016:12) regarding determination of the building's energy use at normal use and in a standard year, BEN.
New buildings vs Retrofit existing buildings	Alterations to buildings must not result in a reduced energy efficiency, unless there are exceptional reasons. However, energy efficiency may be reduced if the alteration to the building still meets the requirements.
nZEB definition and requirements (if available)	The nZEB requirements in Sweden contain the following values: - Primary energy requirement: 85 kWh/m^2a - Primary energy factor for electricity: 1.6, for district heating: 1.0, for natural gas: 1.0

2.7.5 RES in buildings legal framework

According to the latest National Survey Report of PV Power Applications in Sweden [23] self-consumption by PV systems and selling to the grid are available in Sweden as well as collective self-consumption and virtual net-metering.

2.8 Conclusions

The conducted review in the frame of D1.2 highlighted the similarities and differences in the national regulations related to building structures, urban planning, energy, and fire and noise performance. There are a lot of similarities, which is expected due to common European regulations that in most cases form also the basis for the national ones. However, there are some “missing” regulations for some categories in some countries while others had some categories merged in one. Finally, in some cases, there exists more than one law or regulation applied for a specific category.

The lack of detailed regulatory framework and corresponding regulations for façades intended for deep renovation of existing buildings as “add-on” components is apparent. This concerns all possible types of related requirements like structural and anchorage, building permits and urban planning etc. One reason for this “weakness” might be that the general prefabricated façade “PnU” concept is quite new. This shortcoming will be further clarified during the PLURAL project and hopefully the project could make meaningful contribution to eventually add these type of interventions to the relevant policies and legal frameworks.

A more specific conclusion about the nZEB definition can also be derived. All six of the demo countries have quite a different approach when it comes to define a nZEB building. Some are based on specific absolute values of energy consumption but in different forms (primary, final, weighted etc) and some are based on energy class or a value for the average U-Value of the building envelope. This makes more difficult the comparison of requirements between the demonstration cases.

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 958218

3 Standardisation framework of PnUs main components

In this chapter the PLURAL solutions for prefabricated façades are presented and broken down to their main components. a full list of the components of each PnU is presented together with the related standards, certification and classifications. Since the technologies and integrated PnUs are still under development, assessment and optimization in the frame of WP4, the installation / manufacturing standards & certifications for each PnU will be updated and finalized in the frame of D1.3: Certification requirements accounting for occupant legal and privacy monitoring due in M24.

Some of the components that will be selected to be integrated in the PnUs are commercial products (e.g. insulation sheets, heat pumps, PV panels) while others are based on experimental designs and prototypes that are going to be improved and customized for the specific requirements of the project (e.g. the eAHC unit, high performance windows with integrated mechanical ventilation, multifunctional coatings).

3.1 Smart wall components

3.1.1 Description of the Smart Wall

The multifunctional wall panel of the “Smart wall” core system was developed in 2019 and combines several technologies including fully prefabricated walls with eco-friendly insulation, slim-type fan coil for heating and cooling, mechanical ventilation, IEQ control system consisting of filters, energy recovery system and batteries, high performance commercial PV panels and heat recovery windows. It can be applied either to the building’s exterior as a façade panel, or to the interior as an additional internal component.

FIGURE 3.1-1. INTERNAL AND EXTERNAL SIDE.

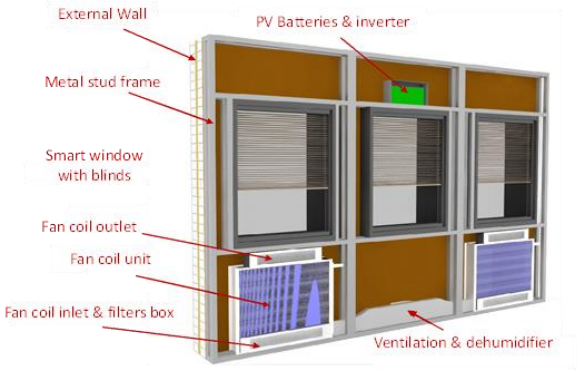

FIGURE 3.1-2. SMART WALL LAYOUT.

As a plug and use panel, "Smart Wall" contains flexible pipe and electrical wiring connections that can accommodate either the existing or a new heating/cooling system, as well as connections to various electrical services (switches, plugs etc.). Construction materials are selected with respect to the environmental-friendly and high - performance behavior of the wall. The majority of elements (98% of the materials, apart from the air filters) forming the "smart wall" module is eco-friendly, recyclable and non-combustible. The structural frame can be composed of several materials such as timber, aluminum, high-performance polymers or even industrial plastics that can be supported from 3D printing technology. The utilization of 120 mm recyclable mineral wool will decrease the wall's U-value to 0.28W/(m^2K). The ventilation system of the "Smart Wall" is based on a standard integrated function of modern fan coils, to recycle the air from the interior of the room. However, ventilation is planned to utilize an integrated compact system with heat recovery in order to supply fresh air to the interior through electronically controlled dampers. The air flow and indoor quality can be controlled either manually or automatically via CO_2, temperature and humidity sensors. Furthermore, various combinations of commercial filtration types can be installed in the ventilated unit or the fan coil, depending on the occupants' requirements and the local climatic conditions. In order to further enhance the sustainability of the "Smart Wall", the integration of a power energy system with (BI)PV panels and batteries embedded into the wall panel can be applied. The specific core system presents significant advantages for climates with high demand for cooling.

3.1.2 Standardization of Smart Wall Components

The components of the Smart Wall are presented below along with their related standards, certification and classifications. The components of the Smart Wall are categorized as follows: Envelope components, HVAC systems, Load Bearing structures, Solar Collectors.

TABLE 3.1-1: SMART WALL COMPONENTS AND THEIR STANDRDS

Component	Product	Installation / manufacturing standards & certifications
Envelope components		

Cement board	Outdoor board	• ETA 07-0173 • A1 rating in accordance with EN 13501-1: 2007, non-combustible • EN 12467 (based on CPR 305/2011 for the cement board of KNAUF Aquapanel)
Plaster board	Indoor board	• A2 rating in accordance with DIN 4102, non-combustible • GKB type according to DIN 18180
Smart wall insulation	Rockwool insulation with aluminum foil	• EN 13162:2012+A1:2015 Thermal insulation products for buildings • A1 rating, non-combustible
High performance windows	Window	• CE
Smart wall internal fire extinguishing system	Automatic fire suppression system	• Fire class rating: A, B, C, E
Multifunctional coatings for exterior/interior surfaces	Waterproof paint for exterior walls; acrylic paint for interior walls	• N/A
Multifunctional coating with PCMs for exterior/interior surfaces	Organic PCMs incorporated in acrylic paint	• N/A
Intumescent	Intumescent paint-coating for passive fire protection	• N/A
HVAC systems		
Fan coil unit/ heat pump convector	Heating and cooling device	• (EU) 2016/2281 (Ecodesign regulation) • EN60335-1 • 2014/35/UE (LVD) • 2014/30/UE (EMC)
HEPA filter	Air filter	• EN 1822
Pipes for heating & cooling	PP-R pipe	• With Oxygen barrier • Certified according to DIN 4726 • B2 DIN 4102 (normal inflammable) - no risk of dioxin emissions
ATEX-certified cable glands	Cable glands	• EN 60423 • EN 60529 • AISI 303 steel • IP68 • IP69
ATEX Flexible Conduit	Flexible Conduit	• EN 61386 • IP66 • IP67 • IP68 • IP69K
Smart wall energy storage	Battery	• CE • Recyclable
Load bearing structure and anchoring		
Exterior fittings for cement board	Screws, brackets & fittings	• EN 14566:2008 • A1 rating in accordance with EN 13501-1: 2007, non-combustible

Steel stud frame	Steel hollow section	• S355 according to EN10025/ST52 according to DIN17100
Smart wall anchoring	Metal expandable anchors	• AISI 316 steel • Fire resistant according to EOTA TR020 • Seismic resistant class C2 according to EOTA TR045
Solar Collectors		
Solar panel for external Smart Wall	Solar panel	• ISO 9001:2015 • ISO 14001:2015 • DIN VDE 0100 Installation of power installations with nominal voltages up to 1,000 V • IP68 for junction boxes
Transparent coatings for PV	Transparent coatings for PV	• n/a

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958218

3.2 eWHC components

3.2.1 Description of the eWHC

The external Wall Heating and Cooling (eWHC) module is the solution referring to the wall that is merely applicable externally (either on the external wall or on the roof), as it integrates a low temperature exterior hydronic wall heating system between the existing wall layer and the new added envelope. All major components of this solution are enclosed in a prefabricated timber-based module (envelope-kit) (**Σφάλμα! Το αρχείο προέλευσης της αναφοράς δεν βρέθηκε.**), operating towards nZEB state with minimum ecological footprint and high comfort conditions for inhabitants. This multifunctional unit consists of:

- Timber frame construction with insulation of about 20-30 cm - depending on climate –
- Integrated triple-glazed windows
- Window integrated ventilation system with heat recovery
- Low temperature external wall water-based heating distribution system
- External blinds for window shading
- Building integrated photovoltaic (BIPV) modules for renewable electricity production (roof and facade).

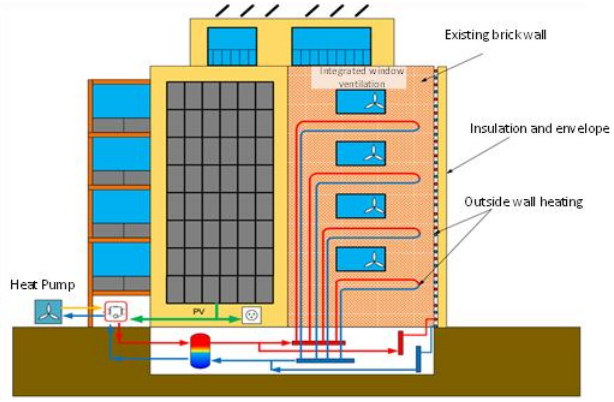

FIGURE 3.2-1. LAYOUT OF EWHC SOLUTION.

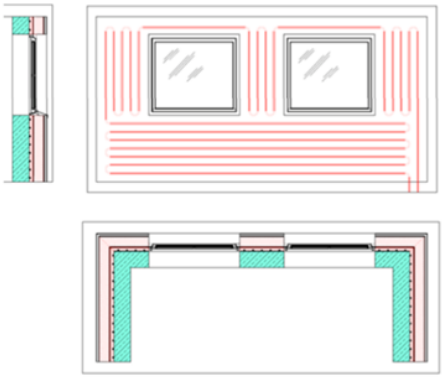

FIGURE 3.2-2. REDESIGNED EWHC ENVELOPE KIT.

This technology introduces the low temperature hydronic heating or cooling distribution from the outside, with minor or low disturbance on the inside of the building. This is accomplished by combining the heat distribution with the mandatory new high-performance insulation. Such solution addresses mostly buildings with high heating demand in colder climates, since it activates the thermal mass of the existing wall and shifts the heating period to day time, increasing "self-consumption" and mitigating as a result the energy demand for heating. However, eWHC applications may also cover low cooling demands in heating dominated countries such as Switzerland, Germany and Czech Republic. This issue will be investigated in the upcoming

tasks of the PLURAL concept. eWHC concept can be enriched with the integration of solar energy converters for the production of heat and electricity (PV or BIPVT collectors). Such a combination can be used for thermal energy harvesting or even passive cooling during night hours.

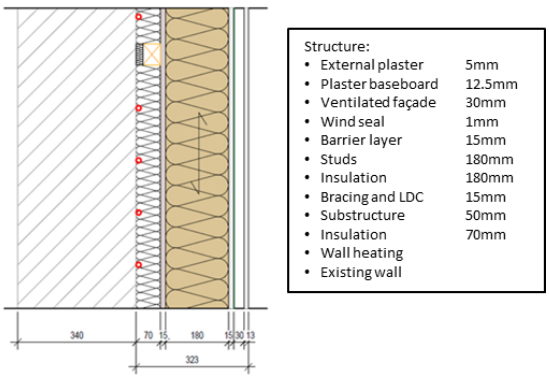

FIGURE 3.2-3. THE PRELIMINARY LAYOUT OF THE EWHC WALL.

3.2.2 Standardization of eWHC Components

TABLE 3.2-1: EWHC COMPONENTS AND THEIR STANDRDS

Component	Product	Installation / manufacturing standards & certifications
Envelope components		
Vapor barrier	Gyso	EN13984. EN 1350-1
insulation	n/a	EN 13162
reinforcement	LDS OSB	n/a
glazing	Window	CE
HVAC systems		
"floor" heating pipes	Haka Gerodur - PE-RT	KOMO, DIN 16833 / 16834
Heat recovery (heat exchanger)	n/a	n/a
Solar collector	any	Solar-Keymark certification
Solar panel (PV)	any	• ISO 9001:2015 • ISO 14001:2015 • DIN VDE 0100 Installation of power installations with nominal voltages up to 1,000 V • IP68 for junction boxes

3.3 eAHC components

3.3.1 Description of the eAHC

The eAHC PnU system is an air handling unit with an advanced heat/cold recovery system. It combines a patented combination of standard passive heat exchanger in series with active thermoelectric heat exchanger providing the capability of temperature control of supplied air. The active air heat exchanger uses thermoelectric elements to heat up the air in the winter season or cool down the air during the summer. The switching between cooling and heating is simply provided by reversing the current in the thermoelectric modules. The solid-state cooling-heating technology simplifies the AHU and provides a novel solution to be easily integrated in the facade panels. Since there is no compressor circuit, the produced sound from the operation is significantly reduced. eAHC unit is combined with a sensor platform for monitoring and control of Indoor Air Quality. The integration of PV systems is a mandatory addition to the eAHC unit, since it can provide adequate energy that can be used for cooling - mainly in summer season and especially during daytime. Photovoltaic energy sources can be used for direct heat generation in winter or cold generation in the summer. An important advantage is that the system can operate without using expensive battery energy storage and can adjust the power to the energy generated. The eAHC wall element is applicable only for the external building surface.

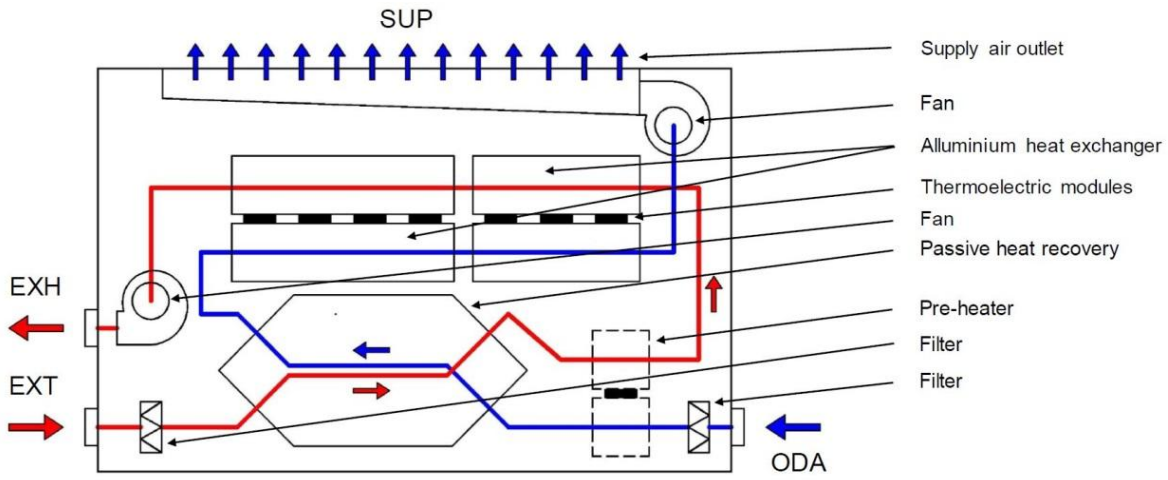

FIGURE 3.3-1. EAHC SOLUTION LAYOUT.

The eAHC is going to be integrated in a prefabricated structure made by DEN which functions as a ventilated folding façade and is attached in the exterior existing façade of a building.

3.3.2 Standardization of eAHC Components

The materials, connections, anchors etc. used in the manufacturing of the DEN systems are certified. Every system has its own design and there is no standard certification procedure for this type of systems. DEN has

applied for ETA certification and provides a "Denvelops Manual" to the customers. A Denvelops certification for the installation procedure is provided at the end of each project.

TABLE 3.3-1: EAHC COMPONENTS AND THEIR STANDRDS

Component	Product	Installation / manufacturing standards & certifications
HVAC systems		
Heating and cooling system	Air handling unit with heating & cooling	• EN 308 • EN 13141-8
Heat recovery	Air handling unit with heating & cooling	n/a
Façade		
Ventilated, folding façade	Denvelops prefabricated façade	• ETA (pending)
BIPV	PV panel	• ISO 9001:2015 • ISO 14001:2015 • DIN VDE 0100 Installation of power installations with nominal voltages up to 1,000 V • IP68 for junction boxes

4 Regulation compliance preview of the PnU renovation in the demo buildings

In this Chapter, a preliminary view of the compliance of the PLURAL solutions when installed at the demo will be done. Early issues regarding the prefabricated kits will be identified based on the current regulations gathered in chapter 2, and the data of the demo buildings gathered in Task 7.1 which includes full building survey of the existing state as well as a preliminary design of the proposed PLURAL renovation with the PnU solutions. Additional information about short renovation description and specifications of pre and post renovation state can be also found in the D1.5 – Specification Sheets.

The compliance preview will be carried out in the most crucial aspects of the PnU kits and their integration to the demo buildings. These are:

1. Building permit needed to proceed to renovation with the PnU solutions according to urban planning regulations.
2. Mechanical issues regarding the stability of the prefabricated PnU kits when various conditions apply (wind, snow, seismic action etc.)
3. Fire safety focusing mostly on the materials of the outer or inner layer of the PnU kits depending if they are applied to the external or the internal part of the existing walls of the demo buildings.
4. Health, safety and hygiene issues related mostly with ventilation and daylight requirements
5. Energy performance with a focus on thermal properties of the PnU combination of materials and the overall U-value achieved.
6. Renewable energy sources legal framework for building applications. PV panels and solar collectors for DHW are the main technologies harvesting solar energy that are considered in the PLURAL solutions. Especially for the PV panels the compliance with the regulation is crucial.

As plural renovation is considered “Deep Renovation”, a type of building permit is generally required in all real demo countries. However, each national regulation has its own definition of deep or major renovations.

After the real demo buildings compliance assessment, the virtual demo buildings will follow. The later ones are not going to be renovated for real and from a practical point of view no compliance is necessary. However, it will help to investigate the degree replicability and the adaptability of the PLURAL renovation concepts based on the PnU kits in more countries. The assessment will describe what would have to be done in order to be in compliance with the regulation

4.1 Greek Real Demo building case

Building constructions and urban planning

As stated in the Greek building construction and urban planning regulations as well as some relative laws, when a building undergoes a major or deep renovation, a building permit has to be issued which means that an energy performance study of the building should be also carried out. A renovation of a building or part of a building is considered as deep if its renovation budget exceeds the 25% of the value of the building or part of a building. This value is calculated specifically for this purpose using values issued by law while the renovation budget values are extracted by the "Analytical Cost of Works for Buildings" issued by the Ministry of Infrastructure and Transportation in 2017. The PLURAL renovation in the Greek demo includes only one floor with two apartments for the demonstration purposes, while the rest of the building was partially renovated (basement and ground floor) or will be renovated (2nd floor).

In general, for small works, another type of permit is required based on the type of works considered to be done at the building. This is a "small scale works" permit that should be issued for a specific list of works and type of repairs that include adding external insulation or ETICS on the exteriors of the walls. In our cases, the Smart Wall is applied on the exterior of the walls and includes insulation. In any case, according to the renovation design of the VVV building at the walls that no Smart Wall kits are going to be installed, external insulation will be applied as the building has no thermal insulation.

All the above considered the municipality of VVV and the other partners involved have come to a conclusion that a permit of small works will be issued and will in include the implementation of the following works:

1. External and Internal insulation
2. Heating systems upgrade
3. Plumbing repairs
4. Electrical systems upgrade
5. General repairs to existing structures

Another issue related to the same regulation category is the space that can be used for the installation of solar panels (PVs) and solar collectors for DHW. According to the preliminary design (PLURAL D7_1_ANNEX_GR02, page 141, figure 64) roof plan, which shows the installation layout of the solar panels and collectors, they will be installed on the common space of the roof of the building. This is totally eligible for such uses even if the building reaches the maximum height limitation of the specific region while no building permit is required. The installation of prefabricated kits, that will cover the façade of the 1st floor, is not foreseen by the regulations (at least not yet). They can either be considered as external insulation (ETICS) or as technical systems that are mounted on the walls.

Mechanical resistance, stability and seismic reaction

Based on the chapter 2 related regulation (Greek seismic regulation) PnU kits can be considered as add-ons and tested as such. The weight and the anchoring of the Smart Wall kit on the buildings wall does not affect its seismic behavior. In deliverable 7.1 (section 4.3.4) it is mentioned that according to the building construction regulation (Greek NOK 2012), all structures should to be subject of structural analysis unless they are ETICS, mechanical add-ons or non-loadbearing. As stated just above, the Smart Wall is a structure not yet described by regulations and there is a gap in regulations in general.

In any case, in favor of safety especially in seismic reaction, a structural analysis will take place at a later step (Task 2.1 – Architectural and structural design of PnU Kits) according to Eurocode 8 (*Design of structures for earthquake resistance - Part 1: General rules, seismic actions and rules for buildings*) to ensure its stability when anchored and that the kit will not fall of or detach from the wall.

From the view of the extra weight of the PnUs that is added to the structures of the building and specifically to the horizontal slabs, the nominal load that the slabs are designed to hold is more than enough, based on the regulations valid at the period of the initial construction of the building (according to the preliminary design presented in D7.1).

Fire safety

Existing buildings are not obliged to comply with the latest fire safety regulations unless they undergo major changes, extensions or change in use which is not the case for the Greek demo building but it is recommended to do so, up to the point that is technically feasible. For residential houses, current fire safety requirements are simple and due to the nature of the majority of building structures in Greece (heavy reinforced concrete) even old buildings comply at least with the structural fire safety. The materials that the building is made of and the fire compartmentation comply with the current regulation. For a residential building the maximum floor area of a fire compartment above ground is 1000 m^2 and the fire resistance of the compartments and the escape routes for a 3-6 floors building is 60 min. In the case of the Greek demo building, the staircase is the fire protected escape route which is made of reinforced concrete and masonry walls that cover the 60 min. The apartment doors, however, should have a minimum of 30 min fire resistance which is unknown if this is fulfilled by the existing wooden doors.

Escape routes requirements are also fulfilled in the A1 and A2 apartments of the Greek demo building as the longest routes to the fire protected staircase are less than 25 m (as it is depicted in the *PLURAL D7_1_Annex_GR01*). The minimum width which should be 0.80 m for residential use is also fulfilled. Emergency lights and signs are required in the common spaces to indicate the exit. In the staircase of the VVV building the basic emergency lights are installed.

Reaction to fire requirements define the type of internal layer materials of walls, floors and ceilings based on their reaction to fire Euroclass. For residential use, in protected fire escape routes class A2-s1,d1 is required and in not protected routes C-s1,d1. In all spaces, the typical internal finishing is cement based

rendering with acrylic paints which covers the requirements. As far as the Smart Wall is concerned and more specifically for the internal installation in some of the spaces of the two demo building apartments, the internal layer material of the kits is Knauf 12.5 mm plasterboard painted with a typical acrylic paint. Plasterboards are very popular nowadays for internal finishing in buildings and are in generally in the category of limited combustibility (A2) so they comply with the requirement above.

Active fire protection measures required for the building based on its size and no of floors are 1 fire extinguisher per floor and in every space that is characterized as a high risk space (power plant rooms, boiler rooms etc.).

The requirements for the protection against spreading fire from the external parts of the building depend on the distance of adjacent buildings. In this case, the minimum distance from any adjacent building is around 8-10 meters which means that the requirement of fire reaction of the external finishing is C-s2,d2. Cement based rendering of the existing external walls, as well as cement-boards that will be the outer layer of the Smart Wall when placed externally normally have a better Euroclass than this and will cover the requirement.

Finally, water pipe network that is going to be placed before the PnU kits in order to be connected with the fan coils are not expected to be of a larger diameter than 40mm. Electric cables requirement for small buildings is D_{ca}-s_2, d_2, a_2. The Smart Wall will contain a control box or Toolbox (Task 2.5 & 4.3) where some control devices will be included that operate in low voltage as well as an active fire protection system, while all exposed elements of the Smart Wall will be painted with intumescent paint. Integrated fan coils in the Smart Wall will have power cables of ATEX category providing limited fire risk. In any case, active and passive fire protection systems of "Smart Wall" panels will be studied at WP4 *(Optimization of PnU components – prototyping – testing)*.

Protection against noise

A regulation issued in 1989 includes an acoustic regulation and sets three categories of acoustic comfort, with new buildings obliged to be at least in the second category. The demo building of VVV was built before this regulation. In reality, even today there are no mandatory tests and designs when constructing a building that prove its acoustic performance. However, all windows should come with a specific categorization of noise protection. There are no requirements to imply that after the renovation a specific state in terms of noise protection should be achieved. Noises coming from any mechanical equipment (e.g. fan coils) embedded in Smart Wall will be considered. Even though such equipment will be installed within insulation that will minimize noise, relative tests will be carried out on WP4.

Hygiene and health

Daylight and natural ventilation are mostly within this category. As far as daylight is concerned all spaces that are used as residential ones should have adequate daylight. In the case of the Greek Demo in all openings a Smart Wall with an opening of the same dimensions will be applied so the daylight in the apartments is not going to be reduced. The same stands for ventilation, as in dwellings it is generally natural by manually opening the windows.

As far as the relevant regulation is concerned, although the building was built before the latest valid regulation (1989) that sets minimum area of openings for ventilation and regulation, the realized openings area when constructed already fulfilled the future requirements. There is at least one big opening in every space (corner rooms have two openings).

One of features that the Smart Wall panels will incorporate, as it was described in the preliminary design, is a mechanical ventilation system with heat recovery through window frames. This and natural ventilation in combination depending on the outdoor conditions will be used for space ventilation. The recommended requirement for fresh air ventilation rate in residential spaces based on technical guidelines is 15 m^3/h per person or 0.75 m^3/h per m^2 of floor area. This means that if the goal is to fully cover the ventilation rate by a mechanical system in order to reduce heat losses in winter (heat recovery), these rates should be taken into account at the design phase of the window integrated ventilation system. For example, for a typical bedroom of two people the ventilation rate is 30 m^3/h.

Energy performance and nZEB

Existing buildings are only obliged to comply with the Buildings Energy Performance Regulation of Greece (KENAK) when they are deeply renovated according to Greek law 4122/2013 amended in 2020 with the 4685. In the frame of this regulation deep renovation of a building is considered when the budget for the renovation exceeds the 25% of the buildings value that is also specified by a specific table. In this case, the building has to reach nZEB levels for existing buildings which means to reach energy class B+ according to KENAK and to fulfill a series of minimum requirements concerning the building shell as well as the building technical systems.

In any case, deep or no renovation, PLURAL target for all the demo buildings is to reach nZEB levels in respect with the national nZEB definition. In addition, all other minimum requirements of KENAK for deep renovation of existing buildings or even for new buildings will be met. These are first of all the U-values of the various parts of the building envelope. In the case of the Greek demo PLURAL renovation these are mostly walls and windows. Roofs and floors of the apartments of the first floor are adjacent to conditioned spaces. Walls according to KENAK (see section 2.2.5) have to reach a U-Value of 0.50 W/m^2K after renovation and new windows should have a U-Value less than 3.00 W/m^2K. According to the preliminary design of the Smart Wall, the opaque part will have a U-Value of 0.35 as there will be 10 cm of rockwool, or thinner vacuum panels where there is a limitation due to electromechanichal equipment (fan-coil or toolbox). Thermal bridges of the frame of the Smart Wall have been also taken into account. New windows

provided by BGTC are also going to have a U window value of around 1.30 W/m^{2}K and the air permeability will be of class 4 meaning the highest airtightness class according to the related standard which reduces the infiltration losses to the minimum.

Finally, the energy class of the post renovation without even taking into account the PV system is B+ which is concerned nZEB for existing building. When the generation of electricity by the PVs is taken into account the energy class is A+.

DHW will be covered by RES more than 60%, as for each of the two apartments a solar collector system will be installed while at the same time the heat pump used for heating will also provide heat for DHW when there is not enough solar irradiation. All water piping will be sufficiently insulated according to the regulation. Automation level of heating and cooling will be also higher than the minimum as there will be a per room autonomy. Finally, all systems accompanying the Smart Wall solution for the PLURAL renovation of the Greek demo will be new and in compliance with all relevant standards and directives (heat pumps by DAIKIN, solar collectors and PV panels) like the 2018/2002 directive.

RES and legal framework

Renewable energy sources installation is allowed in Greece and can be incorporated in buildings with the method of net metering with or without storage. The Greek demo fulfills all the requirements for such a system to be installed. However, the original idea of the Smart Wall concept was to have integrated PV panels and batteries in order to be autonomous. Due to the architecture of the building and the shading of the balconies this is not feasible, so the same area of panels that would be integrated will be installed on the roof. In the frame of PLURAL project, the ambition is to have one PV system with storage for each apartment, with the possibility of exchange of energy between them (“hand shaking”) and with no connection to the grid and no net-metering method. This is because the purpose is to investigate the ability of the Smart Wall to be autonomous. A separate power line to all the Smart Wall loads will be installed for this purpose while appropriate equipment will be installed in order not to allow flow of power to the grid.

Conclusions

Most of the regulations requirements are fulfilled but not all interventions like the add on prefabricated Smart Wall are fully covered by them. Therefore, additional testing is going to be made, to ensure the safety of the users after the renovation components will be installed. Finally, some properties of basic components like the windows are yet to be defined. This means that when the design is finalized and all data are available a final regulation compliance check should be made.

4.2 Czech Real Demo building case

General building and urban planning

According to the current preliminary design, the renovation plan of the Czech demo building in Kassava will include a change of the building's shape and volume. This means that an existing part of the building will be demolished and will be replaced by a new, different one. For this reason, and according to the Act on town and country planning (section 2.4.1) a building permit is necessary from the respective authority.

Mechanical resistance, stability and seismic behavior

According to the preliminary design (PLURAL Deliverable D7.1_R3) the change at the second floor, where the inclined roof will be removed in order for more living space to be created, will not affect vertical and horizontal load bearing structures. However, due to the addition of the eWHC panels externally to the existing walls and of new walls and roof, the existing load bearing capability should be ensured. In other words, the new structure of the second floor and the anchorage system of the PnU modules that will attach to the existing walls have to comply with the structural regulations of Czech Republic which are based to the Eurocodes. Wind and snow load will also have to be taken into account.

Fire safety

Czech regulations and codes for fire safety in Buildings are quite complex as they combine various codes with standards. A basic categorization which determines the grade of fire resistance (FRG) as described in the regulations (section 2.4.3), is the combustibility category of the building's construction system. For example, the existing load bearing walls and slabs are from non-combustible materials. However, the roof has wooden beams which are combustible. Then the fire load should be calculated. Given the two factors above and considering the height of the building and the fire compartments the fire resistance grade occurs. From this overall grade it is then determined the fire resistance grade of every structural element depending on its location in the building (floor, external, internal etc).

In any case, a full fire safety study has to be carried out because of the change of the existing building and the addition of new structural elements. In this study the external and internal finishing requirements (CSN 73 0810, specification in CSN 73 083, CSN 73 0802) should be also included as the PLURAL solution for the demo building is going to have a timber façade which is combustible.

Hygiene, health and environment

In this category minimum requirements of Czech national regulations for daylight, ventilation and heating are described.

Daylight requirements are set in the ČSN EN 17037 where the main parameter to be assessed is the direct sunlight and the requirement to fall into living spaces for at least 90 min between February the 1st and

March the 21. The second floor of the demo building will be redesigned and should take the latest daylight requirements into account.

Ventilation requirements in the residential buildings are set in various regulations and standards. Requirements can be also found in the energy performance regulations about indoor environmental parameters which presents categories of indoor air quality. More detailed requirements are set in ČSN EN 15665 according to which permanent ventilation of at least 15 m^3/h should be set in living spaces with a recommended value of 25 m^3/h while in kitchens, bathrooms and toilets occasional ventilation should apply with respective minimum and recommended values of 100/150, 50/90 and 25/50.

The existing demo building was ventilated naturally by opening the windows. After a window replacement a few years ago moisture problems started due to higher air-tightness. This shows that the infiltration rate used to be very high with the old windows functioning as permanent ventilation. At the same time this highlights the need for adequate ventilation. In the frame of the new ventilation strategy of PLURAL renovation it should be ensured that the minimum values are met with the mechanical ventilation with heat recovery through window frames or with more typical systems (for bathrooms and kitchen). The flow rates of the window embedded ventilation are not yet known and in case its insufficient additional systems should be added.

Protection against noise

Acoustics comfort requirements are set by regulations and strongly depend on the performance of the windows. Apart from providing sound insulation from the outdoor area, the embedded mechanical ventilation system should also comply with the regulation. As far as the opaque elements is concerned, it is mostly certain that they will perform very well providing sound insulation, as the eWHC system with the timber framed façade is going to be added on the existing walls. Nevertheless, in order to ensure high acoustics quality, traffic and ventilation noise investigation when all of the components properties are finalized has to be carried out.

Energy performance and nZEB

In the frame of PLURAL project, the renovation ambition of the demo building in Kasava is to reach nZEB standards. For this reason, the energy assessment will be based at new building levels even if existing buildings are not obliged to reach nZEB standard (unless a subsidy for upgrade dictates that). In any case, majorly renovated buildings should comply with a combination of energy consumption reduction and overall U value of the building envelope U_{em}. This means that these indicator's values should be under the reference values.

The nZEB requirements demand an extra reduction in the energy consumption of the previously reference ones. For single family houses the reduction should be 25% on the non-renewable primary energy and 30% on the U_{em}. In the case of Kasava demo the reference value is 0.41 and for nZEB standard it is 0.29. After the initial simulation a U_{em} of 0.31 was achieved based on the U-values of the separate components. This is

not fulfilling the nZEB requirement but is very close and there are margins for improvement. From 2022, extra reduction in the energy consumption should be achieved that is in range of 20% to 60% for residential buildings depending on the specific heating needs.

Thermal properties of separate envelope elements requirements are set by a national Czech standard in terms of minimum, recommended and passive buildings values. Based on the preliminary design U-values of the walls are within required values but in some elements are slightly higher than the recommended ones. The same also stand for the roof while the floor value is marginally within maximum required but far from the passive ones.

Windows specifications are to be wooden framed with double or triple glazing and U-values of the whole windows 1.3 and 1.0 W/m² K respectively which are between the values of recommended and passive building ones.

The heating and cooling system of the building will be done through the eWHC module with wall heating and cooling piping system fed by a heat pump. As the heating will be a low temperature based the efficiency of the heating mode is expected to be very high.

RES legal framework

PV panels integration to the demo building is planned to be part of the buildings renovation. The preliminary design puts the PV panels on the south inclined new roof which will probably be integrated with the prefabricated roof panels. The number of PVs and the installed power remains to be determined ta later stage simulations. According to the regulations an electric energy “micro source” of up to 10 kW can be installed with simplified connection method if a series of requirements are met regarding the impedance and the flow of the electricity towards the grid. This will be the case for the demo building demo. For higher capacity systems above 10 kW special license is required and a more complex process in case there is also energy fed in the grid with price agreement.

Conclusions

Czech demo building renovation scheme has a main characteristic of changing the shape and volume of the upper half of the building. This by nature creates the need for new designs and assessment to be carried out for structural competency and fire safety in order to fulfill the respective regulations requirements. In addition, finalization of the windows design and their technical properties will also determine the acoustics regulation compliance as well as the ventilation one. Regarding energy performance, the preliminary design falls a little bit short from the nZEB standards for new buildings in the Czech Republic and it also has to be decided if the new nZEB levels of 2022 should be reached too.

4.3 Spanish Real Demo building case

General building and urban planning

The general Spanish building regulation provided, refer mostly to the quality standards of the structure, the materials and the equipment incorporated in a building. In the case of the PLURAL solution for the Spanish demo building in Terrassa, the PnU kit that will be installed is a combination of a mechanical system (ventilation unit with active heat recovery system) and the ventilated prefabricated façade of Denvelops. The second one is already in the market and its materials and structure is applied and tested previously. The ventilation unit on the other hand is more of an innovative product may need a special technical evaluation in order to prove compliance with the basic demands of the Spanish Technical Building Code.

In relation with urban planning regulations that apply in Terrassa region, the main points that that can affect the PLURAL renovation is the urban line of the façade which restricts the total thickness of the façade and the maximum height in case the roof PnU kit will exceed the existing building height. In the case of the first point, according to the data available, the existing façade of the building is in line with the urban line (east façade of the building). Which creates an issue about the violation of the urban line when the prefabricated façade will attach the existing one. However, the prefabricated façade is not planned to be installed at the ground floor but only at the facades of the first and second floor where probably it is allowed to exceed the line in case there is a balcony, or a mechanical system mounted to the wall (like split unit).

Finally, regional regulation of the Catalan government imposes some requirements for ensuring habitability in residential houses that will be examined in the hygiene related regulations.

Mechanical resistance, stability and seismic behavior

The demo building in Terrassa, Spain is made of reinforced concrete structure. An updated Spanish regulation about concrete structures was issued in June 2021 Therefore, the building's structure should be reviewed according to it, to inspect its current condition and to ensure that it fulfills all latest requirements. A full structural survey of the building will be performed to verify each floor status. Further reparation will take place during the first renovation phase in order to restore any damage on the structures which are mostly superficial and moisture due to lack of maintenance.

As far the ventilated façade structure is concerned, the system does not contribute to the stability of the building. The façade structure should comply with the regulations attaining its own essential structural safety requirements taking into account the incorporation of all the components attached on it.

Fire safety

Only the part of the regulation of fire safety in buildings about external fire spread protection is taken into account in this demo building as the intervention will be on the external side of the walls. All other parts of the regulation concern the existing structure and architecture of the building which is not going to change.

The first requirement is about fire resistance of structural elements so it mostly refers to the existing structure. If an element has a fire resistance (EI) lower than 60 min, then a minimum distance from other elements of neighbor buildings should apply depending on the angle of the external walls. Due to the fact that the demo building has an internal courtyard and in the ground floor the angles between the walls is less than 90^{o}, it should be checked that in case the openings have a less than 60 EI if the distances are within limits given the fact that the external walls themselves are made from reinforced concrete and masonry which means at least 60 min EI.

The second has to do with façades and fire reaction classes in order to prevent fire spread on the external part of the building and it is the most important one as it is affected by the PLURAL solution which is the ventilated façade of Denvelops. More specifically in a building more than 10m of height the reaction to fire of the façade elements should be at least C-s3,d0 including the inner layers unless the façade is protected by an EI 30 external layer. The regulation however specifies the fire resistance values for ventilated façades which is the case in Terrassa building. At least a B-s3,d0 class is required for the insulation layer between the ventilated façade and the existing wall for buildings 10 – 28 m of height.

According to the preliminary design of the PLURAL renovation (PLURAL D7_1, ANNEX ES02), the insulation, that will be added between the ventilated façade and the existing wall is planned to be glass wool with rock wool. Both glass wool and rock wool are considered incombustible materials and most insulation commercial products are rated with A1 or A2 at the European reaction to fire classification (Euroclass). However, from the preliminary design can be seen that the innovative ventilation unit (eAHC) is attached directly on the existing wall and it will include an insulation layer itself. Up to now this layer is a thin XPS layer which does not provide adequate thermal resistance and needs reconsideration. Either extra insulation will be put on top, or a layers of higher thermal resistance will replace XPS in the unit. In any case, the fire reaction properties of the external layer or of the unit itself should at least comply with the requirement defined above.

Hygiene and health

Regional regulation of Catalonia sets some minimum values of openings in living rooms and bedrooms which are 0.80 m^2 and 0.40 m^2 respectively, which are fulfilled. The renovation is not going to alter the openings area, so there is no danger of declining from these values.

Protection against moisture and internal air quality are considered the most relevant parts of the national related regulation (DB-HS). The first one gives some values about the façade's minimum water tightness depending on the wind exposure and the average rainfall. Accurate calculation of the final water tightness level cannot be done currently, however, in any case, the addition of the ventilated façade and the insulation layer in between will increase the existing values.

More important and highly related with the PLURAL renovation in the Spanish demo building is the ventilation requirement. The ventilation unit eAHC with heat recovery has to provide the minimum fresh air according to the Spanish technical code CTE, DB-HS that sets the air flow requirements depending on the

dwelling number and type of spaces. The ventilation strategy described in preliminary design of the Spanish demo has been based on the requirements of the code. In bedrooms the eAHC unit will be used for supply and extraction of air and it will be controlled by the IAQ sensor for optimized performance based on actual air quality measurements. Each unit has a flow rate of 20 – 90 m^3/h and when added together they cover the total minimum airflow for the apartment (e.g. 86.4 m^3/h for a 2-bedroom apartment). In the kitchens and the bathrooms of the dwellings there are typical extraction devices for each space (minimum of 50 l/s or 180 m^3/h for kitchen). What is more, in later discussions than the preliminary design report between the partners involved in the Spanish Demo building renovation it was suggested to also have a heat recovery ventilation system embedded in the frames of the new windows. This means that extra flow rates will be available in case the eAHC unit cannot cover the minimum requirements of a specific space (e.g. maximum heat recovery may be achieved in less than the maximum flow rate). What is left to be verified is the section area of the air inlet and extraction ducts that have to also fulfill a minimum requirement. This data is yet not available for the eAHC unit.

Protection against noise

According to the preliminary design the region of the building is quite noisy and to reach the regulation requirements highly sound insulating windows are required (with R_w=45 dB). What is suggested is an acoustic study to be carried out and to analyze more the situation and get more data. As far as the noise emitted from the eAHC unit is concerned, upgrades must be done in order to limit the noise level from the unit below 30 dB, as it will be attached on the existing wall and the thermal insulation that could also play the role of sound insulation will be on the external part of the unit.

As a conclusion, further analysis and upgrades should be made to verify compliance with the acoustics regulation and to ensure the indoor comfort of the building users.

Energy performance and nZEB

According with the PLURAL D7.1 and the national regulation related to energy performance of buildings (DBHE, CTE) if more than 25% of the thermal envelope of a building is renovated then all the building should comply with nZEB standard. For that reason and due to limited budget, the PLURAL renovation will take place only at a specific part of the building which will affect less than 25% of the envelope and only that part will reach nZEB level. After investigation of various renovation scenarios, the most attractive one due to various reasons is considered to be the one that renovates the front and back façade of the building at the first and second floor. This means that it is not obligatory to reach nZEB levels and to fulfill the requirements for deep renovation. However, the intention in the frame of PLURAL project is to reach such levels and use the regulation as guideline.

As a general requirement, for the climate zone of Terrassa, the total annual primary energy consumption of the building unit without taking into account any renewable energy generation should be limited to 32 kWh/m^2 for new buildings and 65 kWh/m^2 for renovated existing ones. The consumption values including

renewables are 64 and 90 kWh/m^2 respectively. These requirements if fulfilled are equivalent with nZEB standard. To reach this values, a RES system is required which is going to be a PV system.

Preliminary simulations made for the whole building showed that for renovated buildings standards, 104 m^2 of PVs on the roof or 125 m^2 in the roof and the east façade are required to reach the threshold values. To reach new building levels however, the PV panels should be installed on all available surfaces at the east facade and the roof with 167 and 144 m^2 of PVs respectively. This is practically not feasible and as long as the renovation nZEB standards are fulfilled it will be considered how many more PVs will be installed. This decision will take into account more realistic conditions and loads that in the theoretical framework of nZEB standards and energy consumption are not taken into account.

The size and location (roof and façade) of the PV system is under investigation and will be finalized when other specifications affecting energy demand are also determined.

Envelope

Envelope specific requirements that mostly affect the PLURAL renovation are the maximum U-values of external walls (0.49 W/m^{2}K), roofs (0.40 W/m^{2}K) and openings – windows (2.10 W/m^{2}K). In most part of the façade the 100 mm insulation with rock wool/glass wool that is intended to be used is more than enough to achieve the requested U-value. However, at the part where ventilation unit (eAHC) will be attached, the 20 mm of XPS of the initial design are not enough and other materials or additional external insulation should be considered in order to also cover the thermal bridges created by the device. Windows will be of aluminum frame with double glazing and Uw of around 1.8 W/m^{2}K.

An additional requirement is the solar gains which set a maximum level per unit of floor area in July. Solar shading is going to be integrated to the ventilated façade and is going to be easy to control the solar gains within limits.

Airtightness requirement sets as maximum infiltration the value of 9 m^3/hm^2. As the building is made of concrete and masonry the main factors of infiltration are the windows. Air permeability class of the new windows that are going to be installed should be transformed to the total dwelling value and check for compliance. Such data are not yet available.

Systems

According to the preliminary design the primary heating system of the demo building, the primary systems for heating will be the already installed electric radiators. The ventilation unit will provide also some heating but its capacity will be limited (600 W) while the COP depends on a number of factors. Further investigation of the regulation is needed to decide if the electric radiators is an acceptable heating system.

As far as cooling is concerned and following an update after the preliminary design the cooling system will be only the ventilation unit with limited cooling capacity. Again, further investigation needed for the actual

efficiency of the eAHC and for the cooling demand of the building unit to be renovated in order to find out if the eAHC can cover it and provide the requested thermal comfort in the summer.

Another requirement is that the 70% of the energy for DHW must come from renewables. The intention of the renovation is to replace the broken solar thermal collectors already installed at initial construction. 10 solar collectors of 2.5 m^2 area each are intended to be installed feeding a central boiler while one electric heater per apartment will cover the resto of the demand. The contribution of the solar energy to the total energy consumption for DHW needs further simulation.

Conclusion: Several issues related with various building regulations and technical codes compliance are still unsolved and have to be taken account in the next steps and design of the final PLURAL renovation overall strategy as well as the finalization of the PnU kit.

RES legal framework

Regulation about renewable energy installations and shelf consumption is quite simple and allows for either a self-consumption without surplus where all the energy generated is consumed on site or surplus option where either a net-metering type of method is applied or the renewable energy is sold in the electricity market. In any case, for a PV system more than 15 kWp a permit should be obtained.

Conclusions

From all of the above it can be concluded that regulation compliance in the Spanish demo case is yet to be resolved in a number of categories and matters. To the highest degree this happens due to the fact that some technical specifications of crucial components of the renovation (insulation of eAHC unit, windows) have not been finalized yet. Attention must be paid so all relevant regulation explained in this report to be taken into account in order not to have any compliance issues.

4.4 German Virtual Demo building case

General building and urban planning

German virtual demo building is going to be virtually renovated using the Smart Wall concept differentiated mostly with the type of materials used. More eco-friendly and reusable materials are chosen to match the philosophy of the real renovation that took place and to recognize possible difficulties caused by this material limitation.

In Berlin, according to the relevant regulation a major change in an existing building requires a building permit. It is unknown if for the renovation of 2007-2008 of the virtual demo building a permit was granted. Due to the major changes and small expands it is more likely that a permit was necessary.

Fire safety

As in all building fire safety, the requirements depend on the type of use. The virtual demo building in Berlin is a single family house with less than 7m of height and has low fire safety requirements. The most important one is the ceiling of the basement that has to be of incombustible materials or fire retardant. Similar requirements are set for the external walls. This means that sustainable, natural materials based on wood can be used with the appropriate treatment to become fire retardant.

Protection against noise

Noise protection regulations set requirements for sound insulation values for various types of noise sources to the indoor building spaces, depending also on the level of noise of the region. In the case of Berlin virtual demo building no attached buildings exist and the requirements are mostly for external sources sound reduction R_w index for the building elements which range from 25 to 50 db depending on the outside levels of noise. Attention should be given to the fan coil incorporated in the Smart Wall panel in case its sound behaviour changes due to the mounting on the structure of the wall panel.

Energy performance and nZEB

The respective regulation for energy performance of buildings sets the minimum requirements for the total primary energy consumption of the new buildings and for the total transmittance heat losses through the envelope, both respective to the reference building. U-Values of the various building envelope elements of the reference building set the maximum values. However, the preliminary design of the Berlin demo building, in order to reach nZEB standards, targets for a 0.14 W/m^2K U-Value for the external walls for example with a maximum allowed to be 0.24 W/m^2K for alterations to existing buildings. As nZEB standards the A+ or passive house category will be used as the definition is not very precise.

This means that the Smart Wall should incorporate an insulation layer thick enough to result in this performance. The parts of the Smart Wall that the embedded systems are located will have a bit lower performance as the insulation will be thinner. However, the frame of the Smart Wall will be from timber and not metallic like in the Greek demo building which creates a lot less thermal bridges. The roof is designed to be covered with similar prefabricated panels as the Smart Wall with some extra layers for waterproofing.

U-Value of windows should be less than 1.3 W/m^2K. Double glazing windows are going to be set for this virtual demo with aluminium frames and U_w of 1.2 W/m^2K. High airtightness is also a requirement both for opaque elements and windows. For this reason, the wooden joints of the wall panels will be sealed with tape.

A point that is not covered by the Smart Wall concept is the floor adjacent to the basement that is uninsulated and to comply with the regulations is should have a maximum U-Value of 0.35 W/m^2K.

AS far as building systems are concerned an air to water heat pump will be considered for heating, cooling and DHW. No solar collectors are included in the design as there will be a PV system generating electricity that can be consumed by the heat pump.

The regulation also sets requirements for a minimum coverage of the energy demand by renewables. This can be covered by a number of combinations depending on the available RES. In this case only a PV system will be considered which fits well with the requirement that 15% of the electricity consumption is covered by RES. Consequently, the PV system should be sized to cover at least this consumption.

RES legal framework

PV systems for self-consumption are allowed in Germany while the surplus is also sold to the grid. At low capacities the regulations are more favourable due to less energy fed in to the grid. In the virtual demo case of PLURAL renovation for Berlin residential building, a PV system is considered to be installed on the roof. The size of it will depend on the renewable share needed for nZEB standards while the analytical terms of the RES framework will be taken into account to select the optimal capacity.

4.5 Swiss Virtual Demo building case

General building and urban planning

In the case of the Swiss demo building located in Bern, the virtual renovation will follow the concept of the real renovation that took place in 2019, when apart from other interventions, the eWHC system for external wall heating and cooling was installed, but not as a fully prefabricated solution. Information about building permits needed for the actual renovation that took place are not currently available.

Mechanical resistance, stability and seismic behavior

For existing building there is a series of norms about structure preservation depending on the material, however no prefabricated additions are included. However, as the solution for this demo building includes external attach of prefabricated façade, the anchorage effectiveness and safety and the load bearing capacity of the existing structures should be investigated.

Fire safety

An existing building should comply with the latest fire safety regulations if there is a major change made during renovation or change in use. For the case of the building shell renovation it may not apply, however each case is examined separately and depending on the level of risk it may be forced to comply with the latest regulations at least as far as the materials area concerned.

Materials classification in respect to their reaction to fire are divided in four categories instead of six at the Euroclass system. For preventing the fire spread to neighbouring buildings depending on the distance

between them, certain reaction to fire class is required for the external walls and for distances under 10, 7.5 or 5 meters. In our case the building is not that close its neighbouring ones.

Protection against noise

Regulation for noise protection in buildings set limit values for various types of spaces and for external or internal sound sources. The sound insulation the building envelope provides against external airborne noise should result in less than 31 dB inside the space for medium sensitivity rooms (all residential spaces are in this category). This stands if the area is away from heavy traffic. Another issue that needs to be addressed is the requirements from sounds coming from technical installations of the building that has to be limited to 33/38 dB (A) depending on the type of function.

Energy Performance and nZEB

Energy performance requirements are set for new buildings and for change of use or renovation of existing ones. Different, U-Value limitations for new and existing are defined in the regulation. However, PLURAL's target is to reach nZEB levels so the stricter requirements possible will be taken into account. The real renovation took place already complies with the respective maximum values for each element and in the same direction will go the virtual renovation. Windows, for example, wiil be of PVC or aluminum frame with triple glazing are designed to have a U_w of 0.9 W/m^{2}K.

Swiss regulation sets also threshold values for all types of building uses for heating demand and heating load as well as limit values for the global weighted energy demand taking into account heating, cooling, DHW and ventilation and calculated with a specified formula. Requirements on technical systems are also set and some of them related with PLURAL renovation concept are:

- Limitation on water supply temperature for heating systems like 35^o for floor heating – to be checked with the external wall heating system eWHC water temperature.
- minimum heat recovery ratio for ventilation systems – to be checked with the decentralized window integrated ventilation system or the eAHC unit
- minimum electricity demand for cooling – to be checked with both eWHC and eAHC when in cooling mode

In addition, a minimum electricity generation from RES of 10 W/m^2 of floor area is required.

Finally, the nZEB definition is not yet fully defined in Switzerland in terms of specific energy class or threshold values however in relation with the national energy label system for buildings, a specific label can be used as the nZEB one for the purpose of PLURAL.

RES legal framework

In Switzerland the electricity generated from a RES system can be sold consumed or be sold to the grid. There is no net metering method. Tariffs are subject of municipalities. In the virtual demo case of Bern, the

ideal PV total installed power will depend on the heat pump's (for eWHC) or eAHC system's consumptions and the ideal connection regime depends on the total electricity consumption of the building.

4.6 Swedish Virtual Demo building case

General building and urban planning

According to the Swedish related regulations, if the virtual renovation of the demo building in Väsby was going to be implemented for real, a building permit would be required due to changes on the façade of the building. Swedish regulation tends to be stricter on the external changes of the buildings. The PLURAL solution that is going to be virtually tested is the one of eWHC concept altered to include more sustainable materials and based on recyclability.

Structural stability and anchorage of the prefabricated façade should be reviewed especially for this relatively high rise building as wind loads are going to be higher.

Fire safety

Based on type of use, population and height of building a classification regarding fire safety is formed in the respective regulation of Sweden. There 4 classes and the virtual demo building of Väsby belongs to class Br1 which is the second more strict due to its height. This means that ceilings should have surface finishes of fire resistance class B-s1,d0, attached to material of A2-s1,d0 or clad in fire resistance class K210/B-s1,d0. Wall surfaces should have surface finishes of at least fire resistance class C-s2,d0. For the exterior walls, extensive requirements for the specific building class are presented in section 2.7.2 and has to be taken into account for the façade materials selection in order to present, even virtually, a façade that could also be applied in reality.

Noise protection

Indicative limits for noise in the building spaces are given however they are not binding.

Energy performance and nZEB

The respective regulation sets the maximum primary energy consumption value for multifamily houses which is 85 kWh/ m^2a. In addition, it sets a maximum value of overall building envelope U-Value of 0.4 W/m^2_{env}K and a maximum electric input capacity for heating and DHW of 47.3 kW. Separate building elements U-Values are also given and there is possibility for exceptions when it is not technically feasible. nZEB standard is the same as above for new buildings, 85 kWh/ m^2a of maximum primary energy consumption without a RES obligation.

RES legal framework

According to the latest National Survey Report of PV Power Applications in Sweden self-consumption by PV systems and selling to the grid are available in Sweden as well as collective self-consumption and virtual net-metering.

5 Conclusions

The basic goal of this deliverable of the PLURAL project was to make an extensive review of the European and national regulations and technical codes (chapter 1 and chapter 2 respectively) which are related with all possible aspects of the project's renovation concepts and their implementation at the demo buildings. The regulations subjects are building construction permits and urban planning, mechanical resistance, fire safety, safety and hygiene, noise protection, energy performance as well as the legal framework of RES installation and self-consumption in buildings.

A first conclusion derived by this review is that installation of prefabricated elements/façades and in general, kits that combine structural parts with electromechanical equipment, is not yet included in the national regulations and codes. Because this renovation concept is relatively new, this lack of regulatory framework is reasonable. As one of the PLURAL's scope is to demonstrate the applicability of such prefabricated renovation, this regulatory issue should be addressed in order to tackle all barriers for future market penetration potential. The second conclusion about national regulations is that they are quite similar to each other and are based in common methodologies and guidelines. One basic difference however was at the definition of the nZEB which is of particular interest in PLURAL as it affects directly the renovation specifications. Even though the term indicates a very low energy demanding building, the specific requirements that have to be met for a building to be considered as nZEB for each country were quite different.

Apart from regulations, an attempt was made to gather all the standards and certifications of the basic components of the PnU kits and the additional ones involved in the broader PLURAL renovation concepts of the demo cases (chapter 3). Due to the early stage of the project it was not possible to obtain the full list at the moment, while some components are going to be constructed specifically for the PLURALs demonstration needs. Conclusive standardization and certification list will be included in the next Deliverable of PLURAL, D1.3.

The last part of the report was a preliminary assessment of compliance of the PLURAL renovations at all demo buildings with the respective regulations reviewed. At this stage, the assessment was based mostly on the current state and preliminary renovation design of every demo building. This means that not all technical specifications of the materials and systems of the interventions are available which means that further compliance assessment will be necessary. However, the general orientation of the renovation strategies has taken into account the most significant parts of the regulations and no significant deviations were observed. Full compliance with the regulations will be then a matter of design finalization, improvements and systems and materials selection, which will be implemented during WPs to follow.

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7 Annexes

7.1 Annex I

Standard parts that provide the fire classification procedure for either fire reaction or fire resistance, depending on the type of product.

TABLE 7.1-1: STANDARDS USED FOR FIRE CLASSIFICATION OF CONSTRUCTION PRODUCTS

	Title	Description
EN 13501-1:2018	Part 1: Classification using data from reaction to fire tests	Reaction to fire classification procedure for all construction products, including products incorporated within building elements. Products are considered in relation to their end use application. Applies to three categories: • construction products, excluding floorings and linear pipe thermal insulation products • floorings • linear pipe thermal insulation products
EN 13501-2:2016	Part 2: Classification using data from fire resistance tests, excluding ventilation services	Specifies the procedure for classification of construction products and building elements using data from fire resistance and smoke leakage tests which are within the direct field of application of the relevant test method. Deals with: a) loadbearing elements without a fire separating function: walls; floors; roofs; beams; columns; balconies; walkways; stairs. b) loadbearing elements with a fire separating function, with or without glazing, services and fixtures: walls; floors; roofs; raised floors. c) products and systems for protecting elements or parts of the works: ceilings with no independent fire resistance; fire protective coatings, claddings and screens; d) non-loadbearing elements or parts of works, with or without glazing, services and fixtures: partitions; facades (curtain walls) and external walls; ceilings with independent fire resistance; raised floors fire doors and shutters and their closing devices; smoke control doors; conveyor systems and their closures; penetration seals; linear gap seals; service ducts and shafts; chimneys. e) wall and ceiling coverings with fire protection ability f) lift landing doors which are tested according to EN 81-58 are excluded from this European Standard
EN 13501-3:2005 +A1:2009	Part 3: Classification using data from fire resistance tests on products and elements used in building service	Specifies the procedure for classification of the resistance to fire performance of construction products and building elements used as components of building service installations, using data from fire resistance tests which are within the direct field of application of the relevant test method. Products/elements for use in ventilation systems include (excluding smoke and heat exhaust ventilation):

	installations: fire resisting ducts and fire dampers	• fire resisting ducts • fire dampers
EN 13501-4:2016	Part 4: Classification using data from fire resistance tests on components of smoke control systems	Specifies the procedure for classification of components of smoke control systems, using data from fire resistance tests which are within the field of application of the relevant test methods. Products covered by this European Standard are: • smoke control ducts • smoke control dampers • smoke barriers • powered smoke and heat exhaust ventilators (fans), including connectors • natural smoke and heat exhaust ventilators
EN 13501-5:2016	Part 5: Classification using data from external fire exposure to roofs tests	Provides the fire performance classification procedures for roofs/roof coverings exposed to external fire based on the four test methods given in CEN/TS 1187:2012 and the relevant extended application rules. For the classification of a roof/roof covering, only those test methods and those application rules need to be applied for which the corresponding classification is envisaged. Products are considered in relation to their end use application. NOTE: The distinction between roofs with a steep slope and facades, in terms of the test and classification standard to be applied, may be subject to national regulations.
EN 13501-6:2018	Part 6: Classification using data from reaction to fire tests on power, control and communication cables	Provides the reaction to fire classification procedure for electric cables. NOTE: For the purpose of this European Standard the term "electric cables" covers all power, control and communication cables, including optical fibre cables.

TABLE 7.1-2: DESCRIPTION OF FIRE REACTION OF THE VARIOUS EUROCLASSES AND SUBCLASSES

Main Class	Subclass Smoke visibility	Subclass Burning droplets
Non-combustible materials: No contribution to fire at any stage of the fire		
A1	Not applicable	Not applicable
Non-combustible materials: No significant contribution to fire at any stage of the fire		
A2	s1, s2 or s3	d0, d1 or d2

Combustible materials: very limited contribution to fire: Very limited heat release and flame spread during the growth stage of a fire		
B	s1, s2 or s3	d0, d1 or d2
Combustible materials: limited contribution to a fire: Limited heat release and flame spread during the growth stage of a fire.		
C	s1, s2 or s3	d0, d1 or d2
Combustible materials: medium contribution to a fire: Will resist a small flame attack for longer at the beginning of the fire and will exhibit sufficiently delayed and limited heat release during the growth stage of the fire.		
D	s1, s2 or s3	d0, d1 or d2
Combustible materials: highly contribution to a fire: Will resist only a small flame attack in the beginning of the fire		
E	Not applicable	d2
Combustible materials: easily flammable: Unacceptable fire behaviour		
F	Not applicable	Not applicable

When assessing construction products (other than flooring), the Euroclass system uses tests according to the relative standards presented in the table:

TABLE 7.1-3: STANDARDS USED FOR ASSESSING CONSTRUCTION PRODUCTS FOR THE EUROCLASS SYSTEM

Euroclass	Coverage
A1	EN ISO 1182 and EN ISO 1716
A2	EN ISO 1182 or EN ISO 1716 and EN 13823 (SBI)
B, C, D	EN 13823 (SBI) and EN ISO 11925-2
E	EN ISO 11925-2

F	Fire behavior not determined/no performance

TABLE 7.1-4: SMOKE AND FLAMING DROPLETS/PARTICLES EMISSION SUBCLASSES DEFINITONS

Class	SBI Criteria	
Smoke Production	s1	SMOGRA ≤ 30 m^2/s^2; and TSP ≤ 50 m^2 within the evaluation period
Smoke Production	s2	SMOGRA ≤ 180 m^2/s^2; and TSP ≤ 200 m^2 within the evaluation period
Smoke Production	s3	Products does not comply with either of the above
Flaming Droplets/Particles	d0	No flaming particles/droplets occur within the evaluation period
Flaming Droplets/Particles	d1	No flaming particles/droplets lasting longer than 10s occur within the evaluation period
Flaming Droplets/Particles	d2	Product does not comply with either of the above