CRoatian One-Stop-Shop

D3.1 Guidelines for cost-effective renovation

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CRoatian One-Stop-Shop

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About CROSS

The general project objective of the CROSS project is to establish and operate a regional one-stop-shop (OSS) in order to accelerate the renovation wave in the public sector covering a territory of four regional and 88 local authorities in Croatia and offering a comprehensive, all-inclusive service from technical, financial to legal advice, procurement and quality assurance of works. The long-term objective is to replicate this concept to a wider area covering Croatia and beyond as well as to ensure the long term sustainability of the OSS.

CROSS will achieve the targeted impacts and goals set out in the project through the completion of the following specific project objectives:

1. Speed-up of public building renovation
2. Provision of support for the preparation of project pipelines
3. Development, validation and implementation of advanced funding, procurement and financing models
4. Stakeholder engagement and long-term sustainability

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1. Description of GDSG project guideline

Project guideline for drawing up of technical documentation (conceptual, main and detailed design) for the construction and/or renovation of public buildings according to the features of the European Green Deal (hereinafter GDSG project guideline) serves primarily as information for designers, but also for all other participants in construction, so that in the phase of preparation and drawing up of project and technical documentation, aspects essential for achieving a sustainable construction standard for public buildings are taken into account.

1.1. European and national framework

For the purpose of construction and/or renovation of public buildings according to the principles of sustainable construction standards, it is necessary to create a conceptual solution and a conceptual/main/detailed design in accordance with the project guidelines below. Although there is a legal obligation in force that all new buildings for which an application for a building permit is submitted from December 31, 2019, must meet the requirements for nearly zero energy buildings (hereinafter: nZEB), **the GDSG project guideline (GDSG - Green Deal Construction Guidelines) in question was created in accordance with the European Green Deal I[1], i.e., one of the strategic priorities of the European Commission, and represents a superstandard**. The European Green Deal is a new growth strategy that aims to transform the EU into a fair and prosperous society with a modern, resource-efficient and competitive economy in which there will be no net greenhouse gas emissions in 2050 and in which economic growth is not linked to the use of resources. The mentioned Deal consists of eight elements, for this guideline the one on construction and renovation with efficient use of energy and resources is particularly relevant, as well as the relevant strategy of the Renovation Wave for Europe[2]. Considerable amounts of energy are required for the construction and renovation of buildings, while in use the share of energy for buildings in the total energy used is about 40%. The European Commission is stepping up its ambitions to achieve the set goals of this Deal: at least doubling the annual rate of building renovation, strict enforcement of legislation related to the energy performance of buildings, the possibility of including emission allowances from buildings in the European trading of emission allowances, review of the regulation on construction products and the creation of an open platform which will bring together all stakeholders in the buildings and construction sector in order to remove all obstacles to the realization of the goals of this Deal. Through such action, it should be ensured that the design of new and renovated buildings is in all phases in accordance with the needs of the circular economy and that it leads to greater digitization and resistance of buildings to climate change[3].

[1] Available at: https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en
[2] Available at: https://ec.europa.eu/commission/presscorner/detail/en/IP_20_1835
[3] Available at: http://bpie.eu/wp-content/uploads/2020/04/An-action-plan-for-the-renovation-wave_DIGITAL_final.pdf

This ambitious Deal is accompanied by a system of financing construction and renovation projects with EU funds. The main instruments that can be used to finance infrastructure (including buildings) with EU funds in the 2021-2027 program period include the InvestEU programme, the Connecting Europe Facility (CEF), the European Regional Development Fund (ERDF), the Cohesion Fund (CF), the Just Transition Fund (JTF) and the Recovery and Resilience Facility (RRF). In order for projects and project documentation for the construction and/or renovation of buildings to be acceptable for financing with EU funds, they must be prepared and designed in such a way that they are aligned with the goals, principles and criteria given in individual calls for proposals, horizontal policies of the EU, the "do no significant harm" (DNSH) principles and Technical guidance on the climate proofing of infrastructure in the period 2021-2027 (2021/C 373/01) – in more detail in chapter 1.3[4].

The legislative framework of the Republic of Croatia mandates that when drawing up the project and technical documentation, designers adhere to the technical guidelines for nearly zero energy buildings[5]). **This project guideline represents a step up, both in terms of the share of renewable energy sources, energy efficiency, the quality of the building's external envelope and thermal protection, comfort and quality in use, ensuring healthy indoor climate conditions, application of a central monitoring and management system (hereinafter: CNUS), quality in the design and use of outdoor spaces, rational use of water, increased safety in case of fire, increased seismic resistance of the building, resistance of the building to climate change, possibility of easy cleaning and maintenance, thus applying numerous aspects of sustainability and circular management of buildings.**

Directive (EU) 2018/844 of the European Parliament and the Council of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency was incorporated into the currently valid Construction Act. Regardless of whether the buildings are under conservation protection or not, energy renovation alone is not enough, but the aforementioned Directive recommends considering the possibility of comprehensive renovation, which, in addition to energy renovation measures, also includes rehabilitation, measures to improve the fulfillment of the basic requirement of mechanical resistance and stability of the building - especially to increase seismic resistance of the building, measures to increase safety in case of fire, measures to ensure healthy indoor climate conditions and other measures that improve the basic requirements for the building. The GDSG project guideline necessarily provides for an integral or in-depth approach to energy renovation, and at the same time implies the application of all energy efficiency measures, which include measures for the external envelope of the building and measures for the technical systems of the building, as well as the use of renewable energy sources (75% of the supplied

[4] Available at: https://eur-lex.europa.eu/legal- content/HR/TXT/?uri=CELEX:52021XC0916(03)&qid=1632821761973

[5] Available at: https://mpgi.gov.hr/naslovna-blokovi/o-ministarstvu-15/djelokrug/energetska-ucinkovitost-u- zgradarstvu/smjernice-za-zgrade-gotovo-nulte-energije/10502

energy must be obtained from renewable energy sources); all the while respecting the principle of building sustainability throughout the entire life cycle.

1.2. Comprehensive approach

In accordance with the above, the GDSG project guideline represents a complete, comprehensive, holistic process of planning, preparation, conception, design, construction/renovation, maintenance, use and management and demolition of buildings based on the principle of sustainability throughout the entire life cycle, and represents a kind of higher standard compared to the current legislative framework. The application of the GDSG project guideline covers a large number of construction aspects such as:

- designing according to the principles of sustainable construction, green, healthy, comfortable and safe buildings as well as ways of fulfilling all the basic requirements for the building;
- application of measures to improve the fulfillment of the basic requirement of mechanical resistance and stability of the building (especially to increase the seismic resistance of the building) in the reconstruction of existing buildings, i.e., improvement of the fulfillment of the basic requirement of mechanical resistance and stability in new buildings;
- application of measures to increase safety in case of fire during the reconstruction of existing buildings;
- implementation of measures to ensure healthy indoor climate conditions;
- application of noise protection measures in existing buildings;
- levels of energy efficiency in buildings sector and building systems;
- share of renewable energy sources;
- rational use of water and mandatory application of technical solutions for its storage;
- standards of the interior space in accordance with the purpose, quality and comfort, method of shaping and application of materials;
- possibilities of multi-purpose use of internal and external spaces of buildings and their adaptability to emerging needs;
- implementation of measures to improve unhindered access and movement in the building;
- sustainable green landscape planning and the application of solutions based on nature:
- application of measures for sustainable urban mobility;
- obligations to use environmentally friendly and recycled materials and proper disposal of construction waste with an LCA *(Life Cycle Assessment)* budget;
- obligations to apply BIM *(Building Information Modelling)* approach to construction/reconstruction and building management;

- obligation to be included in the creation of the project task and project documentation of goals, principles, conditions and criteria given in the documents that describe the management of funding from the EU;
- obligation to be included in the drafting of the project task and project documentation of horizontal EU policies on sustainable development, accessibility for persons with disabilities, gender equality and non-discrimination, i.e., the project must contribute to these policies or at least be neutral in relation to them;
- the obligation to comply with the "do no significant harm" (DNSH) principle;
- obligation to adjust the project documentation to the *Technical guidance on the climate proofing of infrastructure in the period 2021-2027 (2021/C 373/01)*[6].

The content of this document is applicable to both new and existing buildings, as well as simple and other buildings and works that can be carried out without a building permit in accordance with the main design in accordance with *Ordinance on simple and other construction works and works* (Official Gazette 112/17, 34/18, 36/19, 98/19, 31/20 and 74/22) and *Ordinance on less complex works* (Official Gazette 14/20). This GDSG project guideline represents an instruction to designers, and they are not obliged to use it if it is inconsistent with the valid legislative framework or valid standards. **All deviations from the GDSG project guideline during the drawing up of the conceptual solution and conceptual/main/detailed design, the designer is obliged to communicate with the client (representative of the public sector) and explain the reasons for the deviation.**

1.3. Process of drawing up project documentation

In order to ensure the quality control of drawing up project documentation, it is necessary to define the process of preparation and drawing up, that is, to define control mechanisms. Figure 1 below shows the process of drawing up project documentation for construction from the beginning, that is, from the conception of the design to the start of construction.

Given that the design process is an iterative process during which different design solutions are analyzed, which further need to be integrated into one complete solution, it is necessary to communicate these design solutions with the client during the creation of project documentation. These guidelines also aim to change the very common practice where complete designs are delivered to the client, where the possibility of revising and changing design solutions is significantly reduced without significantly extending the planned design period. **Also, these GDSG project guidelines support a systematic approach to the design process where design solutions are analyzed and optimized in the process of drawing up project documentation with the aim of selecting the best quality solutions within the given limitations.**

The phase of planning and conceptualizing the project, which will result in the creation of project tasks for the drawing up of project technical documentation (conceptual, main and

[6] Available at: https://eur-lex.europa.eu/legal-content/HR/TXT/?uri=CELEX:52021XC0916(03)&qid=1632821761973

detailed design), is extremely important. During this phase, it is necessary to define technical, functional and programme requirements, look at spatial planning conditions, limitations and possibilities (with which the project must be harmonized) and other applicable regulations. When reconstructing, extending and/or renovating existing buildings, it is necessary to carry out an inspection and analysis of the existing condition of the building (energy audit, analysis of the state of the structural system, fire protection, indoor climate conditions). It is necessary to acquire bases and create documentation that is applicable considering the topic, scope and goals of the project (location information, geodetic survey, geomechanical study, feasibility study, environmental impact assessment, consolidated documentation on review/preparation for climate change, etc.). In this preparatory phase, it is also necessary to resolve property and legal issues and perform an initial analysis of eligibility for EU funding.

In order for projects to be eligible for EU funding, when drawing up the project task, it is necessary to include the goals, principles and criteria set in the call for proposals, horizontal EU policy on sustainable development, accessibility for persons with disabilities, gender equality and non-discrimination, i.e., the project must contribute to these policies or at least be neutral in relation to them.

It is especially important to design in accordance with the "do no significant harm" (DNSH) principle. In this regard, as described by the EU Regulation 2021/241 on the establishment of the Recovery and Resilience Facility, all investments must contribute to the objectives of Regulation (EU) 2020/852 of the European Parliament and of the Council of 18 June 2020 establishing a framework to facilitate sustainable investment and amending Regulation (EU) 2019/2088:

1. Mitigation of climate change;
2. Adaptation to climate change;
3. Sustainable use and protection of water and marine resources;
4. Circular economy, including waste prevention and recycling;
5. Prevention and control of air, water or soil pollution;
6. Protection and restoration of biological diversity and ecosystems.

Regarding the goals for mitigating and adapting to climate change, the project documentation should be aligned with Technical guidance on the climate proofing of infrastructure in the period 2021-2027 (2021/C 373/01)[7] . Preparing for climate change is the process of including climate change mitigation and adaptation measures in the development of infrastructure projects (including buildings). It enables European institutional and private investors to make informed decisions about projects that are in line with the Paris Agreement. The process is divided into two pillars (mitigation, adaptation) and two phases (review, detailed analysis). The implementation of the detailed analysis depends on the outcomes of the review, which helps to reduce the administrative burden. Figure 2 shows a diagram of the process of preparing

[7] https://eur-lex.europa.eu/legal-content/HR/TXT/?uri=CELEX:52021XC0916(03)&qid=1632821761973

documentation for climate change with the pillars of "climate neutrality" and "resilience to climate change".

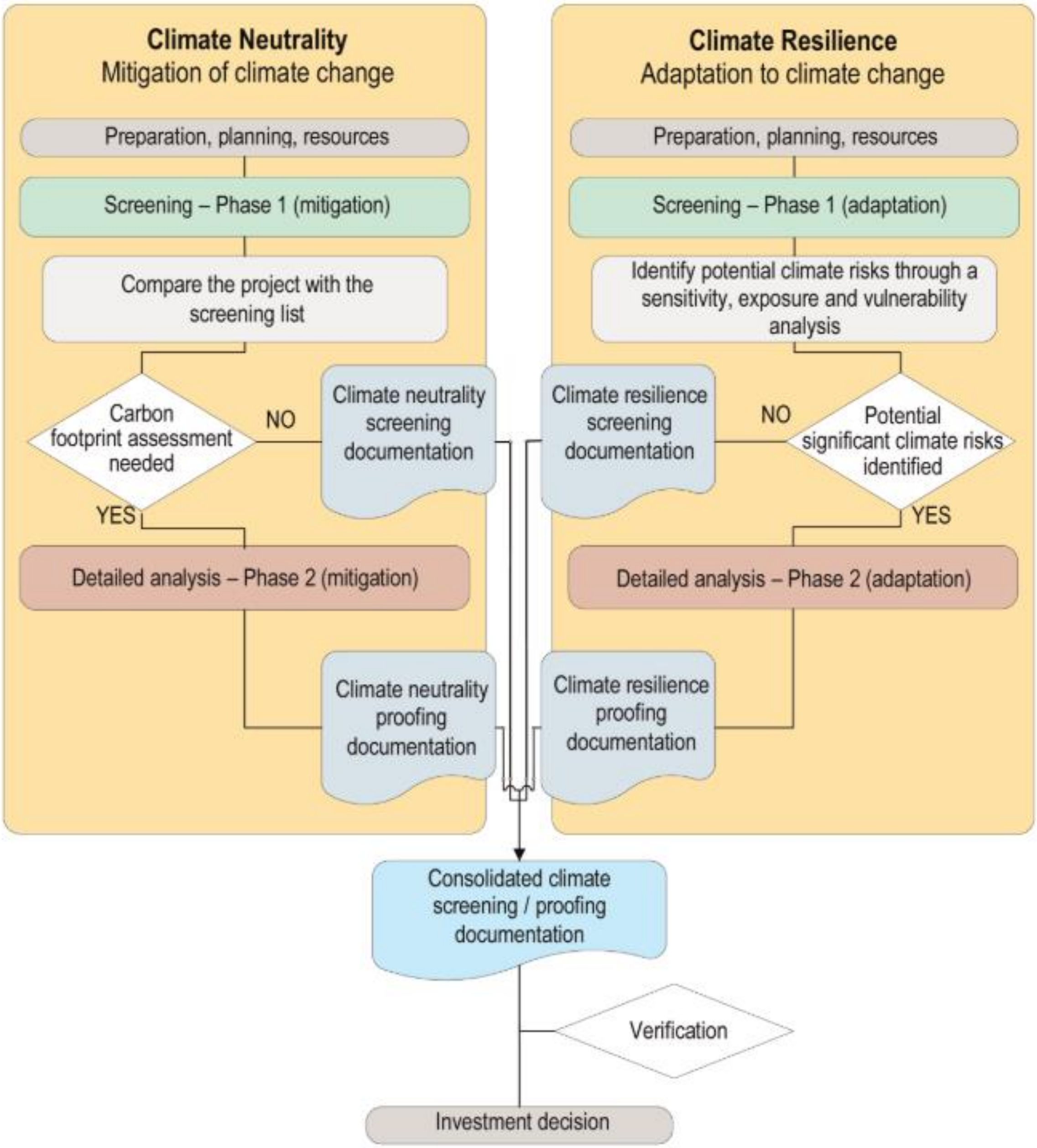


Figure 1. Process of preparing climate change documentation (Source: *Technical guidance on the climate proofing of infrastructure in the period 2021-2027 (2021/C 373/01)*[8])

[8] https://eur-lex.europa.eu/legal-content/HR/TXT/?uri=CELEX:52021XC0916(03)&qid=1632821761973

In the first phase, the project should be compared with Annex 2 (Table 2) of the Technical guidance[9] and see which category the project belongs to. If the project belongs to a category that does not require a detailed analysis of the carbon footprint (most often projects with annual CO_2 emissions less than 20,000 tons/year), **it is enough for the designer to sign and certify the statement on climate neutrality review in which the data on the project's affiliation to the level with regard to the project category are stated.** (Annex 2 – Designer's statement on climate neutrality review). The threshold of 20,000 t/year is set in the **EIB Project[10] Carbon Footprint Methodology**, in which a CO_2 footprint is taken for new buildings and reconstructions for electricity delivered in the building and thermal energy delivered in the building on an annual basis. If it is a project that requires a detailed analysis (it is also necessary to compare with table 2), then in **second phase** it is necessary to follow the EIB Project Carbon Footprint Methodology - the methodology for the assessment of greenhouse gas emissions and variations in project emissions and compile documentation on this.

The GDSG project guidelines imply the creation of a project task that will include all data, information, background and outcomes from the preparatory phase, and in accordance with which the project documentation of the conceptual, main and detailed project will be drawn up. The project task will contain, among other things, a schedule with the total deadline and interim deadlines according to the design phases, with the aim of as high-quality monitoring and control of the design procedures and project documentation as well as the communication of stakeholders in the process. During the design, the compliance of the project with the GDSG project guideline (technical requirements, functional requirements, principles of sustainable construction, lifetime costs, eligibility for financing by EU funds) will be continuously checked.

[9] https://eur-lex.europa.eu/legal-content/HR/TXT/?uri=CELEX:52021XC0916(03)&qid=1632821761973

[10] https://www.eib.org/en/publications/eib-project-carbon-footprint-methodologies

2. Basic standards for buildings

The GDSG project guideline supports architectural freedom when designing a building according to all the architectural principles that are applied, as well as a creative and innovative approach in accordance with the location where the building is located, the spirit of the times in which we live, and available and applicable technologies. The GDSG project guideline emphasizes the special importance of connecting the building and its environment, that is, the quality of the relationship between the indoor closed space and the outdoor open space. Moreover, it emphasizes the need for efficient planning of interventions in the space in such a way that the buildings are multifunctional, that is, they can be adapted to different uses that can realistically be expected during their life cycle with simple construction interventions. Optimal design based on the principles of sustainable construction, environmental and energy awareness, ensuring maximum favorable microclimate conditions as well as optimal living costs represent the basic principles that should be respected when designing public buildings and which these guidelines promote.

The main goals of designing according to the principles of sustainable construction are:

- reduction or complete avoidance of depletion of critical resources such as energy, water, land and raw materials;
- prevention of environmental degradation caused by the construction and use of buildings and infrastructure during their life cycle;
- creation of a built environment that is usable, pleasant, safe and productive.

This GDSG project guideline recognizes six basic themes, i.e., groups of standards in order to build sustainable new buildings, i.e., design, build and use new or reconstruct existing buildings according to the principles of sustainable construction, i.e., green, healthy, comfortable and safe buildings:

- Energy and emissions;
- Environment and location;
- Security and protection;
- Health and comfort;
- Circularity and costs;
- Processes and tools.

Fulfillment of the basic requirements for the building results from *of the Construction Act* (OG 153/13, 20/17, 39/19, 125/19) and related legislation, and it is understood through the GDSG project guideline as an initial standard, that is, the basic requirements for construction are included in the standards of the GDSG project guideline.

Pursuant to Article 7 *of the Construction Act*, each building, depending on its purpose, must be designed and built in such a way that during its life cycle it meets the basic requirements for the building as well as other requirements, i.e., the conditions prescribed by the aforementioned Act and special regulations that affect buildings and other products that are installed in the building. Construction and other products that are installed in the building must meet the requirements prescribed by this Act and special regulations.

The basic requirements for the building are:

1. mechanical resistance and stability
2. fire safety
3. hygiene, health and environment
4. safety and accessibility during use
5. noise protection
6. energy management and heat preservation
7. sustainable use of natural resources

During the reconstruction or comprehensive renovation of existing buildings, it is necessary to analyze the possibilities of improving the basic requirements for the building. When fulfilling the requirements, it is necessary to find optimal solutions that maximize the positive characteristics and standards of buildings, and in this context, the regulations are considered the minimum requirements, while the GDSG project guideline encourages the above standard in those cases where it is possible to achieve it.

2.1. Energy and emissions

When designing a building, it is necessary to optimize its size and content according to the real and realistic needs of the users, because energy needs result from that. It is necessary to optimize energy needs and provide them to the maximum extent from renewable energy sources. Such use of energy, besides being sustainable and climate-friendly, contributes to energy independence. The GDSG project guideline specifically encourages the use of solar energy, geothermal energy and other renewable energy that is located in the immediate vicinity of the building, such as wind energy or biomass. The solar energy and optimal insolation of the building during the year, which is in accordance with the seasonal characteristics, is also important in order to achieve the greatest possible heat gains during the heating period of the building and to meet the hygienic conditions in the building.

Consideration of the energy concept needs to be included in the initial design phase, in order to successfully integrate GDSG principles into the design process. In order to achieve GDSG standards, the coordination of all professions whose design solutions affect the realization of the building (designers of architecture, building physics, construction, thermotechnical systems, electrical installations, water supply and drainage systems and other specialists) is necessary.

2.1.1. Designing a new building – technical requirements for rational use of energy and thermal protection

All new buildings must meet the requirements for nearly zero energy buildings (nZEB). A nearly zero energy building has very high energy properties and that nearly zero, or very low amount of energy is covered to a very significant extent by energy from renewable sources (hereinafter: RES), including energy from renewable sources that is produced on the building or in its vicinity. **This GDSG project guideline requires that for a new building, 100% of the energy delivered annually for the operation of the technical systems in the building be met from renewable energy sources, and that the building requires at least 20% less primary energy than the currently valid national regulation**. Delivered energy[11] means energy, expressed per energy carrier, supplied to the technical building system through the system boundary, to satisfy the uses taken into account such as heating, cooling, ventilation and air conditioning, domestic hot water and lighting. A quality-optimized energy concept enables low energy consumption and the use of energy from renewable sources with the lowest possible investment price and results in a cost-optimal solution in terms of total living costs. The requirements for nearly zero energy buildings (nZEB construction standard) are prescribed in Technical regulation on energy economy and heat retention in buildings (OG 128/15, 70/18, 73/18 and 86/18 and 102/20) for new buildings, while in the case of significant renovation of existing buildings (≥25% of the building envelope area), i.e., during the reconstruction of existing buildings by which they are renovated, partially or completely replace parts of the envelope of the heated part of the building on the surface of ≥75% of the envelope of the heated part of the building is determined by a number of other requirements for rational use of energy and thermal protection that the building must meet, especially with regard to the application of renewable energy sources, the highest permissible value of annual primary energy, the highest permissible values of annual required thermal energy for heating, permitted air permeability etc. The application of these GDSG project guidelines does not exclude the obligation to comply with the valid Technical regulation on energy economy and **heat retention in buildings** (hereinafter: Technical regulation) **with prescribed U values and maximum permissible values of $Q_{H,nd}$ and E_{prim}** (Table 2.1, Table 2.2 and Table 2.3).

[11] In accordance with the glossary and Table 8.a.: *Technical regulation on energy economy and heat retention in buildings* (OG 128/15, 70/18, 73/18 i 86/18 i 102/20)

Table 2.1 Maximum allowed values for new buildings (nZEB) heated and/or cooled to a temperature of 18°C or higher

REQUIREMENTS FOR NEW BUILDINGS	Q''H,nd [kWh/(m2·a)]						Eprim [kWh/(m2·a)]	
	nZEB						nZEB	
TYPE OF BUILDING	continent, θmm ≤ 3 °C			coast, θmm > 3 °C			cont θmm ≤ 3 °C	coast θmm > 3 °C
	$f_0 \leq 0{,}20$	$0{,}20 < f_0 < 1{,}05$	$f_0 \geq 1{,}05$	$f_0 \leq 0{,}20$	$0{,}20 < f_0 < 1{,}05$	$f_0 \geq 1{,}05$		
Multi-apartment	40,50	$32{,}39 + 40{,}58 \cdot f_0$	75,00	24,84	$19{,}86 + 24{,}89 \cdot f_0$	45,99	80	50
Family house	40,50	$32{,}39 + 40{,}58 \cdot f_0$	75,00	24,84	$17{,}16 + 38{,}42 \cdot f_0$	57,50	45	35
Office	16,94	$8{,}82 + 40{,}58 \cdot f_0$	51,43	16,19	$11{,}21 + 24{,}89 \cdot f_0$	37,34	35	25
Educational	11,98	$3{,}86 + 40{,}58 \cdot f_0$	46,48	9,95	$4{,}97 + 24{,}91 \cdot f_0$	31,13	55	55
Hospital	18,72	$10{,}61 + 40{,}58 \cdot f_0$	53,21	46,44	$41{,}46 + 24{,}89 \cdot f_0$	67,60	250	250
Hotel and restaurant	35,48	$27{,}37 + 40{,}58 \cdot f_0$	69,98	11,50	$6{,}52 + 24{,}89 \cdot f_0$	32,65	90	70
Sports hall	96,39	$88{,}28 + 40{,}58 \cdot f_0$	130,89	37,64	$32{,}66 + 24{,}91 \cdot f_0$	58,82	210	150
Store	48,91	$40{,}79 + 40{,}58 \cdot f_0$	83,40	13,90	$8{,}92 + 24{,}91 \cdot f_0$	35,08	170	150
Other non-residential buildings	40,50	$32{,}39 + 40{,}58 \cdot f_0$	75,00	24,84	$19{,}86 + 24{,}89\, f_0$	45,99	/	/

Source: Technical regulation on energy economy and heat retention in buildings (OG 128/15, 70/18, 73/18 and 86/18 and 102/20)

Table 2.2 Defined technical systems for the calculation of delivered and primary energy

	TYPE OF BUILDING	HEATING SYSTEM	COOLING SYSTEM	DHW PREPARATION SYSTEM	SYSTEM OF MECH. VENTILATION AND AIR CONDITIONING	LIGHTING SYSTEM
1	Multi-apartment	YES	NO	YES	Taken into account if it exists	NO
2	Family house	YES	NO	YES		NO
3	Office	YES	YES	NO		YES
4	Educational	YES	NO	NO		YES
5	Hospital	YES	YES	YES		YES
6	Hotels and restaurants	YES	YES	YES		YES
7	Sports halls	YES	YES	YES		YES
8	Store	YES	YES	NO		YES
9	Other non-residential buildings	YES	NO	NO		YES

Note: To calculate the share of renewable energy sources in the total delivered energy, the delivered energy of all technical systems installed in the building can be used

Source: Technical regulation on energy economy and heat retention in buildings (OG 128/15, 70/18, 73/18 and 86/18 and 102/20)

The Ministry of Spatial Planning, Construction and State Assets (MPGI) prepared Guidelines for nearly zero energy buildings[12]. The guidelines are intended for experts who will participate in the design and construction process. The legislative framework mandates that when drawing up design and technical documentation for new buildings, designers must adhere to the above Guidelines for nearly zero energy buildings in order to achieve the prescribed requirements for nearly zero energy buildings. **This GDSG project guideline defines that 100% of the energy delivered annually for the operation of technical systems for a new building should be met from renewable energy sources, which may include district or block heating that is wholly or partially based on energy from renewable sources and/or efficient cogeneration, except in the case when achieving these conditions is not economically, technically and functionally feasible.**

Furthermore, this GDSG project guideline prescribes **that the building requires at least 20% less primary energy than the currently valid national regulation.**

2.1.2. Designing the reconstruction of an existing building – technical requirement for rational use of energy and thermal protection

In the case of significant renovation (reconstruction of an existing building, with which only certain parts of the envelope of the heated part of the building on an area equal to or greater than 25% of that envelope are subsequently installed, restored or replaced), the thermal transmittance, U [W/(m2K)], of the entire construction part on which the construction work was carried out must not be greater than the value below (Table 2.3).

Table 2.3 The highest permissible values of the thermal transmittance, U [W/(m^2·K)], of the construction parts of new buildings and after

Nr.	Construction part	U [W/(m^2 · K)]			
		(θint,set,H ≥ 18 °C		12°C < θint,set,H < 18 °C	
		Θe,mj,min ≤ 3 °C	Θe,mj,min > 3°C	Θe,mj,min ≤ 3°C	Θe,mj,min > 3°C
1.	External walls, walls facing the garage, walls facing the ventilated attic	0.30	0.45	0.50	0.60
2.	Windows, balcony doors, roof windows, other transparent elements of the building envelope	1.60	1.80	2.50	2.80
3.	Glazed part of windows, balcony doors, roof windows, transparent elements of the building envelope (U)	1.10	1.40	1.40	1.40

[12] Available at: https://mpgi.gov.hr/UserDocsImages/dokumenti/EnergetskaUcinkovitost/Smjernice_2_dio_nZEB_mgipu.pdf

4.	Flat and sloping roofs above the heated space, ceilings towards the ventilated attic	0.25	0.30	0.40	0.50
5.	Ceilings above the outside air, ceilings above the garage	0.25	0.30	0.40	0.50
6.	Walls and ceilings towards unheated rooms and an unheated staircase with a temperature of more than 0 °C	0.40	0.60	0.90	1.20
7.	Walls towards the ground, floors on the ground	0.40 [1)]	0.50 [1)]	0.65 [1)]	0.80 [1)]
8.	External door, door to unheated staircase, with non-transparent door leaves and glazed partitions to the unheated or ventilated room	2.00	2.40	2.90	2.90
9.	Walls of the box for blinds	0.60	0.80	0.80	0.80
10.	Ceilings and walls between apartments or between different heated special parts of the building (business premises, etc.)	0.60	0.80	1.20	1.20
11.	Domes and strip lights	2.5	2.5	2.5	2.5
12.	Windshields, observed in direction of opening the doors	3.0	3.0	3.0	3.0

Note: Θe, mj, min is the mean monthly outdoor air temperature of the coldest month at the location of the building.

1) For floors on the ground, the requirement applies up to a depth of 5 m from the floor of the room from the outer wall, the wall towards the ground or the unheated space, except in the case of underfloor heating.

Source: Technical regulation on energy economy and heat retention in buildings (OG 128/15, 70/18, 73/18 and 86/18 and 102/20)

When reconstructing an existing building, which involves renewing, partially or completely replacing parts of the envelope of the heated part of the building on an area equal to or greater than 75% of that envelope, Q''H, nd [kWh/(m2·a) iEprim [kWh/(m2·a) must not be greater than the value from the table below (Table 2.4).

Table 2.4 The highest permitted values for existing buildings heated and/or cooled to a temperature of 18°C or higher during reconstruction on ≥ 75% of the envelope surface of the heated part

RECONSTRUCTION REQUIREMENTS	Q''H,nd [kWh/(m2·a)]						Eprim [kWh/(m2·a)]	
	nZEB						nZEB	
TYPE OF BUILDING	continent, θmm ≤ 3 °C			coast, θmm > 3 °C			cont θmm ≤ 3 °C	coast θmm > 3 °C
	$f_0 \le 0,20$	$0,20 < f_0 < 1,05$	$f_0 \ge 1,05$	$f_0 \le 0,20$	$0,20 < f_0 < 1,05$	$f_0 \ge 1,05$		
Multi-apartment	50,63	$40,49 + 50,73 \cdot f_0$	93,75	27,00	$21.59 + 27,06 \cdot f_0$	50,00	180	130
Family house	50,63	$40,49 + 50,73 \cdot f_0$	93,75	27,00	$19,24 + 38,82 \cdot f_0$	60,00	135	80
Office	21,18	$11,03 + 50,73 \cdot f_0$	64,29	17,60	$12,19 + 27,06 \cdot f_0$	40,60	75	75

Educational	14,98	4,84 + 50,73· f_0	58,10	10,81	5,40 + 27,06·f_0	33,83	90	75
Hospital	23,40	13,26 + 50,73·f_0	66,51	50,48	45,06 + 27,06·f_0	73,48	340	330
Hotel and restaurant	44,35	34,21 + 50,73·f_0	87,48	12,50	7,09 + 27,06·f_0	35,50	145	115
Sports hall	120,49	110,35 + 50,73·f_0	163,61	40,91	35,50 + 27,06·f_0	63,93	420	215
Store	61,14	50,99 + 50,73·f_0	104,25	15,11	9,71 + 27,06·f_0	38,13	475	300
Other non-residential buildings	50,63	40,49 + 50,73·f_0	93,75	27,00	21,59 + 27,06·f_0	50,00	180	130

Source: Technical regulation on energy economy and heat retention in buildings (OG 128/15, 70/18, 73/18 and 86/18 and 102/20)

If the calculated value of the annual primary energy per unit area of the useful area of the heated part of the building is Eprim [kWh/(m2·a)] for the reconstruction of an existing building in the case involving renovation, partial or complete replacement of parts of the envelope of the heated part of the building on the surface >= 75% of the envelope surface, is lower by at least 20% of the maximum allowed values from Table 9 from Annex B of the Technical regulation, it is considered that the conditions for the annual required thermal energy for heating per unit area of the useful area of the heated part of the building, Q''H, nd [kWh/(m2·a)] and for the annual required heat energy for cooling per unit area of the usable area of the heated part of the building, Q''C, nd [kWh/(m2·a)] prescribed by the Technical regulation, are met. **This GDSG project guideline defines that at least 75% of the energy delivered annually for the operation of the technical systems in the building during the energy or comprehensive renovation of the building should be met from renewable energy sources, which may include district or block heating that is wholly or partially based on energy from renewable sources and/or efficient cogeneration, except in the case when achieving these conditions is not economically, technically and functionally feasible.**

For the calculation of ventilation losses for the purpose of calculating QH, nd when designing the reconstruction of existing buildings, it is necessary to use the calculation methods specified in the current *Algorithm for the calculation of the required energy for the application of ventilation and air conditioning systems for heating and cooling the premises of the building*[13]. Compliance with air permeability requirements is proven by testing according to HRN EN ISO 9972:2015, determination method 1, before the technical inspection of the building, called Blower door test – for nearly zero energy buildings and buildings that are designed for Q''H, nd ≤ 50 kWh/(m2a) and are located in the continental part. The requirement refers to the envelope of the heated part of the building. When testing compliance with air permeability requirements, for a pressure difference between indoor and outdoor air of 50 Pa, the measured air flow, reduced to the volume of indoor air, must not be greater than the value n50 = 3.0 h-1 in the case of buildings or individual thermal zones of buildings without a mechanical ventilation

[13] Available at: https://mpgi.gov.hr/UserDocsImages/dokumenti/EnergetskaUcinkovitost/meteoroloski_podaci/Algoritam_HVAC_2017.pdf

device, i.e., n50 = 1.5 h-1 in the case of buildings or individual thermal zones of buildings with a mechanical ventilation device. The allowance for the influence of the thermal bridge must be ≤ 0.05 W/m^2K and it is necessary to design them in accordance with the catalog of good thermal bridge solutions from the Technical regulation.

When replacing and modernizing the technical system (such as replacing the heat generator, replacing the energy source, replacing the central ventilation unit, replacing the lighting system, etc.) and upgrading it, the requirements of the Technical regulation apply, which refer to technical systems or their parts that are installed in new buildings.

Selection of **ecologically and economically optimal energy** concept has a key role in the subsequent exploitation of the building, both in terms of costs and the impact on the human environment. Furthermore, Technical regulation requires consideration of the introduction of intelligent measurement systems to the extent that it is technically, functionally and economically feasible, which is proven by the budget and cost-optimal analysis. When analyzing and selecting measures and calculating costs, special attention should be paid to the regime of use of the building, its purpose, but also the possibility of its future conversion. In the analysis of the optimal solution, it is necessary to look at the investment and operational costs of the concept over a longer time frame (minimum 20 years) in order to take into account the maintenance costs as well as the replacement of worn materials and equipment. The subject parameters will serve as input data for the preparation of the Feasibility study and the cost-benefit analysis.

Directive (EU) 2018/844 of the European Parliament and the Council of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency was incorporated into the currently valid Construction Act. Regardless of whether the buildings are under conservation protection or not, energy renovation alone is not enough, but the aforementioned Directive recommends considering the possibility of comprehensive renovation, which, in addition to energy renovation measures, also includes rehabilitation, measures to improve the fulfillment of the basic requirement of mechanical resistance and stability of the building - especially to increase seismic resistance of the building, measures to increase safety in case of fire, measures to ensure healthy indoor climate conditions and other measures that improve the basic requirements for the building. **The GDSG project guideline necessarily foresees an integral or in-depth approach to energy renovation, and at the same time implies the application of all energy efficiency measures, which include measures for the outer envelope of the building and measures for the technical systems of the building, as well as the application of renewable energy sources (75% of the annual energy delivered for the operation of the technical systems in the building should be met from renewable energy sources); all the while respecting the principle of building sustainability throughout the entire life cycle.**

2.1.3. Life Cycle Assessment

When talking about the ecological concept as part of a comprehensive integral approach, the Life Cycle Assessment (LCA) is key. It refers to the systematic calculation of the total impact of the building on the environment during the entire life cycle of the building, in which the amount of CO_2 emissions that will be emitted by the building throughout its life cycle with the consumption of energy, water and raw materials, is quantified. Such a calculation is possible after the international EPD system (Environmental Product Declaration, ISO 14025, ISO 14040, EN 15804), i.e., declarations of construction products that show lifelong impacts on the environment, has been standardized.

GDSG superstandard (recapitulation of chapter 2.1):

In addition to the essential fulfilment of basic construction requirements, technical requirements, standards and norms and general compliance with valid and applicable regulations, which are related to the project in question, GDSG additionally requires, recommends and evaluates the following:

- **100% of the annual delivered energy for the operation of the technical systems in the new building met from renewable energy sources, which may include district or block heating based entirely or partially on energy from renewable sources and/or efficient cogeneration, except in the case when the achievement of these conditions is not ecomically, technically and functionally feasible.**
- **That the new building requires at least 20% less primary energy that the current national regulation**
- **75% of the annual delivered energy for the operation of the technical systems in the building after the renovation of the existing building is met grom renewable energy sources, which may include district or block heating that is wholly or partially based on energy from renewable surces and/or efficient cogeneration, except in the case when the achievement of these conditions is not economically, technically and functionally feasible.**
- **More than 30% savings of primary energy compared to ex ante assessment during renovation of the existing building.**
- **More than 30% reduction of greenhouse gas emissions compared to the ex ante estimate during renovation of the existing building**
- **Calculation of total CO_2 emissions of the building throughout its life cycle**

2.2. Environment and location

2.2.1. Relationship towards the environment and natural resources

It is necessary to use natural resources rationally when constructing a building, and at the same time to have as little impact on the naturally created environment as possible. The creation of sustainable buildings begins with the proper selection of the building's location, including consideration of the reuse or reconstruction of existing buildings. It is necessary to adapt the design of the building to the greatest extent possible to the characteristics of the terrain and the potential arising from it. The location and orientation of the building and the landscaping of the building plot on which the building is located affect local ecosystems, modes of transportation and energy use.

It is necessary to use water rationally and to collect, conserve and use rainwater; which implies designing in such a way as to enable maximum efficient use of water during the life cycle, to preserve the quality of water systems in the immediate vicinity, and to adopt water recycling mechanisms.

Through the landscape solution, it is necessary to preserve the local or native flora and fauna to the greatest extent possible.

It is necessary to include thinking about the possibility of development and expansion of the building/project on the site in the long term through **adaptations/extensions** according to new (future) user requirements.

2.2.2. Analysis of the location of the building on the building plot

Location, that is, the building plot on which the building is designed is always specific and is defined by its orientation in relation to the sides of the world, i.e., the movement of the Sun, microclimate conditions that include altitude, slope and type of terrain; direction, type and strength of winds, proximity and type of water bodies. The location is also defined by its position within the urban environment: its relationship to neighboring buildings and traffic and other urban infrastructure.

When choosing a building plot for the construction of a building one should take care that it is far from sources of noise and pollution, protected from too strong fog and winds, on healthy, water-permeable ground that is not polluted by waste substances. The position and shape of the building plot must allow adequate sunlight and the possibility of proper orientation and functional arrangement of all open and closed spaces of the building in accordance with their functional requirements and the activities that take place within them.

Optimum terrain slope is on a slight slope towards the south because it allows for better sun exposure, better water drainage and makes it easier to build foundations of the building. The soil must have a certain quality in relation to the bearing capacity of the soil, the level of underground water, the risk of sliding, subsidence, landslides, etc.

It is necessary to analyze the seismic characteristics of the area and microlocation. By fully exploiting the natural elements of the relief and microclimate, the compositional, functional and energy values of the designed building can be improved.

The location of the building on the building plot results from the possibilities defined through the corresponding spatial planning documentation. In accordance with the conditions from the spatial plan, the buildings should be minimally distant from each other in order to avoid the influence of one building on another in case of demolition. It is desirable that the designed buildings are as far away from neighboring buildings as possible in order to avoid shading, that is, to have the possibility of as much natural lighting as possible and better protection against noise and pollution (dust, exhaust gases, smoke, etc.).

2.2.3. Analysis of climate risks and vulnerabilities

It is necessary to carry out an analysis of climate risks and vulnerabilities, in accordance with the Technical guidance on the climate proofing of infrastructure in the period 2021-2027 (2021/C 373/01)[14].

The effects of climate change depend on a whole range of parameters. According to the international results of climate modeling (IPCC, EEA), the Mediterranean basin is designated as a "hot" climate spot with particularly pronounced effects of climate change. The Republic of Croatia, which for the most part belongs to that region, will certainly feel the consequences of climate change, and its vulnerability is assessed as high.

Risk assessment is a comparative analysis of natural causes and their consequences associated with hazards and conditions of vulnerability in which people and property may suffer, and livelihoods, infrastructure and services in a certain area may be endangered. The result of the risk analysis is the evaluation of the probability and level of potential losses and the understanding of why they occur and what effects they have. Vulnerability to climate change serves to understand the interconnectedness of the causes and consequences of climate change and the impact on people, the economy, society and the ecosystem.

In particular, as part of the project and technical documentation, it is necessary to review, analyze and determine problems and design solutions and measures for adapting to climate change related to: alignment with the Paris Agreement and principle "do no significant harm", direct greenhouse gas emissions, indirect greenhouse gas emissions due to increased demand for energy, ancillary activities or infrastructure directly related to the implementation of the proposed project.

Also, as part of the project and technical documentation, it is necessary to review, analyze and determine problems and design solutions and measures for adapting to climate change related to: climate resilience, heat waves, drought, forest fires, flood regime and extreme rainfall, storms and gusts of wind, landslides, sea level rise, coastal erosion, hydrological regimes, salt water intrusions, cold waves and damage from freezing and thawing. **The assessment of climate risks and vulnerabilities, as well as their frequency, was made for the building sector and is described in detail in Annex 3, in which the link with the main project, i.e., the maps in which the risks are addressed is clearly stated.**

[14] https://eur-lex.europa.eu/legal-content/HR/TXT/?uri=CELEX:52021XC0916(03)&qid=1632821761973

2.2.4. Sustainable green landscape planning

During sustainable green landscape planning, it is necessary to be guided, among other things, by the principles of rainwater management, shaping new habitats, planting autochthonous plant species, ecological restoration of degraded environments, and habitat preservation and improvement. It is necessary to preserve the local or native flora and fauna as much as possible through the landscape solution. Properly planned greenery creates a more favorable temperature and air humidity and reduces the impact of wind. Placing tall deciduous greenery along the facades of the building reduces the amount of solar radiation entering the building in the summer, while in the winter it allows it to enter, resulting in thermal gains that are desirable during the period of heating use. Green roofs reduce air temperature, retain dust particles and regulate a constant temperature inside the building. When designing a horticulture project on the land, it is necessary to avoid planting plants whose maintenance requires a large amount of herbicides and irrigation, i.e., whose maintenance requires high costs. The guideline supports the arrangement of plot areas with water features (swimming pools), i.e., gathering spaces that contribute to the quality and use of outdoor space by the users of the building, as well as improving microclimatic conditions and fitting the building with a plot into the urban environment. Horticulture maintenance costs often represent a significant portion of the building's life cycle costs. Based on the above, it is necessary to plan with special attention and analyze all directly and indirectly related costs such as water consumption, mineral supplements, herbicides, annual pruning, etc. In landscape planning, it is also necessary to pay special attention to the influence of vegetation on building elements (e.g., tree roots, leaves, etc.) and to minimize their potential negative effects.

Sustainable green landscape planning includes the application of elements of green infrastructure and nature-based solutions. During the renovation of existing buildings, it is also necessary to analyze, propose and design measures for the application of elements of green infrastructure, in particular:

- Construction of green roofs of buildings
- Implementation of green facades of buildings
- Arrangement of new green areas on the building plot (replacement of existing gray infrastructure into green infrastructure, etc.) - also adaptation of the space for user use (sensory garden, children's playground, seating areas, etc.)
- Arrangement of existing green areas on the building plot (enhancement of existing greenery with new ones, etc.) - also adaptation of the space for user use (sensory garden, children's playground, seating areas, etc.)

In sustainable green landscape planning, it is necessary to take into account the national Program for the development of green infrastructure in urban areas for the period 2021 to 2030[15], adopted with the aim of establishing sustainable, resilient, safe and livable and well-organized cities and municipalities in the Republic of Croatia. Based on the identified existing

[15] https://mpgi.gov.hr/vijesti-8/donesen-program-razvoja-zelene-infrastrukture-u-urbanim-podrucjima/14152

state of green infrastructure in urban areas, it describes development needs and potentials, identifies challenges, defines a development vision, and elaborates goals, priorities and measures for the development of green infrastructure in urban areas of the Republic of Croatia in order to establish sustainable, safe and resilient cities and settlements through increasing the energy efficiency of buildings and construction areas, the development of green infrastructure in buildings and urban transformation and rehabilitation.

GDSG superstandard (recapitulation of chapter 2.2):

In addition to the essential fulfillment of basic construction requirements, technical requirements, standards and norms and general compliance with valid and applicable regulations, which are related to the project in question, GDSG additionally requires, recommends and evaluates the following:

- **Analysis of the seismic characteristics of the area or microlocation**
- **Analysis of landslides and floods**
- **Analysis of the influence of the shape of the building on the wind circulation of the vortex zone and increased speed**
- **Analysis of climate risks and vulnerabilities**
- **Preservation of local or native flora and fauna**
- **Placement of tall deciduous greenery along the facades of the building**
- **Designing the implementation of elements of green infrastructure and nature-based solutions**
- **Management and use of rainwater**
- **Construction and design of outdoor spaces for the gathering and stay of users in accordance with the purpose of the building**

2.3. Security and protection

2.3.1. Mechanical resistance and stability

Whether it is a new building or reconstruction of an existing building, it is necessary to calculate its mechanical resistance and stability. When calculating the mechanical resistance and stability of the building, it is necessary to check it for the effects of seismic forces in accordance with current regulations. These guidelines require checking the mechanical resistance and stability of existing buildings to the effects of seismic forces in accordance with the currently valid legal regulations (Technical regulations for civil engineering structures, NN 17/17, 75/20 and 7/22). The goal of these guidelines is to upgrade, i.e., improve the original characteristics of the structure in relation to those it had before, as well as reduce future seismic response.

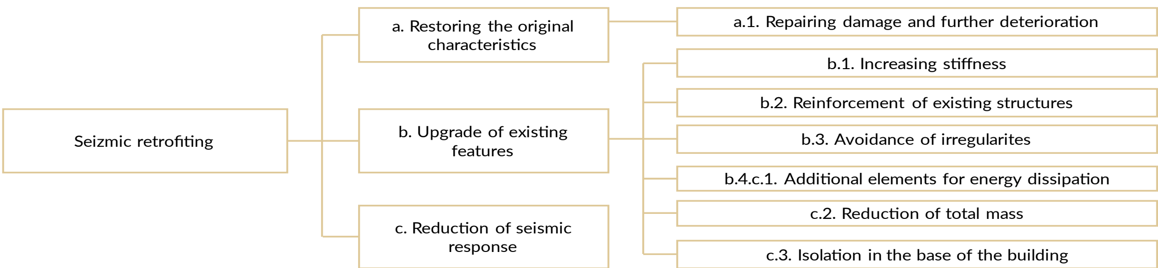
A warning can be the example of the City of Zagreb, where about a third of the housing stock was built by 1964 whereby seismic loads were hardly taken into account during the design. Moreover, additional more than half of the housing stock was built from 1964 to 2013, whereby the analyzed values of horizontal forces from seismic activity were several times lower than those prescribed today[16].

When drawing up and preparing project documentation, of extreme importance is the preparatory stage which refers to the analysis of the existing situation, in which an expert review is ordered for:

- **a) constructive and building condition of the building;**
- **b) conducting an energy audit and creating an energy certificate;**
- **c) inspection of the building related to fire safety.**

When analyzing the existing state of the structure, it is necessary to detect the causes of damage and degradation of structural parts (walls, vaults,...). This is a prerequisite to determine the method of rehabilitation and the choice of method of structural reinforcement. It is also necessary to create an accurate overview of the existing state (hand-plumb) with measured vertical deflections of the structure (deformation).

The method of rehabilitation and the choice of method of structural reinforcement depends on a number of factors such as the typology of load-bearing structures, construction method, year of construction, rural and urban, whether the building was reconstructed, extended or damaged in an earthquake, and others. The structural reinforcement strategy is shown in the diagram below.



Source: Građevinar 59 (2007) 10, 871-877

[16] Earthquake risk for Croatia: an overview of research and existing assessments with guidelines for the future, GRAĐEVINAR 71 (2019) 10, 923-947, Josip Atalić, Marta Šavor Novak, Mario Uroš

With existing structures, it is almost always necessary to repair damages that occurred during the life cycle of the building as a result of subsidence, the effect of water, the effect of load and wind, wear and tear of materials, etc. For the above mentioned, it is necessary to use new modern materials, which have much better characteristics than the original materials, as much as possible. The mentioned materials are used for filling and stabilization of cracks, replacement of the binding agent in masonry structures, restoration of the structure from the effects of water (waterproofing) and others. These damage repair methods, such as grouting, anchoring, masonry application, leveling, smoothing, etc. have been on the market for a long time. The materials used are epoxy resins, two-component epoxy adhesives, salt-resistant liquid hydraulic binders, two-component cement mortars with pozzolanic action and high ductility, liquid waterproofing, hydrophobic coatings, etc.

The upgrading of existing features implies the reinforcement of the existing structure, by reducing its irregularities and/or any discontinuities, by increasing the stiffness of the structure and installing devices that will consume energy during an earthquake[17]. The main goal is to increase the strength of the structure, increase the ductility of the structure, or make a combination by combining strength and stiffness. There are various methods of reinforcing the structure, of which the method of stiffening the existing frames and cladding the existing load-bearing elements is the most widely used. Among the traditional methods, the following are known:

- repair of cracks;
- mortar replacement;
- injection of walls (especially hollow ones);
- reinforcing the corners of the building;
- connecting the walls and increasing the bearing capacity by prestressing with steel bars;
- reinforcement of constructions by cutting vertical cerclages or by performing circumferential steel or RC frames;
- reinforcement of walls and columns with RC plaster (torcreting) or RC cladding[18];
- reinforcement using FRP products.

The use of traditional methods has many disadvantages:

- increase in construction weight;
- increase in seismic forces due to the weight of the concrete lining;
- useful space is reduced;
- speed of performance;
- performance noise;
- interruption of the functionality of the building and eviction of the tenants during the works[19].

[17] Presentation of possible reconstruction procedures after an earthquake, GRAĐEVINAR 59 (2007) 10, 871-877, M.Sc. Venera Vukašinović

[18] Reinforcement of brick masonry walls and columns with FRP strips, Days of Authorized Civil Engineers, Opatija, 2012, Josip Galić, Tomislav Kišiček, Branko Galić

[19] Reinforcement of brick masonry walls and columns with FRP strips, Days of Authorized Civil Engineers, Opatija, 2012, Josip Galić, Tomislav Kišiček, Branko Galić

New technologies and materials enable more elegant and faster solutions for structural reinforcement. Fiber-reinforced polymers (FRP) are primarily used to reinforce masonry structures. Glass fiber products proved to be the most suitable solution. In doing so, two types of products should be distinguished, such as prefabricated FRP elements in the form of rods, cables and lamellae, and dry unidirectional or bidirectional oriented fibers.

By reinforcing using FRP products:

- there is no increase in the weight of the structure;
- execution is simple and fast;
- no specialized contractors are required;
- does not take up space;
- application results in an increase in the bearing capacity and ductility of the walls.

It is often not enough to apply only reinforcement using FRP strips, but it is necessary to combine it with the traditional way of reinforcing the structure or with the execution of completely new structural parts.

In the case of existing buildings, it is almost always necessary to reinforce the foundations (underconcreting, expand or build new ones), increase rigidity and load-bearing capacity with mezzanine (ceiling) structures, reinforce or build a new roof structure (a new steel structure is often built, especially when repurposing the attic space), strengthen the walls and other elements to meet seismic resistance requirements and other methods (new lintels, beams, etc.).

It is necessary to choose project solutions that are economical, easy to implement and that least disturb the existing structure of the building, such as:

- check the foundation soil, improve the foundation soil, strengthen the existing foundations, connect the foundations transversely and longitudinally, underconcrete the foundations or construct completely new foundations;
- when reconstructing/repurposing the roof, use steel frames with or without tension in combination with wood;
- it is necessary to demolish chimneys that are not in use and strengthen those that will remain in use;
- it is necessary to check and secure the stair beds and reinforce them;
- perform coupled mezzanine panels (steel-concrete, wood-concrete) with a pressure plate (approx. 6 cm thick). The increase in the total weight of the building is disregarded. It can also be performed on brick ceilings (Prussian vault, arches);
- connect the ceilings and walls for seismic stability with steel bars that have welded steel tiles that are put onto the exterior facade. It is necessary to connect the internal walls and partition walls (budget is necessary);
- strengthen masonry walls by applying unidirectional or multidirectional oriented glass (carbon) strips that are placed on the walls using epoxy glue. The application results in an increase in the bearing capacity and ductility of the walls. It is used not only on the corners but also around the entire perimeter of all external (or if necessary) internal

walls, collisions of external and internal walls, reinforcement of beams and lintels for bending, connections at the place of horizontal cerclages and for wrapping columns and others (it is possible to carry out budget analysis);
- if necessary, perform completely new structural building elements.

Reduction of seismic response together with reduction and/or isolation of its mass[20]. It is necessary to examine the possibility of installing dampers on existing and new frame-type structures in order to absorb the energy introduced into the building due to ground movement. There are three basic types of dampers:

- metallic;
- those that operate on the basis of friction; and
- fluid viscous dampers.

Also, it is necessary to consider the insertion of special insulating elements between the structure and the foundation that will reduce the fundamental frequency of the structure so that it will not vibrate as strongly as during an earthquake.

- During the reconstruction of buildings that were not damaged in the earthquake, it is necessary to analyze, propose and, in agreement with the Investor, continuously design measures to improve the fulfillment of the basic requirement of mechanical resistance and stability of buildings:
- Increases in the seismic resistance of buildings of at least 10% above the existing seismic resistance of buildings - the ratio of the calculated seismic resistance of the structure and the seismic resistance of the structure according to the series of HRN EN 1998 and the corresponding national supplements (according to the *Technical regulations for civil engineering structures* (OG 17/17, 75/20 and 7/22)

A necessary condition is the development of the building project in accordance with the current regulations - building constructions are to be integrated into the main project.

It is also necessary to prove the satisfaction of the basic requirement of the mechanical resistance and stability of the building due to the increase in the load on the structural elements of the building due to the applied comprehensive renovation measures (adding layers of thermal insulation, solar power plant, etc.) and to design, calculate and graphically and textually describe and process all the necessary measures and interventions on the load-bearing structural system of the building resulting from all energy and comprehensive renovation measures, including rehabilitation or possible reconstruction of individual structural or related parts of buildings.

The analysis of the existing condition of the buildings must be carried out in accordance with the *Guidelines for creating an analysis of the existing state of the building with a proposal for measures and an assessment of the investment in the part - healthy indoor climate conditions,*

[20] Presentation of possible reconstruction procedures after an earthquake, GRAĐEVINAR 59 (2007) 10, 871-877, M.Sc. Venera Vukašinović

mechanical resistance and stability, safety in case of fire published by the Ministry of Spatial Planning, Construction and State Assets[21] on its website.

2.3.2. Fire protection

During the drawing up and preparation of project documentation, the preparatory stage related to the analysis of the existing situation, in which the inspection of the person authorized to prepare the fire protection study is ordered, is extremely important. **The GDSG project guideline mandates the assessment of the existing building's fire safety as if it were a new building, taking into account the currently valid legal regulations regulating fire safety**. The design of buildings in the area of fire protection is regulated by the *Construction Act* (Official Gazette 153/13, 20/17, 39/19 and 125/19), by the Fire Protection Act (Official Gazette 92/10) and a series of by-laws, recognized rules of technical practice and standards.[22]

The basic principles of fire protection during design and construction have been transposed from EU regulations, and are defined by the valid Construction Act and Fire Protection Act, which state that the design and construction of buildings must be carried out in a way that, in the event of a fire, it enables the following:

- Preserve the bearing capacity of the structure over a certain period of time determined by a special regulation;
- Prevent the spread of fire and smoke inside the building;
- Prevent fire from spreading to neighboring buildings;
- Make it possible for people to leave the building unharmed, that is to enable their rescue;
- Enable protection of rescuers.

In principle, this approach was elaborated in the *Ordinance on fire resistance and other requirements for buildings in case of fire* (Official Gazette 29/13 and 87/15), (hereinafter the Ordinance), was adopted in 2013, and in 2015 it was amended as a basic by-law (regulation) in the field of fire protection, which is harmonized with European requirements. The ordinance is defined as a basic module, which should be supplemented with modules for buildings for those purposes (schools, hospitals, kindergartens and nurseries, etc.), so for those purposes, until the adoption of the aforementioned Croatian regulations, recognized rules of technical practice are applied, which mostly include NFPA 101, Life safety code (26) (NFPA – *National Fire Protection Association*) or the Austrian guideline *OIB Directive* 2 (27) (OIB – *Osterreichisches Institut fur Bautechnik*). These regulations apply only to the part of fire protection measures that are not regulated by Croatian regulations, for example, determining the areas of fire and smoke compartments, the need for active protection systems (sprinklers, fire alarms, etc.).

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[21] Available at https://mpgi.gov.hr/UserDocsImages/13808

[22] Fire Protection of Facades, University of Zagreb, Faculty of Civil Engineering, October 2017, Marija Jelčić Rukavina, Milan Carević, Ivana Banjad Pečur

However, **in the part of fire protection measures regulated by Croatian regulations, the provisions of Croatian regulations must be applied**. Thus, with regard to the performance of the facade and the requirements related to the reaction of insulating materials to fire, the quoted Croatian Ordinance is used, since it regulates the mentioned topic, so in that part it is not possible to apply foreign regulations.[23]

These guidelines **require the use of stone/mineral wool** on the facades of public buildings, regardless of purpose and number of floors. Also, **the use of mineral wool is recommended in parts of the attic, basement or other parts where the structural parts of the building are thermally insulated**. The GDSG guideline allows the use of other non-combustible heat-insulating materials on facades, as well as TI panels made of extruded polystyrene in the splash zone of the building perimeter, and panels made of expanded polystyrene or other heat-insulating materials on flat roofs if such materials are made in accordance with fire protection conditions.

Furthermore, as defined by the valid *Fire Protection Act* (Official Gazette 92/10) fire protection must be ensured during the design and construction of the building so that in the event of a fire:

- Preserves the load-bearing capacity of the structure over a certain period of time determined by a special regulation,
- Prevents the spread of fire and smoke inside the building,
- Prevents fire from spreading to neighboring buildings,
- Makes it possible for people to leave the building unharmed, i.e., to enable their rescue,
- Enables protection of rescuers.

These guidelines **require the application of the above conditions for existing buildings, i.e., buildings that are being reconstructed or extended**. Furthermore, in order to meet the required conditions, it is recommended to use modern technologies in the fire protection segment, such as:

- Fire protection systems with sensors for heat, radiation and smoke,
- Smoke and heat extraction systems,
- Excess systems in safety staircases,
- System for ensuring the power supply of security systems and fire protection systems,
- System for automatic fire extinguishing and fire indicator system,
- Valves,
- The use of modern standardized materials according to the EU classification in terms of flammability, smoke and droplets;
- Anti-panic lights,
- Provide evacuation routes and mobile extinguishing equipment,
- Provide fire access, hydrant network inside and outside the building,

[23] Fire Protection of Facades, University of Zagreb, Faculty of Civil Engineering, October 2017, Marija Jelčić Rukavina, Milan Carević, Ivana Banjad Pečur

- Other.

When renovating buildings, it is necessary to analyze, propose and, in agreement with the Investor, continue to design measures to increase safety in case of fire. A necessary condition is the preparation of a fire protection report by a person authorized to prepare a fire protection elaborate. The analysis of the existing condition of the buildings must be carried out in accordance with the *Guidelines for creating an analysis of the existing state of the building with a proposal for measures and an assessment of the investment in the part - healthy indoor climate conditions, mechanical resistance and stability, safety in case of fire* published by the Ministry of Spatial Planning, Construction and State Assets on its website https://mpgi.gov.hr/UserDocsImages/13808.

2.3.3. Implementation of security measures and improvement of unhindered access and movement in buildings

In accordance with the fundamental requirement for construction, safety and accessibility during use, Article 12 of the *Construction Act* (Official Gazette 153/13, 20/17, 39/19, 125/19) defines that the building must be designed and built so that it does not present unacceptable risks of accidents or damage during use or functioning, such as slipping, falling, collision, burns, electric shocks, injuries from explosions and burglaries. In particular, buildings must be designed and built taking into account accessibility and use by persons with reduced mobility. It is therefore necessary, according to the provisions of the *Ordinance on ensuring access to the disabled and to persons with reduced mobility* (Official Gazette 78/13) and other relevant legislation, to design mandatory elements of accessibility for the mentioned persons so that they can move, stay and work in the buildings in question without hindrance. Obligatory elements of accessibility are determined by the size, properties, installations, devices and other equipment of the building in order to ensure access, movement, stay and work of persons with disabilities and reduced mobility at the same level as other persons. At the same time, these applied mandatory accessibility elements must be marked with accessibility signs.

During the reconstruction of an existing public building, if all the necessary elements of accessibility are not provided, it is necessary to provide them through a building reconstruction project, i.e., a comprehensive building renovation project. Accessibility measures need to be seen not only through possible vertical movements, i.e., ensuring vertical communication in the building for people with disabilities and reduced mobility, but also the horizontal possibility of communication in such a way that the floors on the floor are made at a level without obstacles for wheelchair movement, as well as the width of internal and exterior doors that allow unimpeded entry into all rooms. In addition to the above, special attention should also be paid to escape routes and the simple and unhindered way of using them by people with disabilities and reduced mobility. In addition to immobility, attention should also be paid to other forms of disability such as blindness, visual impairment and deafness. Therefore, it is necessary to provide markings and controls in more than one sensor format -

sound, tactile, visual (video intercom, tactile and sound markings on the elevator, avoiding small text and others).

In order to encourage sustainable user mobility, promotion of electric mobility, reduction of CO_2 emissions and facilitating and optimizing the work processes that take place in the building, the GDSG project guideline requires the construction of parking spaces and charging stations for electric vehicles in accordance with the prescribed standard, which is covered in more detail in chapter 5.5. Moreover, the GDSG project guideline recommends and encourages the promotion of the use of bicycles, electric scooters and other similar means of transport, as well as the implementation of parking spaces for bicycles, storage areas and the possibility of charging scooters, as well as wardrobe and sanitary areas for people who use the mentioned vehicles. In particular, it is necessary to always take care when designing and to enable accessibility and use of the space for parents with small children who use strollers.

GDSG superstandard (recapitulation of chapter 2.3):

In addition to the essential fulfillment of basic construction requirements, technical requirements, standards and norms and general compliance with valid and applicable regulations, which are related to the project in question, GDSG additionally requires, recommends and evaluates the following:

- **Reconstruction of existing buildings according to the *Technical regulations for civil engineering structures* (Official Gazette 17/17, 75/20 and 7/22), as if it were new buildings (possible deviations from the current regulation with explanation and approval of the designer);**
- **Use of modern techniques to protect buildings from earthquakes, such as strap reinforcements and the use of dampers**
- **Reconstruction of existing buildings in accordance with the currently valid legislation regulating safety in case of fire, as if it were new buildings, i.e., to the extent that it is feasible**
- **Construction of parking lots for bicycles and storage and places for charging smaller electric vehicles and design of the wardrobe and sanitary area for people who use the mentioned vehicle**
- **Accessibility of all areas of the building to people in wheelchairs - escape routes adapted for wheelchair users**
- **Ensure accessibility for all forms of disability (blindness, visual impairment and deafness)**

2.4. Health and comfort

2.4.1. Healthy indoor climate conditions

The quality of the interior space of the building has a significant impact on the health, comfort and productivity of the users. During the reconstruction of existing buildings, it is necessary to improve, or when designing new ones, to ensure healthy indoor climate conditions, in accordance with or above the current standards through the following: the amount of natural daylight, the level of air humidity, the required amount of air exchange and the method of ventilation of the space, other hygienic conditions, noise protection and quality solutions related to room acoustics, avoiding the use of materials with emissions of volatile organic compounds and the application of a monitoring and control system for the aforementioned properties.

In accordance with the fundamental requirement for construction hygiene, health and environment, according to Article 11 *of the Construction Act* (Official Gazette 153/13, 20/17, 39/19, 125/19), the building must be designed and built so that during its lifetime it does not pose a threat to the hygiene or health and safety of employees, users or neighbors and that during its entire lifetime does not have an extremely large impact on the quality of the environment or the climate, during construction, use or removal, and in particular as a result of anything from the leakage of toxic gas, emission of hazardous substances, volatile organic compounds (VOC), greenhouse gases or hazardous particles into indoor and outdoor space, emissions of dangerous radiation, releases of dangerous substances into groundwater, seawater, surface water or soil, releases of dangerous substances into drinking water or substances that otherwise negatively affect drinking water, incorrect discharge of waste water, emissions of flue gases or improper disposal of solid or liquid waste and the presence of moisture in parts of the building or on the surface inside the building.

The internal comfort conditions of the space include optimal temperature and air humidity, air flow speed, amount of pollutants (dust and volatile compounds) in the air, sunlight and natural lighting, noise protection and acoustic quality of the rooms. According to ASHRAE1 and ISO2 standards, thermal comfort in a space is defined as a state of consciousness that expresses satisfaction with the thermal characteristics of a space. The thermal comfort of the room depends on the temperature of the air in the room, the surface temperature of the peripheral building parts, the relative humidity of the air in the room and the air flow. Thermal comfort depends on the level of activity of the users of the space as well as on the clothing worn[24].

Optimal **lighting** is the one in which the equalization of the intensity of daylight in certain parts of the room is achieved. When designing, it is necessary to strive for the maximum use of daylight in all spaces, depending on their purpose. It is desirable to direct the daylight onto the ceiling surfaces, which will then reflect them onto the useful floor space. The internal treatment of the surface must be harmonized with the characteristics of the windows, especially in relation to the reflection of light and the potential possibilities for creating flashes, contrasts and shadows. In order to avoid shadows, the cross-section of window sills and columns between openings should be designed as small as possible. It is necessary to reduce glare by choosing the materials and colors of the main elements in the interior of the space. Artificial lighting should supplement daylight until the required standard of illumination of the space is

[24] Available at: https://mpgi.gov.hr/UserDocsImages/13808

reached according to the purpose or standards, and it must be as similar as possible to natural lighting. The arrangement of the lighting fixtures in the room must enable even lighting of all parts of the room and prevent the creation of greater contrasts. When considering the solution to ensure the optimal level of illumination and the maximum use of daylight, it is necessary to consider limiting the direct sunlight through applicable architectural solutions, but also by optimally designing the vegetation on the plot (use of vegetation as protection from the direct influence of the sun on interior spaces during the summer months). Special attention should be paid to the existence of a view through the window.

Purpose of **ventilation** is the continuous renewal of the air in the room in order to bring its quality closer to the quality of clean, outdoor air. When it comes to ventilation, the type, size and way of opening the windows plays an important role, the ventilation must be even, without changing the speed of the air flow and creating draughts. Cross ventilation is preferable, which can be achieved in rooms oriented on both sides. It is necessary to introduce mechanical ventilation of the space if it is not possible to ensure a sufficient number of air changes naturally. The quality of microclimatic conditions is achieved, apart from ventilation, by using environmentally friendly materials and elements that do not evaporate various toxic and other unnatural compounds over a long period of time. Also, plants suitable for indoor use make a significant contribution in filtering the air and improving its quality, i.e., in improving the indoor microclimatic conditions. Moisture also significantly affects not only the quality of microclimatic conditions and the feeling of comfort, but also, among other things, has an impact on the health of the user, i.e., the reduced possibility of transmission of certain infectious diseases. When designing, it is necessary to plan and foresee the indoor vegetation as well as ways to maintain the optimal level of air humidity, especially during the winter months. It is particularly important to ventilate ground and basement rooms and to control and measure the amount of radioactive particles for the eventual appearance of radon and thoron, i.e., noble gases that arise from the earth, building materials or water. By ventilating rooms, sunning them, installing air purifiers, regular cleaning and disinfection of air conditioners, the conditions for the creation of microorganisms in the air are prevented. It is important to avoid temperature asymmetries - it is necessary to make a budget (hot next to the radiator, cold on the other side of the room). Therefore, it is recommended to install panel heating and cooling systems (ceiling, floor), not by convection but by radiation, compatibility with heat pumps and the possibility of activating thermal masses.

Volatile organic compounds (VOC) are substances that evaporate easily and are a mixture of many different chemicals such as: acetone, benzene, butanal, carbon disulfide, dichlorobenzene, ethanol, formaldehyde, terpenes, toluene, xylene. The effect on humans ranges from experiencing unpleasant odors to serious health effects (e.g., causing cancer). It is necessary to use equipment, coatings and means with low values of pollutants. Furthermore, in accordance with the DNSH principle, it is necessary to provide evidence that construction parts and materials used in the building that may come into contact with tenants **emit less than 0.06 mg of formaldehyde per m3 of material or component and less than 0.001 mg of category 1A and**

1B carcinogenic volatile organic compounds per m^3 of material or component, after testing in accordance with CEN / TS 16516 and ISO 16000-3 or other comparable standardized test conditions and determination method.

A very important element is noise protection. The GDSG project guideline mandates the application of the DGNB standard, i.e., DIN 4109 and 4109-1, as a minimum requirement for acoustic insulation. Regarding reversible noise, i.e., room acoustics (echo), it is necessary that rooms with special requirements regarding speech intelligibility (rooms for meetings, seminars, classrooms, etc.) comply with the requirements of DIN 18041:2016-03.

When renovating buildings, it is necessary to analyze, propose and, in agreement with the Investor, design measures to ensure healthy indoor climate conditions. Examples of measures that can be applied:

- **ventilation system with regulation of the amount of air accordin to actual needs (the so-called "on demans ventilation") – air quality sensors in the room – humidity, temperature, floating particles, flow rate, volatile oranic substances, CO_2, radon**
- **ensuring a satisfactory level of room lighting and natural lighting in rooms, lighting management, lighting sensors, glare**
- **removal and replacement of materials infected with mold and fungi**
- **removal of asbestos lining, cover and insulation**
- **ensuring the quality of drinking water in the building**
- **ensuring appropriate acoustic quality of the space (isolation from external noise, reduction of noise sources in the building)**
- **damp remediation (depends on damage and subject of remediation)**
- **materials that do not contain formaldehyde and carcinogenic volatile organic compounds of 1A and 1B category**

A necessary condition for ensuring healthy indoor climate conditions is the drawing up of a comprehensive building renovation project in accordance with current regulations, which will ensure the definition of requirements for the building, risks, and the way to meet healthy indoor climate conditions in accordance with the purpose and manner of use of the building.

The analysis of the existing condition of the buildings must be carried out in accordance with the *Guidelines for creating an analysis of the existing state of the building with a proposal for measures and an assessment of the investment in the part - healthy indoor climate conditions, mechanical resistance and stability, safety in case of fire* published by the Ministry of Spatial Planning, Construction and State Assets[25] on its website.

[25] Available at: https://mpgi.gov.hr/UserDocsImages/13808

2.4.2. Standards of the interior space in accordance with the purpose, quality and comfort, method of shaping and application of materials

For the structural components of the building, the properties that the structural component must satisfy are set. The following table provides an overview of certain structural components and the minimum properties that each of them must meet (Table 2.5).

Table 2.5 Minimum properties of structural components

Properties that the structural components must meet	Structural components to which the properties that they must meet are applied						
	external walls	exterior windows and doors	internal walls and partitions	internal doors	floors	ceilings	roofs
easy maintenance and cleaning	✓	✓	✓	✓	✓	✓	✓
mechanical resistance and stability	✓	✓	✓	✓	✓	✓	✓
diffuse vapor removal	✓						✓
lighting		✓	✓	✓		✓*	✓*
connecting and separating interior spaces		✓	✓	✓	✓	✓	
ventilation		✓		✓		✓*	
flat surface	✓	✓	✓	✓	✓	✓	✓
safety of movement					✓		
security against intrusion by unauthorised persons	✓	✓	✓*	✓*			✓
safety against fall and injury	✓	✓	✓	✓	✓		✓
thermal protection	✓	✓	✓*	✓*	✓	✓	✓
durability in use	✓	✓	✓	✓	✓	✓	✓
protection from precipitation, atmospheric influences and water	✓	✓					✓
fire protection	✓	✓	✓	✓	✓	✓	✓
noise protection/sound protection	✓	✓	✓	✓	✓	✓	✓

✓ = always applicable

✓* = applicable in certain cases

External walls, external windows and doors, roofs, mezzanine structures towards the external space, floors on the ground are structural components that make up the external envelope of the building and as such are exposed to external (environmental) conditions, temperatures and changes in external air and soil temperatures, atmospheric influences, precipitation and the influence of water. The primary task of the aforementioned parts of the external envelope is to protect against the aforementioned influences and thereby create preconditions for meeting other conditions that are set before the building and are related to the useful floor space within the external envelope of the building. In addition to thermal protection, the mentioned parts must protect the building from rain, wind, and snow in such a way that there is no damage to the external envelope and water penetration through it into the interior of the building. Also, it is necessary to make sure that materials suitable for the climate in which it is being built are used. The durability of the mentioned building elements largely depends on the environment in which they are located, i.e., the influences on them. **By choosing appropriate materials, project solutions and installation methods, it is possible to achieve greater durability and greatly reduce damage and, consequently, maintenance costs. When considering the selection of materials and project solutions, it is necessary to refer to the above and choose the optimal technical solutions.** External windows and doors, in addition to the above, must provide daylight lighting and ventilation of the interior of the building. Windows and doors must be designed so that the user can use them in an easy and simple way, so that it is impossible to open them towards the outer space, but to open them towards the inner space in such a way as not to disturb work processes in the working environment; protective fences should be constructed in front of windows or doors that are on the facades and that do not have parapets. On the outside of the external windows, glass walls and doors, it is necessary to provide suitable protection from the sun, and on the inside, depending on the purpose of the room and the need arising from it, foresee the possibility of performing movable elements that block the view or create darkness. When dimensioning external windows and doors, also consider the technical details of the performance and their dimensions in order to avoid later problems in maintenance and use. In doing so, be sure to look at the number of load-bearing positions, i.e. fittings, the possibility of twisting, the possibility of replacing seals, the need for painting, replacement of cracked glass, etc. In cases where it is justified, consider the use of mosquito nets and other elements that could protect functional spaces from the entry of insects from the outside.

The type of doors, the necessary fittings and equipment, the level of fire resistance if requested, and the method and direction of opening the door must comply with fire protection requirements and must be easy to use (pay attention to the weight of the door and the possibility of opening it by all users). When it comes to doors, pay special attention to possible damage due to their use and apply protective measures where justified. Also, consider maintenance costs (painting, hardware repairs, etc.). Special attention should also be paid to the problems of noise and safety of use (antibacterial door handles, door bumpers, protection against slamming or sudden door closing, etc.).

Internal dividing walls and partitions whether they are glazed or solid, sliding/detachable or fixed, are designed in accordance with the purpose of the room in which it is located, and their finish and the choice of material from which they are made result from that. Their surfaces must be flat, smooth and sufficiently resistant to damage and wear, suitable for cleaning and maintenance, especially the wall surfaces of sanitary facilities.

Pay special attention to special cleaning conditions and disinfection needs in sanitary areas. The use of aggressive agents can greatly affect the durability of certain materials, that is, the selection of special materials can require the use of expensive and special cleaning agents. It is necessary to pay attention to this problem as well as to the problem of the performance of certain details in relation to the possibility of cleaning and ensuring the required sanitary standards. Pay attention to the availability of materials in case of the need to replace them due to damage.

Glazing of all building parts must be performed in accordance with the relevant rules and regulations in order to prevent the possibility of injury in the event of glass breakage. Also, pay attention to all technical parameters, which includes the passage of heat, protection from the sun, and especially pay attention to the conditions for cleaning the glass parts. Glass walls must be accessible to provide easy access for cleaning, they must be protected from the potential occurrence of calcification (external glass walls) as well as other accumulations on the glass. Protection can be achieved by choosing special types of glass, but also by project solutions where the external glass surfaces would be protected from the direct impact of the weather. Special attention should be paid to the entrance areas and to ensure a sufficient area of mats (reduction of soiling, and thus the necessary work of cleaners and water consumption), then the color of the floor, the setting of plinths to protect the wall, etc.

Floors must ensure safety in movement in such a way that the material of the final (walking) coating meets the required anti-slip properties required according to the purpose of the space in which the floor is located. The mentioned materials must ensure the durability of the use of floor surfaces and their easy maintenance. Floors in rooms where there are sanitary equipment, taps or other connections for water supply or sewage must be waterproof with an appropriate slope towards the openings of drainage channels. In the case of a building that, in accordance with the purpose of the room, has a large amount of installation lines and devices that should be placed in the floor, a double floor is recommended. Also, pay attention to the possibility of potential damage and, in accordance with the same, choose materials that are more resistant to mechanical loads, resistant to cleaning agents and their availability in cases of necessary replacement of materials or parts.

Ceilings, depending on the project solution, must ensure durability and safety of use, as well as the possibility of performing and attaching all necessary installations (electrical engineering, fire alarm, automatic fire alarm and extinguishing system, mechanical ventilation, heating, cooling, lighting). In the case of a building that, in accordance with the purpose of the room, has a large amount of installation lines and devices that should be located under the ceiling, it is definitely recommended to have a plasterboard suspended ceiling in a cassette version or a full-surface version with an inspection access.

All construction components, in their design and execution, in addition to what is stated in this Guideline, all official standards, norms and provisions of regulations in the field of construction are applied in relation to the purpose and type of building that is being designed or reconstructed.

GDSG superstandard (recapitulation of chapter 2.4)

In addition to the essential fulfilment of basic construction requirements, technical requirements, standards and norms and general compliance with valid and applicable regulations, which are related to the project in question, GDSG additionally requires, recommends and evaluates the following:

- **Maximum use of daylight in all spaces (primarily working) depending on their purpose**
- **Two-sided orientation and the possibility of cross-ventilation of the space for work and living**
- **Removal and replacement of materials infected with mold and fungi**
- **Removal of asbestos lining, covers and insulation**
- **Ensuring the quality of drinking water in the building**
- **Ensuring appropriate acoustic quality of the space (isolation from external noise, reduction of noise sources in the building)**
- **Apply the mentioned normas from the DGNB standard regarding noise protection and acoustics**
- **Damp remediation**
- **Use of environmentally friendly materials that do not emit hazardous or volatile organic compounds**
- **Use of materials that do not contain formaldehyde and carcinogenic volatile organic compounds of the 1A and 1B category**
- **Use of vegetation to regulate lighting, protection from the sun and achieve internal climatic conditions**
- **Importance of having a view through the window**
- **Avoiding temperature asymmetries**
- **Durability of materials and construction components**
- **Simplicity of maintenance of installed materials or construction componenst**
- **Possibility of simple replacement or adjustment of built-in materials, i.e., construction components**

2.5. Circularity and costs

2.5.1. Possibilities of multi-purpose use of internal and external spaces of building and their adaptability to emerging needs

Buildings need to be designed as functionally as possible according to the requirements arising from their purpose, so that the processes and activities taking place in the building are as efficient and productive as possible, and the health, comfort and safety of the users who use the building are as high as possible.

Increasing demands are placed on buildings, and they have more and more complex systems, which inevitably results in an increase in investment costs in their construction or reconstruction. The GDSG project guideline refers to buildings of public use, therefore it sets the requirement for the greatest possible utilization of the building itself, that is, the greatest possible number of hours of use of the building per year in relation to the total annual number of hours. It also supports the elaboration of the vision and program of the building's use during the drawing up of the project assignment in order to use the building as purposefully, comprehensively and efficiently as possible and to justify the investment in its construction or reconstruction.

For the sake of more efficient and energy-efficient use of buildings, which after all partially results from technical regulations, it is necessary to clearly apply zoning when designing a building. A zone is an area of a building with the same energy and functional mode of use. In accordance with the GDSG project guideline, it is necessary to establish a measuring point for monitoring and measuring energy and water consumption for each zone. The zonal division of the building contributes to its more rational use, i.e., flexibility during various scenarios of use, which is inevitably reflected in the consumption of energy and water. When designing, it is especially important to take into account the possibility of multi-purpose use of the building, parts of the building, or spatial units of the building. Buildings are designed for an extended period of use (minimum 50 years), and during the life cycle of the building and its use, changes are expected regarding the purpose, the way of use, and the requirements and needs of the owner or user of the building.

In order to achieve the required possibility of multi-purpose use, it is desirable to use suitable structural systems of skeleton, modular and prefabricated type. The skeleton construction, which consists of a constructive system of load-bearing columns and beams, results in the largest useful surface area of the building's floors, which then opens up greater possibilities and freedom when designing individual functional assemblies and spaces of the building, i.e., arranging and later (during the use of the building) interior remodeling. The modularly designed and built, prefabricated and assembled construction enables faster and easier execution, rationalization of costs and, if necessary, easier replacement of individual elements with the same or similar ones according to new requirements. The guideline specifically encourages greater use of steel and wooden prefabricated construction that can be dismantled and recycled. In the case of non-load-bearing building elements: infilling of facade walls, partition walls and other elements dividing spaces/rooms in the interior, it is also recommended to use modular prefabricated elements produced from natural recyclable materials as much as possible.

The flexibility of the space and the possibility of its multipurpose use is achieved by using various types of glazed or solid sliding and folding doors and partitions. With such a design method, it is possible to combine several spaces into one larger one or divide one larger space into several smaller ones in accordance with the needs of the user and the current desired way of use. During this kind of design, which respects the flexibility and multi-purpose character of the space, it is necessary to take care of the adequate equipment of the space related to energy needs (electrical installations with connections, lighting, heating, cooling and ventilation installations) which will not be impaired by changes in the way of use. For this purpose, it is recommended to use free installation spaces within suspended ceilings or double floors and to use a drywall system for partition walls. Spaces for communication: corridors and staircases should be designed in such a way that, to the greatest extent possible and in accordance with the basic requirements for the building, they enable additional activities/content to take place in them besides the basic one (communication) and thus become multi-purpose spaces. Corridors and staircases should be connected as much as possible with the basic purpose spaces they serve in order to become as functional as possible and give additional value to the basic purpose, i.e., the flexibility of the space. Special attention should be paid to service shafts - dimensioning with a margin of min. 30% for the implementation of possible new installations or upgrades of existing ones (in the 50 years of the building's life cycle, there will be significant changes in technologies, etc.)

Buildings designed according to the GDSG project guidelines should be adaptable to emerging needs especially those that appear suddenly as a result of natural disasters (floods, earthquakes, storms, etc.) and crisis situations caused by human activity (war or state of emergency, epidemics, etc.). In such situations, when new and often completely contradictory requirements are set before the building in relation to its designed function, its multi-purpose and flexible character described in the previous paragraphs must come to the fore.

2.5.2. Obligations to use environmentally friendly and recycled materials and proper disposal of construction waste

For the construction and renovation of buildings, the GDSG project guidelines imply the use of the following materials to the greatest extent possible:

- natural materials;
- local materials in the context of the location (in order to further emphasize the local context and connection with the terrain) and the place of production (in order to reduce transport costs and CO_2 emissions arising from it);
- materials that are produced by recycling or have the possibility of recycling;

- materials that can be reused or degraded;
- durable materials;
- materials that are damp proof;
- materials that have a low emission of volatile organic compounds;
- materials that support energy efficiency and water conservation and efficiency

The guideline also implies the use of harmful, unnatural, non-degradable or toxic materials as little as possible. In accordance with the basic requirement for the building of sustainable use of natural resources according to Article 15 *of the Construction Act* (OG 153/13, 20/17, 39/19, 125/19), buildings must be designed, built and removed in such a way that the use of natural resources is sustainable, and in particular they must guarantee the following: reuse or the possibility of recycling the building, its materials and parts after removal, the durability of the building and the use of environmentally acceptable raw materials and secondary materials in buildings.

According to these guidelines, the **priority in the selection of materials and construction products is given to those that are locally produced and/or locally available**. This means that you should use, for example, locally sourced and sustainably sourced timber (FSC) as it has the lowest impact on emissions due to reduced transport costs and energy use in the production process or locally sourced windows and doors that use locally produced parts, etc.

When choosing materials and construction products, the **possibility of degradation and recycling** of them should be kept in mind and it is important to choose those with a greater capacity for reuse, ecological disposal and recycling. Furthermore, the materials and products used **in the interior, must guarantee high quality standards for a healthy stay** in the interior. This means that they must not contain solvents, softeners and other compounds that, through their evaporation, negatively affect the air quality in the room. All such products must have a sustainability data sheet proving that they have been tested and that they have an environmental product declaration (EPD) and an eco-label (e.g., the TUV test label for harmful substances).

Through the design, construction and use of the building, it is necessary to reduce to the smallest possible extent, i.e., completely remove the waste generated by the construction or use of the building. It is mandatory to implement an efficient and environmentally friendly waste sorting and management system in such a way that it is promoted with project solutions such as sorting at the point of waste origin. Furthermore, during reconstruction/demolition, it is necessary to recover as much of the existing construction material/waste as possible and to comply with the *Guidelines for the waste audits before demolition and renovation works of buildings issued by the European Commission*, May 2018[26].

[26] Available at: Guidelines for the waste audits before demolition and renovation works of buildings issued by the European Commission

2.5.3. Life cycle costs

Life cycle costs of the building (LCC) in addition to the construction cost of the building, include the cost of use and maintenance of the building as well as the cost of removal. The biggest impact on all the mentioned cost categories can be achieved in the design stage. These guidelines set out the principles and instructions in the design of buildings that encourage sustainable construction and the need to analyze the later costs of maintaining individual elements and parts of the building. In order for the owner of a public building to be able to plan the budget necessary for the building to be used in accordance with its purpose during its service life, it is necessary to analyze and predict the costs of its use and maintenance. In accordance with the above, these guidelines require the creation of projections of the costs of maintenance and use of the designed building, i.e., the costs of its life cycle, with a minimum of the following categories of costs:

- Construction costs;
- Costs of planned preventive maintenance;
- Costs of statutory inspections and tests;
- Costs of reactive maintenance;
- Costs of replacement of used materials and equipment;
- Building use costs;
- Building removal costs.

When projecting the building's life cycle costs, it is necessary to use current prices and make projections for a minimum 15-year period, while it is recommended that projections be made for a 30-year period for those buildings for which it is certain that the purpose will not change (e.g., hospitals and schools).

The reason for such a long period of time lies in the fact that most of the maintenance costs occur between the 15th and 25th year, when major interventions, the so-called investment maintenance, especially in the part of mechanical installations and equipment, sanitary areas as well as other parts and elements of the building, are expected. In this way, contracting authorities can plan funds in the budget on time, that is, be aware of the costs of ownership of an individual building in time. Also, in this way, during the use of the building, it is possible to control deviations from the original plans and to plan improvements or alternative solutions for existing elements, parts and equipment, and to optimize the life costs of the building during the entire period of use.

Under the costs of planned preventive maintenance, it is necessary to specify costs such as regular mechanical and electrical equipment services, regular planned painting, mowing and trimming of horticulture, etc. This category of maintenance costs is characterized by predictability and the possibility of planning them, and thus the possibility of planning the development of these activities in periods when they will least interfere with the normal use of the building by the user.

In the category of statutory inspections and tests, it is necessary to list all inspections and tests defined/required by law and other regulations. This especially applies to renewals of equipment attestations, construction inspections and other tests that are required by the regulations of the Republic of Croatia and are often not carried out. The mentioned attestations and tests ensure the control of the equipment and the safe use of the building.

Costs of reactive maintenance represent a special category of costs that cannot be predicted and refer to breakdowns and damage due to use, for the correction of which funds must be provided. In order to ensure the smooth use of the building, it is necessary to have funds reserved for these needs. In cost estimates for this category, the designer or consultant should be guided by experiences from similar buildings, given that these costs vary depending on the purpose of the building, its users, etc.

The costs of replacement of used materials and equipment should be estimated in accordance with the life cycle of that building. For example, sanitary equipment cannot be expected to have a life cycle of 30 or more years, that is, sanitary facilities will require complete reconstruction at least once every 20 years. The same can be predicted for a good part of the mechanical equipment as well as the installation of the building. All the mentioned activities need to be planned separately because they can require significant funds.

The costs of using the building need to be further elaborated, given that they will differ depending on the purpose. Energy costs (for heating, electricity, water, waste disposal, etc.) are costs that each building will have regardless of purpose, as well as insurance costs and cleaning costs, but costs such as janitorial and doormen service or security are costs that depend on the purpose of the building. The mentioned costs represent a significant amount

These guidelines prescribe the creation of life cycle cost projections for reasons of optimizing them in the design stage. Only by creating a projection of maintenance and use costs can the most cost-significant items be identified, which can then be tried to be optimized with different project solutions in the design stage.

GDSG superstandard (recapitulation of chapter 2.5)

In addition to the essential fulfillment of basic construction requirements, technical requirements, standards and norms and general compliance with valid and applicable regulations, which are related to the project in question, GDSG additionally requires, recommends and evaluates the following:

- **Building utilization requirement (maximize the ratio between the number of utilized hours per year and total number of hours per year)**
- **Functional and energy zoning of the building**
- **Possibility of phased construction**
- **The multifunctional character of the space**
- **Adaptability of the building and premises to another/new purpose**
- **Use of skeleton, modular, prefabricated construction and construction components**

- **Use of sliding and folding doors and walls**
- **Designing corridors and staircases as multifunctional spaces with added value (ratio of useful areas and the total net area of the building)**
- **Reserves in ducts due to upgrades**
- **Use of materials and products that have the least impact on the environment, and are proven by the EPD declaration;**
- **Use of materials and products that are produced locally and in a sustainable way, and are proven by the FSC declaration;**
- **Use of materials and products that have an eco-label, which is proven by proof of testing from an authorized institution**
- **Obligation to analyze and estimate construction costs;**
- **Obligation to estimate maintenance costs;**
- **Obligation to estimate the costs of building use;**
- **Obligation to assess the removal of the building.**

2.6. Processes and tools

2.6.1. Integrated approach

The design and construction of buildings has a wide and direct impact on the environment, society and economy. Designing according to the principles of sustainability must balance the needs and requirements of these three areas by applying an integrated approach in order to create win-win design solutions. **The guideline mandates the adoption of a continuous integrated approach of all involved stakeholders (investor, designers, public administration, contractors, supervising engineers, owners, users) from the beginning of the design, through the construction of the building and during the use of the building.**

The design and subsequent construction of a new building or the reconstruction of an existing one must be an interdisciplinary process that includes close, continuous and synergistic cooperation of all professions in order to successfully realize the project task and ultimately obtain an efficient, high-quality and sustainable building. Consideration of building management and maintenance issues when designing a building will contribute to an improved working environment, greater efficiency and productivity, reduced energy costs and prevention of system failures later in the use of the building itself, which will consequently reduce costs in the life cycle of the building.

The process does not end with the construction of the building, but it continues throughout the lifetime period of the building's use by continuously monitoring the building's behavior during its use, keeping a log of use, monitoring the state of installed materials and technical systems, efficient building management, timely planning and implementation of building maintenance measures, monitoring energy and water consumption. Continuous awareness and education of building users and influence on their thinking and behavior related to the way of using energy, water, installed technical systems and everything else related to the building as a whole is particularly important.

2.6.2. BIM approach to design

Due to the advantages provided by the BIM approach (*Building Information Model, Building Information Modeling, Building Information Management*) on the construction project and recommendation of the European Union Public Procurement Directive on the mandatory application of BIM technology in all public procurement projects requires the drawing up of project documentation and a BIM execution plan with the aim of presenting the project approach, capacity and expertise and competence for the implementation of the project, regardless of whether it is a new or existing building.

Guidelines for creating a BIM execution plan are given in the publicly available *General Guidelines for BIM Approach in Construction* issued by the Croatian Chamber of Civil Engineers, June 2017[27]. *BIM execution plan* will be used as a basis for contracting projects for the reconstruction of public buildings and the construction of new buildings.

Before contracting, the *BIM execution plan* is prepared by the Bidder in the tender stage with the aim of presenting the project approach, capacity, expertise and competence for the implementation of the project.

Furthermore, the new ISO 19650-1(2):2018 standard has been accepted by CEN as EN ISO 19650-1(2):2018 and as such has been adopted in its entirety without modification as HRN EN ISO 19650-1(2): 2019, and is about the organization and digitization of building and engineering information including Building Information Modeling (BIM). Information management should be applicable throughout the life cycle of the building. The amount of information that needs to be managed increases through the operational phase, and especially during the asset management phase, and therefore it is very important to transfer only relevant and essential information through these two phases and in both directions. The information management process should include initial and detailed planning of how and when to deliver information, to whom to deliver it and how to communicate in all directions. Moreover, the information management process should be adapted to the size and complexity of the construction project. With the BIM approach, we can more easily achieve cost optimization, especially when it comes to buildings with nearly zero energy consumption, because it enables us to cooperate with all professions at an early stage and carry out energy simulations in the phase of conceptual design development, which is very important. The practical application of the BIM approach refers to all phases of the building's life cycle, from planning, design, construction, commissioning, management and maintenance, as well as demolition and recycling.

[27] Available at: http://www.hkig.hr/izdvojeno/Opc769e-smjernice-za-BIM-pristup-u-graditeljstvu/16

Precisely because of the above, the BIM project management approach as a technology (modeling) but also as a methodology (management, cooperation of all participants) is imposed as the only possible standard of project management, contributing to increasing the accuracy and quality of projects, reducing or eliminating errors and changing the project during construction, increasing productivity (analyses show increase of up to 40%), increasing competitiveness on the market, reducing employee stress and ultimately reducing maintenance costs, which ultimately brings substantial financial savings to the investor.

A BIM project requires taking care of the models that are being created. If BIM models are not created using the appropriate methodology, they can be useless, and the effort devoted to their creation will be in vain. Therefore, new participants and their responsibilities must be included in order to guarantee the success of the application of the BIM methodology. This includes:

- **BIM manager:** a methodology expert with a strategic role, must provide solutions to problems, establish standards and research in order to be at the forefront and be able to lead his team. This role can be performed by an independent party working for the investor, e.g., project manager, but also a dependent party on the project, e.g., chief designer.
- **BIM coordinator:** expert in software tools, information management and modeling. He knows the procedure and workflows, he has to control and manage the models so that everything is done correctly and in order to maintain the expected quality in BIM models. They appear for a particular profession and are a direct link between BIM managers and project participants.
- **BIM engineer:** an expert in tools for the author's design of his part of the BIM project whose responsibility is to create information models and technical documentation.

The investor must appoint collaborators, while in the tender documentation for the BIM project he must define *Client's BIM requirements*. This document defines and specifies models made for specific phases of the project, together with the required level of detail and information. These models belong to the key deliverables of the BIM project and contribute to effective decision-making in specific phases of the project.

***Client's BIM requirements* consist of three main categories:**

- Technical - information about the software platforms that will be used in the project, requested
- level of development, etc.
- Management – details of the management process to be adopted in the BIM project.
- Business - details of BIM model delivery, data delivery schedule, etc.

After contracting the BIM project, it is necessary to define the matrix of roles and responsibilities and the course of cooperation.

Each investor has different needs that require different information structures. It is necessary, in accordance with the needs of the investor, to analyze the future use of the model in the phase of building use, define what information will be used and maintained, so that it is useful. In other words, it is necessary to create a connection between the BIM data of the designed/executed model and the facility management platform.

GDSG superstandard (recapitulation of chapter 2.6):

- **Due to all the advantages of the BIM approach, this guideline obliges the application of BIM for new construction and for the reconstruction of existing buildings, regardless of the size and complexity of the intervention.**

3. Building envelope

3.1. Shape factor

The building shape factor represents the relationship between the area and the volume of the heated part of the building, f0=A/V (m-1). Heat losses through the area of the heated part of the building will be smaller, if the area of the heated part of the building A (m2) is smaller in relation to the volume of the heated part of building Ve (m^3). Therefore, it is important to say that the design of the building plays an important role in the process of designing the energy efficiency of the building because it directly affects the value of the shape factor. "Compact" and larger buildings have a more favorable, lower value of the shape factor.

GDSG superstandard (recapitulation of chapter 3.1):

- **Optimum/favorable shape factor considering the purpose of the building and the plot.**

3.2. Orientation and protection from excessive insolation of the facade

The orientation of the building is important because it creates the potential for utilizing solar energy, while on the other hand, care must be taken not to create an excessive need for energy for cooling due to solar gains. The same can be influenced by the orientation, quantities, or surfaces of the openings towards the sides of the world and protection from the sun. In buildings with average window dimensions, the orientation will have a small impact, while in buildings with large glass panels, the orientation will have a greater impact on the required energy for heating and cooling.

Looking from the energy point of view, it is desirable that the majority of openings are oriented to the sides of the world that do not provide extreme conditions (east, west), and a smaller amount to the sides of the world with extreme conditions (north, south). Shades on the south, east and west sides must be designed as architectural solutions for partial or complete shading (brise soleil and/or other shading methods such as photovoltaic panels, cantilevers (consoles) with an interrupted thermal bridge), or various protective layers on the glass and planting suitable vegetation. In the case of using boxes for blinds, they must be thermally insulated and meet the condition of the highest permissible value of the heat transfer coefficient, $U \leq 0.6$ [W/m^2K].

GDSG superstandard (recapitulation of chapter 3.2):

In addition to the essential fulfillment of basic construction requirements, technical requirements, standards and norms and general compliance with valid and applicable regulations, which are related to the project in question, GDSG additionally requires, recommends and evaluates the following:

- **Mandatory application of sun protection solutions on the outside of external windows, glazings and doors located on the south, east and west facades**

3.3. Thermal insulation

The thickness of the thermal insulation must be such that it meets the conditions in terms of the highest permissible value of the thermal transmittance according to the conditions in the *Technical regulation* (conditions are given below). In case of publication of public calls for the allocation of financial assistance for energy renovation and the use of RES in public buildings, it is necessary to comply with the minimum technical conditions defined by the call, which are, as a rule, stricter than those in the Technical regulation. Also, regardless of the conditions from the *Technical regulation* or a public call, it is necessary not to plan too thick thermal insulation because the saving effect will not be achieved (it is not cost-optimal). Due to the different interpretation of the current legislation and the new *Design and execution manual* in terms of fire protection of building facades issued in 2017 by the Faculty of Civil Engineering, University of Zagreb[28], in which the complexity of the application of two different materials on the facades as part of the GDSG project guidelines, is indicated, the use of stone/mineral wool on the facades of public buildings is required. The GDSG guideline allows the use of other non-combustible heat-insulating materials on facades, as well as TI panels made of extruded polystyrene in the splash zone of the building perimeter, and panels made of expanded polystyrene or other heat-insulating materials on flat roofs if such materials are made in accordance with fire protection conditions.

Special attention should be paid to solving constructional details essential to prevent direct wetting of the facade and the formation of algae and fungi. In the case of systems with a thicker reinforcing and finishing-decorative layer, retention of condensate on the facade during the night is significantly shorter, so it is advisable to increase the thickness of the reinforcing layer to a minimum of 3 mm or increase the size of the finishing-decorative plaster. Critical places should be additionally coated with a coating with the addition of biocide (north sides, near trees or bushes, etc.). Also, the use of roundels is recommended to prevent spotted thermal bridges. In ETICS systems, silicone-silicate (SiSi) plaster should be chosen for the final-decorative layer of plaster, which is more resistant to weather conditions, but is also water-repellent and has satisfactory vapor permeability. At the same time, pay attention to the tone of the facade and

[28] Available at:
https://bib.irb.hr/datoteka/879428.Jelcic_Rukavina_Carevic_Banjad_Pecur_Zastita_procelja_zgrada_od_pozara.pdf

the reflection factor due to the appearance of cracks. It is necessary to apply the guidelines issued by the *Croatian association of thermal facade systems manufacturers*, and refer to guidelines for making ETICS systems, algae and fungi on facades, stone and ceramic cladding on ETICS systems, calculation of fasteners and more[29]. **As part of these GDSG project guidelines, the use of a ventilated facade system is recommended as opposed to an ETICS system.**

The advantages of the ventilated facade compared to the ETICS system are multiple:

- they enable the drainage and drying of rainwater (at open joints) and condensate and thereby improve the quality of the building's thermal insulation, reduce the risk of wet spots on the walls caused by capillary moisture, all in favor of a longer service life of the substructure;
- they regulate the fluctuation of humidity and temperature and thus reduce the risk of thermal bridges. Due to the difference in temperature and humidity between the upper and lower part of the building, a natural flow of air ("stack effect") occurs behind the facade cladding. This air flow has the ability to dry and remove moisture and condensate, which in this way can evaporate by ventilating the interspace behind the cladding, resulting in a building that "breathes", which helps maintain a healthy and pleasant indoor climate. In addition, in the summer period, heat loads and heat transfer to the interior are further reduced;
- durability and economic profitability due to resistance to weather influences, the durability of the material enables less frequent maintenance intervals and thus lower costs during the life cycle of the building;
- the possibility of installing thermal insulation up to 20 cm thick on the outside of the structure, and in this way very low U-values can be achieved (U=0.10-0.15 W/m2K) which leads to a considerable saving of the necessary energy for heating and cooling;
- high aesthetic component due to the great possibility of choosing and combining the spectrum of colors, surface treatment and format;
- The ETICS facade is not recycled - the ventilated one can be divided into raw materials and recycled, even reused.

Large-format ceramic plates, HPL (*high pressure decorative laminates*), stone panels, fiber-cement panels, composite aluminum panels and aluminum, steel, copper or other metal panels, can be used as external cladding. The choice of external cladding should be optimal, taking into account fire protection, then the weight of the cladding, which directly affects the type of substructure in such a way that heavier elements require a stronger substructure and thereby increase the cost of the facade, wind load, etc. When choosing, preference should be given to products that are CO_2 - neutral and ultimately completely recyclable. The product must have an environmental product declaration (EPD) on the lifelong impact of the product on the environment with transparent, verified and comparable data.

[29] Available at: http://www.hupfas.hr/

It is also recommended to consider the integration of a solar power plant on the facade so that the solar modules are also the final cladding of the ventilated facade. Such modules are mostly made of recycled glass panels and are joined as a sandwich and are not visible and are protected.

GDSG superstandard (recapitulation of chapter 3.3):

In addition to the essential fulfillment of basic construction requirements, technical requirements, standards and norms and general compliance with valid and applicable regulations, which are related to the project in question, GDSG additionally requires, recommends and evaluates the following:

- **mandatory use of stone/mineral wool in facade systems and in other constructions**
- **parts that are insulated (non-flammability class A1);**
- **use of ventilated facades instead of the ETICS system;**
- **use of photovoltaic panels as final facade elements.**

3.4. Exterior joinery/hardware

Exterior joinery/hardware must be designed in such a way as to meet the highest permitted values of the thermal transmittance defined by the current Technical regulations, and in accordance with the latest technological achievements in production and installation. For public buildings, wooden profiles with an external aluminum coating are preferred for durability, static resistance and cheaper maintenance, or modern thermally insulated aluminum profiles with a total heat transfer coefficient of U≤1.10 W/m^{2}K total, U≤0.90 W/m^{2}K glass.

As part of this Guideline, for all exterior joinery, it is recommended to choose wooden frames with an exterior aluminum cladding. As an alternative choice, in case of the need to reconstruct larger areas or external entrance doors, aluminum joinery is recommended. The selection of glass must be optimal, paying attention to the thermal transmittance (U) for heating, then the degree of transmission of the total energy of solar radiation (g) for cooling and the light transmission factor (τV) for illumination.

Wood-aluminum windows are more expensive than PVC or aluminum windows, but they provide a longer service life and a better microclimate of the space. Aluminum protects the wood on the outside, so the maintenance of the joinery is reduced to a minimum. Wood is a natural material that has optimal thermal properties and significantly reduces energy needs for heating and cooling. The materials are fully recyclable. It is necessary to use products that have passed the quality check according to the EN 14351-1:2006; 2010 standard system and have proof of wood origin from forests that are managed according to strict ecological, social and economic standards (e.g., FSC certificate).

The production of joinery from wood-aluminum profiles in Croatia is significantly less represented than, for example, the production of joinery from PVC profiles. Increased use would affect the increase in the range of products of local producers, investment in development and research, and raising the quality of products and services as required by modern standards of low-energy, passive and green construction. Furthermore, wood and aluminum are sustainable, green materials that are found in nature in their original form and in large quantities and are fully recyclable.

GDSG superstandard (recapitulation of chapter 3.4):

In addition to the essential fulfillment of basic construction requirements, technical requirements, standards and norms and general compliance with valid and applicable regulations, which are related to the project in question, GDSG additionally requires, recommends and evaluates the following:

- **It recommends the use of external joinery with a wooden profile and aluminum cladding;**
- **It dictates the amount of the thermal transmittance in the amount of U≤1.10 W/m^{2}K total, U≤0.90 W/m^{2}K glass.**

3.5. Airtightness of the envelope

Parts of the building that make up the envelope of the heated space of the building, including joints between individual building parts and openings or transparent elements that do not have the possibility of opening, must have minimum airtightness.

The installation of joinery/hardware should be designed according to **RAL guidelines**[30] for installing windows and doors. The given link refers to the online pages of the German institute for windows, doors and facades called "ift Rosenheim" as the headquarters institution in Europe for the implementation of the latest achievements and knowledge for the quality installation of windows, doors and facades. It is mandatory to carry out an examination of airtightness requirements (the so-called *blower door test*) which is carried out according to the prescribed standard HRN EN ISO 9972:2015 before the technical inspection of the building.

[30] Available at: chrome-extension://oemmndcbldboiebfnladdacbdfmadadm/https://www.ift-rosenheim.de/documents/10180/1206724/PI161195_RAL_Installation_Guideline.pdf/1c75b997-d944-4118-9280- 4b9139454762

GDSG superstandard (recapitulation of chapter 3.5):

Complying with the applicable regulations related to testing the airtightness of the envelope is required:

- **for a pressure difference between indoor and outdoor air of 50 Pa, the measured air flow, reduced to the volume of indoor air, must not be greater than the value n50= 3.0 1/h in buildings or individual thermal zones of buildings without a mechanical ventilation device, i.e., n50= 1.5 1/h for buildings or individual thermal zones of buildings with mechanical ventilation devices;**
- **Installation of joinery/hardware in accordance with RAL guidelines, as well as sealing of all penetrations on the envelope and elements of the envelope such as vapor barriers, etc., in accordance with the rules of the profession, and the use of typical elements of the manufacturer for this purpose are stipulated.**

3.6. Thermal bridges

During the reconstruction, it is necessary to consider possible construction works for the purpose of reconstructing the external envelope, which affect the resolution of thermal bridges using technical solutions with ready-made thermal insulation elements that minimize thermal bridges on prominent parts of the building. Other thermal bridges should be dealt with in accordance with the *Technical regulation on the rational use of energy and thermal protection in buildings (Official Gazette 128/15, 70/18, 73/18 and 86/18 and 102/20)*. In order to extend the life of the waterproofing of the roof, increase protection against ultraviolet radiation and protection against noise, it is recommended to consider the option of designing a green roof.

3.7. Energy renovation and use of renewable energy sources in public buildings sector – technical requirements

The purpose of energy renovation of buildings is to reduce energy consumption in public buildings, within which energy renovation measures that will result in a reduction of energy consumption for heating/cooling (QH, nd and QC, nd) at the annual level (kWh/year) in relation to the annual energy consumption for heating/cooling before the implementation of the mentioned measures and the use of renewable energy sources, are supported. This GDSG project guideline defines somewhat stricter conditions than those prescribed by the Technical regulation, all for the purpose of creating prerequisites for applying for and using grants from EU funds or national funds in the future**. Annex 1 shows the technical conditions of the GDSG project guideline.**

4. Heating, cooling, ventilation and DHW preparation system

To ensure the necessary amount of thermal energy, the following options should be considered with regard to the type of energy source. As part of this Guideline, models for the elaboration of the mechanical part of the installation are given. It is noted that project solutions must be analyzed according to the following chronology. If the development of the technical solution establishes the impossibility of using, for example, geothermal energy for heating and cooling the building, it is necessary to consider the following described model. Larger heating, cooling and ventilation systems in accordance with the provisions of the chapter 8 they must be equipped with internal automation connected to the central monitoring and control system.

4.1. Heating and cooling system

In any case, regardless of the method of energy production, it is mandatory to apply regulation and balancing of the heating system (thermostat sets, differential pressure regulators, cascade regulation of boilers and frequency-controlled pumps with an energy efficiency index of less than 0.15 (EEI<0.15) and etc.) and elements for irradiation.

4.1.1. Heating system

The following options should be considered for the heating system:

Examine the possibilities of using geothermal energy or air energy, that is, the possibility of using heat pump technology (water-water, soil-water, air-water, air-air).

Heat pump for heating (and optional cooling):

- Installation of a water/water heat pump as a central source of heat/cooling energy for space heating/cooling and/or DHW preparation at the building level, including all parts of the system up to the connection to the pipe distribution subsystem of the central space heating/cooling system and DHW preparation:
    - SCOP for a heat pump according to HRN EN14825:2019 (or "equivalent") for heating for water supply temperature of 35°C and average climate ≥4.3 and for water supply temperature of 55°C and average climate ≥3.7
    - graduated or continuous effect regulation from a minimum of 25% to 100%
    - GWP ≤ 1.500
- Installation of a ground/water heat pump as a central source of heat/cooling energy for space heating/cooling and/or DHW preparation at the building level, including all parts

of the system up to the connection to the pipe distribution subsystem of the central space heating/cooling system and DHW preparation:
  - SCOP for a heat pump according to HRN EN 14825:2019 (or "equivalent") for heating for water supply temperature of 35°C and average climate ≥4.0, and for water supply temperature of 55°C and average climate ≥3.4
  - graduated or continuous effect regulation from a minimum of 25% to 100%
  - GWP ≤ 1.500
- Installation of an air/water heat pump as a central source of heat/cooling energy for space heating/cooling and/or DHW preparation at the building level, including all parts of the system up to the connection to the pipe distribution subsystem of the central space heating/cooling system and DHW preparation:
  - SCOP for a heat pump according to HRN EN14825:2019 (or "equivalent") for heating for water supply temperature of 35°C and average climate ≥3.3 and for water supply temperature of 55°C and average climate ≥2.9
  - graduated or continuous effect regulation from a minimum of 25% to 100%
  - GWP ≤ 1.500
- Installation of an air/air heat pump (VRF) with heat recovery as a central source of the heating/cooling energy for space heating/cooling and preparation of DHW at the building level:
  - SCOP ≥ 4,0
  - SEER ≥ 6,0
  - GWP ≤ 2.150

In doing so, it is necessary to use the relevant version of the geothermal or air heat pump with an integrated tank for the preparation of hot water. In order to eliminate the operation of heat pumps during the summer months, and in the case of the need for a larger amount of domestic hot water, it is necessary to provide a solar collector system: installation of solar collectors, DHW storage tank for central preparation of DHW at the level of the building and associated automation for regulation. The technical requirement for collectors is to have a product quality certificate - *Solar Keymark*. This measure includes the installation of a water meter to monitor the DHW consumption profile.

If it is established that it is impossible to use heat pumps for heating and cooling the building, it is necessary to consider the installation of a biomass boiler for space heating purposes.

<u>**Woody biomass boiler room**</u>

a) Boiler (heating)
   Installation of a woody biomass boiler with a regulation system according to the external temperature to meet the peak heating needs of the building. In the case of a nominal boiler power of less than 100 kW, use pellet boilers, and in the case of higher power, use wood chip boilers. The efficiency of the boiler must be at least 0.90. It is necessary

to provide for the installation of a heat store whose capacity is dimensioned according to the power of the boiler.

b) Preparation of domestic hot water
For the purposes of preparing domestic hot water, envisage the installation of a free-standing storage boiler of adequate volume with two heat exchangers. Envisage the use of a solar collector system for heating domestic hot water during the summer months connected to the lower exchanger and reheating to the required temperature with biomass boilers on the upper exchanger.

Centralized heating system (district heating)
For space heating and domestic hot water preparation, it is possible to use district heating systems if this type of heating is available at the location of the building itself (if it is available, it is considered the primary way to meet heating and domestic hot water needs). It is necessary to emphasize that this type of heating and domestic hot water preparation system is the most efficient way of ensuring a sufficient amount of thermal energy, and if such systems use renewable energy sources, all legislative regulations are met.
In order to define the most suitable method of heating, it is necessary to consider the listed possibilities of a combination of CTS and a photovoltaic system and a collector system for the preparation of domestic hot water, and in order to achieve the minimum share of renewable energy sources defined by this guideline (depending on whether it is a reconstruction or the construction of a new building).

4.1.2. Cooling system

The following options should be considered for the cooling system:

Geothermal heat pump
If a geothermal heat pump is used for space heating, it must be used for cooling with an appropriate distribution system. The heat pump for the preparation of domestic hot water, heating and cooling must meet the conditions given in chapter 4.1

Air source heat pump
If a geothermal heat pump is used for space heating, it must be used for cooling with an appropriate distribution system. The heat pump for the preparation of domestic hot water, heating and cooling must meet the conditions given in chapter 4.1

Central cooling system with VRV cooler
In the case of heating the space with biomass boilers, that is, with CTS, it is necessary to provide for the cooling of the space with a central cooler (air heat pump). It is recommended to install a cooler with propane or CO_2 as the working substance. Due to the optimal usage regime and

reserve in case of failure, it is recommended to install two or more coolers of lower power instead of one of higher power. The cooler must meet the energy efficiency requirements given in chapter 4.1.
It is necessary to examine the possibility of utilizing the waste heat of the heat pump cooler for the purpose of reheating domestic hot water during the summer months. It is possible to install a three-pipe system that enables simultaneous heating and cooling of certain rooms, or a two-pipe system that cannot be used to heat and cool the building at the same time.

GDSG superstandard (recapitulation of chapter 4.1):

- **75% of the delivered energy for heating, cooling and DHW from renewable energy sources in the reconstruction of buildings;**
- **100% of the delivered energy for heating, cooling and DHW from renewable energy sources in the construction of buildings**

4.2. Building ventilation system

Whether in the case of energy renovation or construction, it is necessary to design and implement mechanical ventilation with recovery. In the case of minor reconstruction, but also the need for greater air exchange (larger number of users or risk of moisture condensation), it is necessary to provide a local pressure/exhaust ventilation system with recovery for certain spaces (halls, corridors and waiting rooms).
In the case of non-residential buildings, the number of exchanges of indoor air with outdoor air is determined according to the Algorithm (in accordance with Article 27, Paragraph 2 of the current *Technical regulation on energy economy and heat retention in buildings*) and according to the Standard operating time values of mechanical ventilation systems for non-residential buildings, given in the table below (Table 4.1). Pay special attention to school and kindergarten buildings where greater air exchange is required. The designed solution should be equipped with internal automation connected to the central monitoring and control system.

Table 4.1 Standard operating time values of mechanical ventilation systems for non-residential buildings

Purpose of space	Period of use (h)*	Number of hours of system use (t_{use} (h/day)	Number of heating/cooling system stops** $t_{v,mech}$ (h/day)	The minimum required flow of outside air per unit area V_A, ($m^3/(m^2h)$)
Office, administrative and other business buildings of similar purpose	07:00 - 18:00	11	13	4
School, college buildings, and other educational institutions	08:00 - 20:00	12	14	10
Kindergartens	07:00 - 18:00	11	13	10

Libraries - reading rooms	08:00 - 20:00	12	14	8
Libraries - rooms with shelves	08:00 - 20:00	2	14	2
Hospitals and rehabilitation buildings	00:00 - 24:00	24	24	4
Hotels, motels, etc.	00:00 - 24:00	24	24	3
Museums	00:00 - 24:00	24	24	4
Other buildings with permanent operation (stations, etc.)	00:00 - 24:00	24	24	4
Department stores, shopping centers, shops	08:00 - 21:00	13	15	4
Sports buildings	08:00 - 23:00	15	17	3
Workshops and production halls	07:00 - 19:00	12	14	20
Congress centers	09:00 - 18:00	9	11	7
Theaters and cinemas	13:00 - 23:00	10	12	25
Canteens	08:00 - 15:00	7	9	18
Restaurants	10:00 - 00:00	14	16	18
Kitchens	10:00 - 23:00	13	15	90
Server rooms, computer centers	00:00 - 24:00	24	24	1,3
Garages	00:00 - 24:00	24	24	16
Equipment storage, archives	07:00 - 18:00	11	13	0,15
Buildings not listed	07:00 - 19:00	12	14	10

** The heating/cooling system starts working 2 hours before the start of use of the space*
*** In the Algorithm according to HRN EN ISO 13790, these values refer to the number of hours of operation of the heating/cooling system td (h/d).*
In the event that certain spaces have known operating values (museum spaces with controlled conditions), which are not lower than those mentioned above, it is necessary to take them into account.
In case the zone includes several rooms with different daily times of use of mechanical ventilation, for mech $t_{v,mech}$, the maximum amount is taken.

Source: Algorithm for the calculation of the required energy for heating and cooling the building space according to HRN EN ISO 13790

Table 4.2 Efficiency of the recuperator

Waste heat recovery unit (recuperator)	Minimum efficiency* (η)
Countercurrent plate recuperator with square cross section channels	0.85

** In accordance with the following standards: HRN EN ISO 13790, HRN EN 15243, HRN EN 15241, HRN EN 15242, HRN 15251, HRN EN 13779 and with the following temperature parameters: Outside air (t11=0°C), waste air (t12= 4°C), exhaust air (t11=20°C), supply air (t22=16°C)*

Automatic regulation of ventilation is desirable. This, among other things, will enable air exchange during the night in the summer months (ambient air temperature lower than the air temperature in the building), which will result in a cooling effect of the space, as well as regulation of ventilation operation based on the proportion of CO_2 in space. Electricity consumers in the ventilation system must be energy class A or higher. It is mandatory to foresee the management and control of the ventilation system primarily through moisture and carbon dioxide sensors (CO_2).
Special attention should be paid to the noise produced by newly installed devices in the room. In addition to the need to satisfy the valid legal regulations for noise for individual purposes of the premises, it is necessary to look at the possibilities of additional noise attenuation, such as the implementation of additional insulation or the implementation of a reversible noise compensation system.
These guidelines require that the noise level at nominal flow in indoor spaces be a maximum of 35 dB.
Furthermore, it is necessary to integrate the newly installed devices and channels into the interior in such a way that they are integrated as naturally and elegantly as possible and that they do not disturb the view of the interior space.

GDSG superstandard (recapitulation of chapter 4.2):

- **All ventilation systems equipped with plasma ionizers, electrostatic filters and filters**
- **for protection against dust, allergens (pollen), bacteria, viruses and unpleasant odors;**
- **The maximum noise level at the nominal flow rate in internal spaces is 35 dB;**
- **Ventilation systems with integrated CO_2 and CO sensors, temperature and humidity sensors, and automatic control of system operation;**
- **Systems equipped with moisture regeneration;**

Systems equipped with high-efficiency frequency-controlled EC motors.

4.3. Domestic hot water preparation system (DHW)

Domestic hot water (DHW) can be prepared by separate (individual) systems or a combination of them depending on the selected technologies in accordance with technical regulations. The emphasis is on the use of renewable energy sources, which directly depends on the preparation periods.

If the facility needs DHW preparation throughout the year, and especially in the winter months, the system that we consider the primary source should be designed to meet all DHW needs, which is recommended to be prepared using a boiler system for heating (defined in Chapter 4.1 of this document). If the boiler system is not used and the DHW preparation is needed, it is possible to use some of the alternative systems. DHW preparation can be done using electricity through a flow-through and/or storage boiler, for which electricity can be provided through a system of photovoltaic panels, which ensures the use of renewable energy sources. Flow-through electric water boilers are most often used in buildings and rooms where there is no need for a large amount of hot water and where there is no need for a constant supply of hot water.

Instead of using boilers, for systems of centralized preparation of domestic hot water, an alternative system is the use of heat pumps that use water as a medium for supplying heat, which can also be used to prepare DHW. If heat pumps are used, smaller devices with a nominal power of 2 to 12 kW and a drive power of 0.6 to 5.2 kW are used. Since heat pumps of this type are powered by electricity, a combination of photovoltaic panels for the production of electricity and the mentioned heat pumps is recommended. Furthermore, it is possible to use solar energy in solar collector systems that function in such a way that the heat medium on the roof of the building is heated, which the circulation pump transfers to the hot water tank, while the heat exchanger heats the drinking water. This type of system, depending on the size of the tank and the values of solar radiation for a certain geolocation, can be used as a so-called secondary energy source that is used during the summer months. If the system is dimensioned with a suitable heat tank, or in combination with another mentioned system for the preparation of DHW, it is possible to eliminate the primary sources entirely.

If the preparation of DHW is to be ensured in the period from May to October, the system, which we call the secondary source, should be dimensioned in such a way that it covers all needs, so that the operation of the boiler for the preparation of DHW is avoided when there is no need for heating, which increases the annual efficiency and lifetime of the primary source. Attention should be paid to the actual needs for DHW depending on the primary function of the facility.

GDSG superstandard (recapitulation of chapter 4.3):

- **Use of renewable energy sources for the preparation of DHW**
- **Use the primary source of heating for the production of heat energy for the purpose of preparing DHW;**
- **It is mandatory to use thermal solar collectors for the preparation of DHW;**
- **In the case of using electric flow-through water boilers for the preparation of DHW, a solar power plant of adequate power for the purpose of electricity production, must be installed.**

5. Electrotechnical installations of heavy and weak current

5.1. Indoor lighting of the building

The technical characteristics of the proposed lighting solutions must be of energy class A, in accordance with RoHS guidelines (Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment), EuP guidelines (Directive 2009/125/EU establishing a framework for the setting of ecodesign requirements for energy-related products) and ballast guidelines (Directive 2000/55/EC on energy requirements for ballasts). The luminaires used must have an efficiency of at least 130 lm/W, which includes all optical and electrical losses in the luminaire. When choosing a luminaire, it is necessary to ensure that the correlated color temperature of the light source is adapted to the purpose of the individual room and to the specific requirements defined by the HRN EN 12 464-1:2012 standard. Internal lighting must be designed in such a way that users can control the output light flow of luminaires that illuminate a particular unit, and it is necessary to provide sensors for monitoring the illumination of the space (in rooms where there are transparent parts of the external envelope, i.e., natural light) and space occupancy sensors that would made possible by autonomous dynamic regulation of the output light of the luminaire.

In every interior space, it is necessary to achieve the required lighting indicators (minimum mean illuminance-Em, unified glare factor-UGRL, color rendering index-Ra) in accordance with the standard for internal lighting HRN EN 12464-1:2012, which must be proven by the lighting calculation made in the publicly available programs Relux or Dialux.

GDSG superstandard (recapitulation of chapter 5.1):

- **In every interior space, it is necessary to achieve the required lighting indicators (minimum mean illuminance-Em, unified glare factor-UGRL, color rendering index-Ra) in accordance with the standard for internal lighting HRN EN 12464-1:2012;**
- **The correlated color temperature of the light source is adapted to the purpose of the individual room and to the specific requirements defined by the HRN EN 12 464-1:2012 standard.**
- **Luminaires with a minimum efficiency of 130 lm/W, including all optical and electrical losses**
- **in the luminaire;**
- **In rooms where there are transparent parts of the external envelope, foresee sensors for monitoring illumination, which would enable autonomous dynamic regulation of the lumen output of the luminaire;**
- **Provide occupancy sensors in all rooms.**

5.2. Outdoor lighting

The technical characteristics of the proposed lighting solutions must be in accordance with HRN EN 13201 as well as to the Law on Protection from Light Pollution (OG 14/19). Luminaires must be of high energy efficiency (minimum 130 lm/W) and light source color of a maximum of 3000 K, that is, 2200 K in protected areas in order to preserve the ecosystem and biodiversity. It is mandatory to apply multi-stage power regulation of the light source, which will enable energy savings and reduction of light pollution in the late night hours.

GDSG superstandard (recapitulation of chapter 5.2):

- **The technical characteristics of the proposed lighting solutions must be in accordance with HRN EN 13201 as well as the Law on the Reduction of Light Pollution;**
- **Luminaires must be of high energy efficiency (minimum 130 lm/W) and of the light source color of a maximum of 3,000 K;**
- **It is mandatory to apply multi-stage power regulation of the light source, which will enable energy savings and reduction of light pollution in the late night hours;**
- **Consider the possibility of installing accent lighting on the exterior facades.**

5.3. Compensation of reactive energy

It is necessary to examine the necessity of installing a device for compensating reactive energy, in accordance with the characteristics of consumers in the building and the parameters of electricity consumption. If it is necessary to install a reactive energy compensator, it must be dimensioned so that after its installation, a power factor (cos ϕ) greater than or equal to 0.99 is ensured.

5.4. Solar power plant with a battery system for storing electrical energy

5.4.1. Solar power plant

Photovoltaic modules are primarily installed on the roof of the building (integrated solar power plant). The integrated solar power plant is built in accordance with Article 5, Item 9 of the *Ordinance on simple and other buildings and works* (OG 112/17, 34/18, 36/19, 98/19, 31/20 and 74/22) and is considered a simple building. It is necessary to determine the available areas suitable for the construction of a solar power plant and based on the data on the leased connection power, type of connection (single-phase/three-phase) and electricity consumption - to make a simulation of the energy balance (production/consumption) with the defined power of the solar power plant. By bringing a new *Act on Renewable Energy Sources and Highly Effective*

Cogeneration (Official Gazette 138/21) public institutions that use solar power plants to satisfy part of their own needs for electricity are classified as users of self-supply installations.

In accordance with the above, if the available roof area allows it, the solar power plant is dimensioned in such a way that on an annual level the needs for electricity (high and low tariff) are met in as high a percentage as possible. In addition, it is also necessary to prove on a budgetary basis that on an annual level, more electricity is not supplied to the network than it is taken from the network, because otherwise the institution loses the status of a user of a self-supply facility and moves to the (less favorable) category of customers with its own production. For the purpose of obtaining a connection agreement (hereinafter: EES) by the competent office of the HEP Distribution System Operator d.o.o. (hereinafter: HEP ODS), the conceptual electrical design of the solar power plant is being prepared with a defined framework technical solution for the connection of the solar power plant to the installation of the facility and to the distribution network (metering point of the facility - OMM). After the conclusion of the EES, the main electrotechnical project of the solar power plant is drawn up, in which the already developed technical solution is confirmed or supplemented, all in accordance with the requirements of the EES.

In the Main project, it is necessary to elaborate in detail the method of carrying out the cabling to the switch cabinets and attach other necessary folders such as the construction project of the power plant construction with proof of mechanical resistance and stability, the electrical project of lightning protection and the fire protection study. For the main project, relevant certificates from public law bodies and, if necessary, a building and use permit must be obtained (if the relevant laws stipulate such a procedure in the specific case). After the construction of the solar power plant, and before putting it into permanent operation, it is necessary to carry out test run, which includes a series of technical and safety tests performed by an authorized person in the presence of a representative of HEP ODS. Only in the event that the roof is not suitable for the construction of a solar power plant due to its surface, orientation or slope, it is necessary to consider construction on earthen surfaces in the vicinity of the facility, on the same cadastral parcel where the metering point is located.

5.4.2. Battery system for storing electrical energy

It is also necessary to consider the possibility of integrating a battery system for storing the electrical energy produced from the solar power plant in order to maximize the benefit of the energy produced at the location of the facility, i.e., for own consumption. The battery system must be designed for grid operation in combination with a solar power plant connected to the same OMM, and where it is possible to transfer excess electricity to the grid, i.e., use the electricity produced in the solar power plant at the time of a potential interruption of the power supply from the grid. Technologies that are declared to be completely environmentally acceptable and of better performance (such as a battery system with salt water as a medium or vanadium flow batteries) in relation to lithium-ion batteries - must be developed as possible solutions.

Management of the solar power plant, the battery system and the flow of energy produced in the solar power plant is preferably carried out using the facility's central monitoring and control system (CNUS). **GDSG superstandard (recapitulation of chapter 5.4):**

Basic technical requirements for solar power plant equipment:

- **Efficiency of photovoltaic modules: ≥20%**
- **Linear degradation of the output power of photovoltaic modules in 25 years: ≤15%**
- **Photovoltaic module manufacturer's warranty on the product: ≥10 years**
- **DC-AC converters from reputable manufacturers with (extended) product warranty (≥10 years) and the ability to connect via Android/iOS/Windows devices for performance control**
- **The designed solution should enable connection to the existing CNUS of the facility if applicable**

Basic technical requirements for a battery system for electricity storage:

- **Manufacturer's warranty on the product: ≥10 years**
- **Expected life cycle of the system: ≥20 years**
- **Number of cycles at the depth-of-discharge (DoD) of 80%: ≥5000**

The battery system must have a built-in exchanger and its own control system to which it is possible to connect via Windows/Android/iOS devices

5.5. Electromobility and the establishment of charging infrastructure in buildings

Pursuant to European Directive 2018/844 amending Directive 2010/31/EU on energy performance of buildings, in which Article 8 titled Technical building systems, electromobility and smart readiness indicator regulates the promotion of electromobility, sets requirements for systems, i.e., infrastructure for charging electric vehicles in buildings. National policy framework (NOP) for the establishment of infrastructure for alternative fuels[31] establishes a legal framework for the use of alternative energy. The direct transposition of legislation to the design of public buildings is the latest Act on Amendments to the Construction Act (Official Gazette 125/19)[32] in which Article 21 (21.a, 21.b, 21.d) defines the promotion of electromobility and the establishment of charging infrastructure in public buildings. This GDSG project guideline presents recommendations for the establishment of charging infrastructure for new buildings and buildings undergoing significant renovation according to their purpose if they have more

[31] https://mmpi.gov.hr/infrastruktura/dokumenti-136/nacionalni-okvir-politike/17813
[32] https://www.zakon.hr/z/690/Zakon-o-gradnji

than ten parking spaces. The investor, or real estate owner, is responsible for fulfilling the requirements of this chapter.

Type of purpose of the building	Share of parking spaces with the possibility of charging (charging station)	Channel infrastructure
Office building	50%	YES
Educational institution	25%	YES
Hospital	25%	YES
Hotel and restaurant	50%	YES
Sports hall	25%	YES
Shopping centers	50%	YES
Other non-residential buildings	25%	YES

Source: REGEA

Channel infrastructure, i.e., pipes for electric cables enable the installation of charging points for electric vehicles at a later stage, if there is a real need for it. In addition to providing parking spaces with the possibility of charging, the establishment of the infrastructure requires the designer to ensure the optimal number of charging stations for electric vehicles. Charging stations should provide 50% of type 2 sockets with 22 kW power and 50% of type 2 sockets with 11 kW power. The charging stations of both mentioned capacities come with two AC type 2 connections. Charging stations do not include low transmission power charging (1.3kW-3.7kW).

Since, regardless of the quantity and type of connection, the maximum power per connector corresponds to the nominal power of the charging station, the designer is obliged to provide an energy management system for installed charging stations for electric cars in order to optimize the required power due to the increase in electricity demand of the building where the charging infrastructure is being established. In addition, the energy management system independently regulates the charging period of all connected electrical charges depending on the current charging request.

Recommendations of these guidelines in the chapter according to the Construction Act (OG 153/13, 20,17, 39/19 and 125/19) do not apply if:

- the request for the issuance of a location or building permit, i.e., an equivalent request was submitted by March 10, 2021
- the necessary channel infrastructure would depend on micro-isolated systems, which would cause significant problems in the operation of local energy systems and threaten the stability of the local network
- the costs of installing charging infrastructure and channel infrastructure higher than 7%

- of the total cost of a significant renovation of the building.

During the renovation of the building, it is necessary to analyze, propose and, in agreement with the Investor, design measures for the Design of charging stations (11 kW) or electric vehicle charging stations (22 kW) with a connection system in accordance with accepted European standards (type 2 in accordance with EN62196 -2)[33], with the program for consumption records, reporting and analytics as part of the program for integration into the building management system (CNUS) and with the energy supplier to regulate the charging power (through the Energy management part of the program), in the building or in the parking lot on the building plot of the building, including internal installations from switch cabinet to the charging station

Construction of vehicle charging infrastructure in combination with a solar power plant
When drawing up project documentation for the construction of infrastructure for charging electric vehicles, it is necessary to take into account the impact of increased demand for electricity on the construction of a solar power plant (if the same is foreseen as part of the construction of a new or reconstruction of an existing building), which has a direct impact on the dimensioning of a larger nominal power of the solar power plant. In addition, it is necessary to introduce the option of electricity production from solar power plants in the charging optimization system, which can directly affect the optimization of the required rental power.

GDSG superstandard (recapitulation of chapter 5.5):

- **recommendations for the establishment of charging infrastructure for new buildings and buildings undergoing significant renovation according to their purpose if they have more than ten parking spaces (more in the table);**
- **AC charging stations should provide 50% of type 2 sockets with a power of 22 kW and 50% of type 2 sockets with a power of 11 kW;**

[33] Annex II of the Alternative Fuels Infrastructure Directive - https://op.europa.eu/webpub/eca/special-reports/electrical-recharging-5-2021/hr/index.html#annexII

6. Water supply and drainage installations

In order to store rainwater and use it as technical water for flushing sanitary facilities and maintaining grass areas around the building, it is necessary to provide underground tanks or cisterns for collecting rainwater. It is recommended to use the natural slope of the terrain if it exists. In the system, if necessary, provide a room for housing the pump, expansion tank and water meter. It is necessary to design automatic switch-over in case of lack of water in the cistern. Provide a unit with monitoring and regulation of the rainwater collection and utilization system, which detects errors in the rainwater collection system and makes the necessary adjustments. When there is not enough rainwater in the collection tank (e.g. underground tank), the device switches to the supply of water from the water supply and thus supplies consumers, e.g., toilet or tap, with a sufficient amount of water. The connection between the main inlet of the water tank and the suction pipe of the water tank is closed by means of a built-in three-way valve.

In the case of the main water measuring manhole, it is mandatory to plan the installation of a pressure regulator and an electric valve for remote control of the water supply and automatic closing in case of detection of a major rupture of the measured part of the installation.

In order to limit and reduce water consumption, it is necessary to foresee sensor faucets and flushing tanks with reduced flushing volume in the project. All outtake devices, if applicable, must be graded **in the first two classes of water consumption** according to the European Water Label (www.europeanwaterlabel.eu). In the event of a greater distance of the outtake points from the central preparation of domestic hot water, or if their number is relatively small, do not recirculate the hot water, which will avoid the occurrence of large heat losses. Perform local preparation of domestic hot water for these dislocated outtake points.

In the drainage section, it is mandatory to plan separate rainwater drainage systems and the building's internal sewage system. For drainage inside the building, it is mandatory to use polypropylene low-noise sewage pipes, i.e., pipes with increased sound insulation with a maximum permissible noise level of 25 dB (when measuring noise in a media flow rate of 4 l/s).

GDSG superstandard (recapitulation of chapter 6):

- **Obligation to design rainwater storage for the purpose of flushing sanitary facilities or irrigating green areas;**
- **Obligation to install a pressure regulator on the measured part of the installation of the water network and to install an electric valve for remote control of the water supply;**
- **Obligation to install sensor faucets and flushing tanks with reduced flushing volume; and**
- **Obligation to carry out separate rainwater drainage systems and internal building sewers, as well as use low-noise sewer pipes with a maximum permissible noise level of 25 dB (when measuring noise in a media flow rate of 4 l/s);**

- **Obligation to use water devices that are classified in the first 2 classes of water consumption of the EU Water Label, and in accordance with the instructions on** http://www.europeanwaterlabel.eu / **.**

7. Remote measurement of energy and water consumption

According to the Energy Efficiency Law[34], public buildings are required to regularly display information on energy and water consumption through the Energy Management Information System (ISGE). It is necessary to foresee the installation of a system for remote measurement of energy and water consumption, which includes installation, commissioning and testing of the system according to the "FUNCTIONAL TURNKEY" system. In addition to connecting the device to ISGE, it is necessary to foresee further integration of the system with the central monitoring and control system (CNUS) of the building if it is used.

Remote reading of electricity consumption

Data on electricity consumption is taken from the electricity meter, according to which electricity is billed. The electricity meter must be equipped with a pulse or M-Bus output with communication equipment through which information on the consumption of working and reactive energy will be downloaded, according to the currently active tariff (RVT and RNT) and the maximum engaged current power within 15 min. If the existing meter is not equipped in the described way, it is necessary to provide for the installation of the building owner's internal control meter, which includes all the electricity consumers of the building and which has the ability to send the required data via impulse outputs. The data from the communication devices of the meters must be connected to the readings on the central platform (CNUS) through various available data transfer protocols (such as M-Bus, SIGFOX, LORAWAN, NBIoT, GSM, RS485.). In addition, the intended CNUS on which consumption data will be displayed and stored must be directly connected to ISGE in order to fulfill consumption monitoring requirements.

Remote reading of heat energy consumption

To measure the consumption of thermal energy, the data is taken from the existing meters according to which thermal energy is billed or from the building owner's internal control meters. The connection of the reading device (module) to the heat meter is made through the existing pulse or M-bus output, that is, the RF contact to which the communication equipment is upgraded. If the existing thermal energy meter does not support connection via pulse output or M-bus interface, or the certified period has expired, it is necessary to estimate the costs of replacing a meter that is compatible with communication equipment via available protocols (such as M-Bus, SIGFOX, LORAWAN, NBIoT, GSM, RS485.).

[34] According to the Energy Efficiency Law: https://www.zakon.hr/z/747/Zakon-o-energetskoj- u%C4%8Dinkovitosti

Remote reading of gas consumption

Data on gas consumption (if the building uses gas as a heating energy) is taken from the gas meter according to which gas consumption is billed by connecting to the pulse output of the meter, through the existing pulse or M-bus output or to the built-in REED contact. Depending on the design, communication equipment is connected to the meter for sending data via available protocols (such as M-Bus, SIGFOX, LORAWAN, NBIoT, GSM, RS485.) in CNUS and consequently in ISGE. The connection to the gas meter should be made through passive galvanic separation, which has a certificate and is in accordance with the requirements of the competent institutions. If the existing gas meter does not support connection to the impulse output or does not have a REED contact installed, the offer must include all additional costs of replacing or equipping the measuring point, which is performed by the local gas distributor, i.e., the installation of control meters is not allowed. Gas meters must be installed according to the Ordinance on technical and metrological requirements related to standards (OG 21/16)[35].

Remote reading of water consumption

For the purpose of acquiring data on water consumption, water meters are used, according to which water consumption is billed, or internal control water meters of the building owner. If the existing water meter does not support connection via optical coupling or does not have a REED contact installed, the offer must include all the costs of replacing or equipping the measuring point. Remote reading must be performed through standard open protocols whose examples are listed for each meter. The central place for the collection of measurement data, as part of the CNUS, must be freely programmable with the possibility of software and hardware upgrades that support standard open measurement protocols. The central processing unit must be connected to ISGE through a data reception service that will forward measurements to ISGE. For detailed guidelines for system design, please contact the North-West Croatia Regional Energy and Climate Agency (REGEA), available at: http://www.regea.org/.

GDSG superstandard (recapitulation of chapter 7):

- **Obligation to install a system for remote measurement of energy and water consumption and connections with CNUS and consequently with ISGE;**
- **The central processing unit of the system of remote reading of energy and water consumption must be freely programmable with the possibility of software and hardware upgrades that support standard measurement protocols such as: M-bus, wireless M-bus, LONTalk, RF, ZigBee, SIGFOX, LORAWAN, NBIoT, GSM, RS485**

[35] https://narodne-novine.nn.hr/clanci/sluzbeni/2016_03_21_593.html

8. Automation system and Central Monitoring and Control System (CNUS)

The automation system must be designed according to the HRN EN 15 232-1:2017 standard, where it is necessary to foresee the integration of CNUS with a high-performance automation system.

All systems of heating, cooling, ventilation and preparation of domestic hot water, as well as renewable energy sources and the battery system of electrical energy storage must be equipped with internal automation or logic controllers. Logic controllers must be able to communicate with the integration DDC controller via standard and open protocols (Modbus, BACnet, etc.), while the integration DDC controllers must be able to connect to the CNUS via the TCP/IP protocol (TCP/IP port).

It is necessary to create an automation project with a connection scheme for all devices, meters and other equipment in the field of automatic regulation (sensors, executive members, other input and output signals) that are integrated on the DDC controller. In the project, it is necessary to provide a table of inputs and outputs (analog and digital) and communication through standard and open protocols. In the project, it is necessary to provide a detailed technical description of the operation of the entire system with a table of access points (variables that are exchanged with the DDC controllers of the devices in the system) and a block diagram of the logical operations of the main integration DDC controller. In the tables of access points for all devices, it is necessary to mark which variables need to be displayed in the basic view of the CNUS, which variables in the extended view of the CNUS, which variables need to be initialized and which variables are not important with regard to the default configuration of the device. System integration should be performed according to the equipment manufacturer's list of variables in such a way that the user has control over alarms (errors in operation, notices of required maintenance, etc.), system operation status (working (%)/not working) and control over important system parameters (temperature, air flow, etc.). The project must contain a list of basic necessary values that need to be enabled to the user for change, information and for alarm events. It is necessary to foresee the use of standard interconnections (LAN, RS485, M-bus).

In buildings with larger systems, it is necessary to foresee the installation of additional sensors that will monitor the conditions in the building and manage the operation of other equipment. At a minimum, it is necessary to provide sensors for CO_2, CO, humidity, temperature, room lighting, presence sensors and sensors that detect the opening of facade openings - windows and doors. It is necessary to foresee the integration of sensors with the regulation of heating, cooling, DHW preparation, ventilation, lighting, sun protection, etc. Furthermore, with the use of CNUS, it is necessary to take into account the user's ability to manage at the room or zone level.

It is necessary to foresee the implementation of the central monitoring and control system (CNUS). The central monitoring and control system is a program for management and monitoring in which the following data should be integrated:

- pre-programmed logic controllers from equipment and from installed sensors and/or actuators;
- freely programmable DDC regulators that enable the integration of data from other
- management systems (e.g. KNX);
- measurements (e.g. from electricity, gas, water consumption meters, calorimeters via the M-bus standard).

Displays in CNUS should be organized in such a way that the main screen displays the basic data and links to special windows as follows:

- Heating system and preparation of domestic hot water;
- Cooling system;
- Ventilation system;
- Electricity production and energy storage system;
- Internal lighting system;
- Exterior lighting system (if applicable);
- Charging station system (if applicable)
- Floor plans and parts of project documentation;
- Display of all meters separately;
- Info panels - current consumption and utilization of all energy sources and all sources of heating and cooling energy.

In CNUS, it is necessary to enable monitoring and management of process commands according to logic controllers, display of a large number of variables, display of dynamic process changes, organization into groups and subsystems, handling of user accesses with various process displays (Room / Zone / Building) and management options, dealing with alarms and working time periods. In CNUS, it should also be possible to visualize processes, manage and view from one place, and store variables in the database, whereby the data must be able to be converted into other forms suitable for reports (e.g., .xlsx).

CNUS must enable the evaluation of the building's energy efficiency with regard to reference values, the detection of losses in terms of the efficiency of the building's technical systems. For the mentioned needs, the automation project needs to define key performance indicators (KPIs) for each of the following systems:

- Energy management including all consumers at the location;
- CO, CO_2, temperature, humidity, lighting indicator system
- Electricity production and storage system
- Heating system;
- Cooling system;
- Ventilation system;

- Heating distribution system;
- Cooling distribution system;

When determining the key performance indicators for each system, it is necessary to predict the parameters that are related to the input energy into the system, the needs of the system users and the output performance of the system.

It is necessary to foresee the installation of CNUS on a computer that is networked into the communication system with other components. Access to CNUS can be through other computers that are in the same or different computer network with the necessary network and CNUS settings. The advantage of this system is that no logical operations take place in the computer on which CNUS is installed, the entire process takes place in logic controllers (DDC), so that the process management is independent. The number of inputs/outputs to the CNUS must be determined by the project.

All electrical consumers must be displayed in an expanded display in three different colors with regard to status, preferably green=on, red=fault, gray=off. It is necessary to plot all temperature sensors in the boiler room scheme, as well as those that are read via communication protocol from the controller of individual devices, while in the list of variables they are defined for the basic display. Next to all the elements that can have a variable (modulating effect) it is necessary to draw the corresponding icon. All values that can be set need to be accessed in two views that correspond to two different levels of access (basic/advanced). For energy sources, it is necessary to create 3 views from existing data (current production/consumption/from RES).

Depending on the construction of the electricity production system (solar power plant or other), it is necessary to display all the production parameters on the generator side (e.g., photovoltaic modules) and the converter side (e.g., inverter) if applicable and display them in three different colors considering the status, preferably green=on, red=fault, gray=off. In addition, it is necessary to show the interaction of the power plant with the grid if it exists.

It is necessary to provide for the display of the battery system if it is installed with defined parameters (charge/discharge power, capacity, charge level) and additionally display it in four different colors with regard to the status, preferably green=charging, yellow=discharging, red=fault, gray=standby).

Within the floor plan, the set temperature, current temperature, symbol and capacity of the internal cooling/heating unit, room occupancy status (if there is a presence detector), window open status, heating and cooling status, lighting status, blind position, etc., must be visible within the floor plan. The floor plan display should be made in a simplified version (only the most important parameters according to the user's wishes), and the expanded version is opened by pressing the zoom icon.

In addition to visualization, control and monitoring of the building system, CNUS should enable:

- Keeping records on the basic parameters of the building (area, number of users, etc.);
- Digitization of available building documentation (permits, projects, etc.);

- Management of building maintenance (creating work orders);
- Alarming in the event of a breakdown (consumption of water or energy at a moment when it is not expected), the need for maintenance (according to the working hours of the equipment, maintenance intervals, etc.) and reports of malfunctions from the equipment (alarms should be meaningful and provide specific information, i.e., the interpretation of individual errors/faults);
- Archiving of generated data in the database (alarms, consumption, maintenance, costs);
- Monitoring of energy consumption and production in the building and visualization on the internal system with a mirror to the web;
- Energy management, i.e., the ability to manage the production and consumption of electricity and thermal energy;
- The possibility of creating scenarios according to the functional units of the building and for the entire building.

The software must be implemented according to standard publicly available protocols and must be in the Croatian language. The software must have the ability to connect to the client's aggregation platform, where data will be collected from a set of buildings owned by the client for the purpose of central cost control, monitoring and planning of maintenance and other operational costs.

GDSG superstandard (recapitulation of chapter 8):

- **For all systems, it is necessary to create an automation project with a diagram of connection of all devices, meters and other equipment in the field, with a table of inputs and outputs of the main integration DDC controller, a block diagram of the logic operations of the integration DDC controller and a list of basic and advanced values according to the table of access points of the equipment manufacturer which the user can change and monitor (depending on the installed equipment);**
- **Provide for the connection of all parts of the system (depending on the installed technologies) with the internal automation or logic controller, which must have standardized and open communication protocols and the main integration DDC controller with the possibility of connecting to the CNUS via standard TCP/IP protocols;**
- **For all systems, it is necessary to provide for the implementation of the Central Control and Monitoring System (CNUS) as well as the functionalities described in this chapter of the guideline.**

Annex 1 Criteria for assessing the project's compliance with the GDSG project guideline

CRITERIA FOR ASSESSING THE COMPLIANCE OF PROJECT SOLUTIONS WITH THE GDSG GUIDELINE

GDSG part	Requirement	Applicable		Note	Required parameters	Applicable		Note
		YES	NO			YES	NO	
2.1. Energy and emissions	100% of the annual delivered energy for the operation of technical systems in the new building is met from renewable energy sources, which may include district or block heating that is wholly or partially based on energy from renewable sources and/or efficient cogeneration							
	The new building requires at least 20% less primary energy than the currently valid national regulation							
	75% of the annual delivered energy for the operation of technical systems in the building after the renovation of the existing building is met from renewable energy sources, which may include district or block heating that is wholly or partially based on energy from renewable sources and/or efficient cogeneration							
	More than 30% of savings in primary energy compared to ex ante assessment during the renovation of the existing building							
	More than 30% reduction in greenhouse gas emissions compared to the ex ante assessment during renovation of the existing building							

	Calculation of total CO_2 emissions of the building through its life cycle							
2.2 Environment and location	Analysis of the seismic characteristics of the area or microlocation							
	Analysis of landslides and floods							
	Analysis of the influence of the shape of the building on the wind circulation of the vortex zone and increased speed							
	Analysis of climate risks and vulnerabilities							
	Preservation of local or native flora and fauna							
	Placement of tall deciduous greenery along the facades of the building							
	Designing the performance of elements of green infrastructure and solutions based on nature							
	Management and use of rainwater							
	Construction and design of outdoor spaces for the gathering and stay of users in accordance with the purpose of the building							
2.3 Security and protection	Reconstruction of existing buildings according to the Technical regulations for civil engineering constructions (Official Gazette 17/17, 75/20 and 7/22), as if it were new buildings (possible deviations from the current regulations with explanation and designer's approval)							
	Use of modern techniques for the protection of buildings against earthquakes such as strap reinforcements and use of dampers							

	Reconstruction of existing buildings in accordance with the currently valid legislation that regulates safety in case of fire, as if it were new buildings, i.e., to the extent practicable							
	Construction of parking spaces for bicycles and storage and places for charging small electric vehicles, as well as construction of wardrobe and sanitary areas for people who use the mentioned vehicles							
	Accessibility of all areas of the building for wheelchair users - escape routes adapted to wheelchair users							
	Ensure accessibility for all forms of disability (blindness, impaired vision and deafness)							
2.4 Health and comfort	Maximum use of daylight in all spaces (primarily working) depending on their purpose							
	Two-sided orientation and the possibility of cross-ventilation of the space for work and living							
	Removal and replacement of materials infected with mold and fungi							
	Removal of asbestos lining, covers and insulation							
	Ensuring the quality of drinking water in the building							
	Ensuring appropriate acoustic quality of the space (isolation from external noise, reduction of noise sources in the building)							
	Apply the specified standards from DGNB standards related to noise protection and acoustics							
	Damp remediation							

	Use of acceptable ecological materials that do not emit hazardous substances or volatile organic compounds								
	Use of materials that do not contain formaldehyde and carcinogenic volatile organic compounds of category 1A and 1B								
	Use of vegetation to regulate lighting, protection from the sun and achieving indoor climate conditions								
	Existence of a view through the window								
	Avoiding temperature asymmetries								
	Durability of materials and construction components								
	Simplicity of maintenance of installed materials or construction components								
	Possibility of simple replacement or adjustment of built-in materials or structural components								
2.5 Circularity and costs	Building utilization requirement (maximize the ratio between the number of used hours per year and the total number of hours per year)								
	Functional and energy zoning of the building								
	Possibility of phased construction								
	The multifunctional character of the space								
	Adaptability of the building and premises to another/new purpose								
	Using skeleton, modular, prefabricated structures and structural components								
	Use of sliding and folding doors and walls								

	Designing corridors and staircases as multipurpose spaces with added value (ratio of useful area and the total net area of the building)							
	Reserves in ducts due to upgrades							
	Using materials and products that have the smallest impact on the environment, and is proven by the EPD declaration							
	Use of materials and products that are produced locally and in a sustainable way, which is proven by the FSC declaration							
	Use of materials and products that have eco-label, and it is proved by proof of examination from an authorized institution							
	Analysis and estimation of construction costs							
	Estimation of maintenance costs							
	Estimation of the costs of using the building							
	Building removal estimation							
2.6 Processes and Tools	Application of BIM for new buildings and reconstruction of existing buildings regardless of size and complexity of the intervention							
3.1 Shape factor	Optimal/favorable shape factor with respect to the purpose of the building and the plot							
3.2 Orientation and protection from excessive insolation of the facade	Application of sun protection solutions on the outside of external windows, glazings and doors located on the south, east and west facades							

3.3 Thermal insulation	Use of stone/mineral wool in facade systems and in other structural components of structures that are being insulated (non-flammability class A1)							
	Use of ventilated facades versus the ETICS system							
	Application of photovoltaic panels as finishing facade elements							
3.4 Exterior joinery/ hardware	Use of external joinery with a wooden profile and aluminum cladding							
	Thermal transmittance in the amount of $U \leq 1.10$ W/m^{2}K in total, $U \leq 0.90$ W/m^{2}K glass							
3.5 Airtightness of the envelope	For a pressure difference between indoor and outdoor air of 50 Pa, the measured air flow, reduced to the volume of indoor air, must not be greater than the value n50= 3.0 1/h in buildings or individual thermal zones of buildings without a mechanical ventilation device, i.e., n50= 1.5 1/h for buildings or individual thermal zones of buildings with a mechanical device for ventilation							
	Installation of joinery/hardware in accordance with RAL guidelines, as well as sealing of all openings on the envelope and elements of the envelope such as vapor barriers, etc. in accordance with the rules of the profession and the use of standard elements of the manufacturer for this purpose							
3.6 Thermal bridges	During the reconstruction, it is necessary to consider possible construction works for the purpose of reconstruction of the external envelope, which affect the resolution of thermal bridges using technical solutions with prefabricated thermal insulation elements that minimize thermal bridges on prominent parts of the building.							

	Thermal bridges resolved in accordance with *Technical regulation on energy economy and heat retention in buildings*								
3.7 Energy renovation and use of renewable energy sources in public buildings - technical requirements	Roof (above the heated space Ɵi≥18°C)	U≤0,20 W/m^2K for Ɵe,mj,min≤3°C U≤0,25 W/m^2K for Ɵe,mj,min>3°C							
	External wall (of the heated space Ɵi≥18°C)	U≤0,25 W/m^2K for Ɵe,mj,min≤3°C U≤0,40 W/m^2K for Ɵe,mj,min>3°C							
	Floor towards the ground (of the heated space Ɵi≥18°C)	U≤0,25 W/m^2K for Ɵe,mj,min≤3°C U≤0,45 W/m^2K for Ɵe,mj,min>3°C							
	Buried parts of the envelope (of the heated space Ɵi≥18°C)	U≤0,25 W/m^2K for Ɵe,mj,min≤3°C U≤0,45 W/m^2K for Ɵe,mj,min>3°C							
	Floor towards the outside space (of the heated space Ɵi≥18°C)	U≤0,20 W/m^2K for Ɵe,mj,min≤3°C U≤0,25 W/m^2K for Ɵe,mj,min>3°C							
	Floor towards the unheated basement/garage (of the heated space Ɵi≥18°C)	U≤0,20 W/m^2K for Ɵe,mj,min≤3°C U≤0,25 W/m^2K for Ɵe,mj,min>3°C							

Ceiling towards the unheated attic (above the heated space ϴi≥18°C)	U≤0,20 W/m^{2}K for ϴe,mj,min≤3°C U≤0,25 W/m^{2}K for ϴe,mj,min>3°C							
Exterior joinery (of the heated space ϴi≥18°C)	Uw≤1,10 W/m^{2}K complete (Ug≤0,90 W/m^{2}K glass) for ϴe,mj,min≤3°C Uw≤1,40 W/m^{2}K complete (Ug≤1,10 W/m^{2}K glass) for ϴe,mj,min>3°C							

4.1 Heating and cooling system	Heating system (and optional cooling) - heat pumps	Installation of a water/water heat pump as a central source of heating/cooling energy for space heating/cooling and/or preparation of DHW at the building level, including all parts of the system up to the connection to the pipe distribution subsystem of the central heating/cooling system of the space and preparation of DHW: • SCOP for the heat pump according to HRN EN14825:2019 (or "equivalent") for heating for water supply temperature of 35°C and average climate ≥4.3 and for water supply temperature of 55°C and average climate ≥3.7 • graduated or continuous regulation of the effect of a minimum of 25% to 100% • GWP ≤ 1.500 Installation of a ground/water heat pump as a central source of heat/cooling energy for space heating/cooling and/or DHW preparation at the building level, including all parts of the system up to the connection to the pipe distribution subsystem of the central space							

	heating/cooling system and DHW preparation: • SCOP for the heat pump according to HRN EN 14825:2019 (or "equivalent") for heating for water supply temperature of 35°C and average climate ≥4.0, and for water supply temperature of 55°C and average climate ≥3.4 • graduated or continuous regulation of the effect of a minimum of 25% to 100% • GWP ≤ 1.500 Installation of an air/water heat pump as a central source of heat/cooling energy for space heating/cooling and/or DHW preparation at the building level, including all parts of the system up to the connection to the pipe distribution subsystem of the central space heating/cooling system and DHW preparation: • SCOP for the heat pump according to HRN EN14825:2019 (or "equivalent") for heating for water supply temperature of 35°C and average climate ≥3.3 and for							

		water supply temperature of 55°C and average climate ≥2.9 • graduated or continuous regulation of the effect of a minimum of 25% to 100% • GWP ≤ 1.500 Installation of an air/air heat pump (VRF) with heat recovery as a central source of heating/cooling energy for space heating/cooling and preparation of DHW at the building level: • SCOP ≥ 4,0 • SEER ≥ 6,0 • GWP ≤ 2.150						

Heating system - woody biomass boiler room	Installation of a woody biomass boiler with a regulation system according to the external temperature to meet the peak heating needs of the building. In the case of a nominal boiler power of less than 100 kW, use pellet boilers, and in the case of higher power, use wood chip boilers. The efficiency of the boiler must be at least 0.90. It is necessary to provide for the installation of a heat store, the capacity of which is dimensioned according to the power of the boiler.							
	For the purposes of preparing domestic hot water, envisage the installation of a free-standing storage boiler of adequate volume with two heat exchangers. Provide for the use of a solar collector system for heating domestic hot water during the summer months connected to the lower exchanger and reheating to the required temperature with biomass boilers on the upper exchanger.							
Heating system - use of centralized heating system (district heating)								
Cooling system	Geothermal heat pump							
	Air source heat pump							

		Central cooling system using VRV cooler							
	75% of the delivered energy for heating, cooling and DHW from renewable energy sources in the reconstruction of buildings								
	100% of delivered energy for heating, cooling and DHW from renewable energy sources in the construction of buildings								
4.2 Building ventilation system	All ventilation systems equipped with plasma ionizers, electrostatic filters and filters for protection against dust, allergens (pollen), bacteria, viruses and unpleasant odors								
	Maximum noise level at the nominal flow rate in internal spaces is 35 dB								
	Ventilation systems with integrated CO_2 and CO sensors, temperature and humidity sensors and automatic management of system operation								
	Systems equipped with moisture regeneration								
	Systems equipped with high-efficiency frequency controlled EC motors								
4.3 Domestic hot water preparation system (DHW)	Using renewable energy sources for preparation of DHW								
	Primary heating source should be used for the production of thermal energy for the purpose of preparing DHW								
	Using thermal solar collectors for preparation of DHW								
	In the case of using electric flow-through water boilers for the preparation of DHW, it is mandatory to install a solar power plant of adequate power to produce electricity								

5.1 Indoor lighting of the building	In every interior space, it is necessary to achieve the required lighting indicators (minimum mean illuminance-Em, unified glare factor-UGRL, color rendering index-Ra) in accordance with the standard for indoor lighting HRN EN 12464-1:2012							
	Correlated color temperature of the light source adapted to the purpose of a particular room and specific requirements defined by the HRN EN 12 464-1:2012 standard							
	Luminaires with a minimum efficiency of 130 lm/W, including all optical and electrical losses in the luminaire							
	In rooms where there are transparent parts of the external envelope, provide sensors for monitoring illumination, which would enable autonomous dynamic regulation of the lumen output of the luminaire							
	Provide occupancy sensors in all rooms							
5.2 Outdoor lighting	The technical characteristics of the proposed lighting solutions must be in accordance with HRN EN 13201 as well as the Law on the Reduction of Light Pollution							
	Luminaires must be of high energy efficiency (minimum 130 lm/W) and light source color of maximum 3000 K							
	It is mandatory to apply multi-level regulation of the power of the light source, which will enable energy savings and reduction of light pollution in the late night hours							
	Consider the possibility of installing accent lighting on the exterior facades							

5.3 Compensation of reactive energy	If it is necessary to install a reactive energy compensator, it must be dimensioned so that after its installation, the power factor (cos ϕ) is greater or equal to 0.99.								
5.4 Solar power plant	Basic technical requirements for solar power plant equipment	Efficiency of photovoltaic modules: ≥20%							
		Linear degradation of the output power of photovoltaic modules in 25 years: ≤15%							
		Manufacturer's warranty for photovoltaic modules: ≥10 years							
		DC to AC converters from renowned manufacturers with (extended) product warranty (≥10 years) and the ability to connect via Android/iOS/Windows devices to control performance							
		The designed solution should enable connection to the existing CNUS of the facility if applicable							
	Basic technical requirements for a battery system for the storage of electrical energy	Manufacturer's warranty on the product: ≥10 years							
		Expected life cycle of the system: ≥20 years							
		Number of cycles at depth-of-discharge (DoD) of 80%: ≥5000							
		The battery system must have a built-in alternator and its own control system, which can be connected using Windows/Android/iOS devices							

5.5 Electromobility and the establishment of charging infrastructure in buildings	Establishment of charging infrastructure for new buildings and buildings undergoing significant renovation according to their purpose if they have more than ten parking spaces							
	AC charging stations should provide 50% type 2 sockets with a power of 22 kW and 50% of type 2 sockets with a power of 11 kW							
6. Water supply and drainage installations	Installation of rainwater storage for the purposes of flushing sanitary facilities or irrigation of green areas							
	Performance of the pressure regulator on the measured part of the water network installation and installation of electric valve for remote control of water supply							
	Installation of sensor faucets and flushing tanks with reduced flushing volume							
	Implementation of separate rainwater drainage systems and internal sewage, as well as the use of low-noise sewage pipes with a maximum permissible noise level of 25 dB (when measuring noise in the media flow rate of 4 l/s);							
	The use of water devices that are classified in the first 2 classes of water consumption of the EU Water Label, and in accordance with the instructions on http://www.europeanwaterlabel.eu/							
7. Remote measurement of	Installation of a remote system for measurement of energy and water consumption and connecting them to CNUS and consequently in ISGE							

energy and water consumption	The central processing unit of the system of remote reading of energy and water consumption must be freely programmable with the possibility of software and hardware upgrades that support standard measurement protocols such as: M-bus, wireless M-bus, LONTalk, RF, ZigBee, SIGFOX, LORAWAN, NBIoT, GSM, RS485							
8. Automation system and Central Monitoring and Control System (CNUS)	Automation project was created for all systems with the connection scheme of all devices, meters and other equipment in the field, with a table of inputs and outputs of the main integration DDC regulator, block diagram of logical operations of the integration DDC regulator and list of basic and advanced values according to the table of access points of equipment manufacturers which the user can change and monitor (depending on the installed equipment);							
	The foreseen connection of all parts of the system (depending on the built-in technologies) with the internal automation, i.e., the logic controller, which must have standardized and open communication protocols and the main integration DDC regulator with the possibility of connecting to CNUS through standard TCP/IP protocols							
	For all systems, it is necessary to foresee the implementation of the Central Monitoring and Control System (CNUS) as well as the functionalities described in this chapter of the guideline							

Annex 2 Designer’s statement on climate neutrality review

Designer's statement on climate neutrality review

A statement with which I, _________authorized designer, confirm that I have prepared a climate neutrality assessment for the project_. According to the analysis, the project belongs to the category of infrastructure projects for which it is not necessary to do detailed quantification and monetization of greenhouse gas emissions.

In ___________, on _______________

Signature

Annex 3 Assessment of climate risks and vulnerabilities, as well as their frequency for the buildings sector

	Climate risk	Expected effect	Existing degree of risk	Expected change in intensity	Expected change in frequency	Indicators related to risk	Adaptation measures to the expected risk in the main project	Link to the main project (map, page, ref.)
Building sector	**Extreme heat**	Increasing the need for cooling	**Needs to be assessed*	**Needs to be assessed*	**Needs to be assessed*	Average maximum air temperatures (tmax) (annually and seasonally); Warm days; Hot days; Warm nights; Duration of warm periods, Tropical nights; Damage to infrastructure (€)	**Entered by the designer*	**Entered by the designer*
	Gusts of strong wind	Physical damage to the building	**Needs to be assessed*	**Needs to be assessed*	**Needs to be assessed*	Damage to buildings (€), Time period of inability to use the building	**Entered by the designer*	**Entered by the designer*
	Appearance of waterspouts and tornadoes	Physical damage to the building	**Needs to be assessed*	**Needs to be assessed*	**Needs to be assessed*	Damage to buildings (€), Time period of inability to use the building	**Entered by the designer*	**Entered by the designer*
	Occurrence of hail	Physical damage to the building	**Needs to be assessed*	**Needs to be assessed*	**Needs to be assessed*	Damage to buildings (€), Time period of inability to use the building	**Entered by the designer*	**Entered by the designer*
	Heavy precipitation in a short period of time	Flooding of the building - physical damage	**Needs to be assessed*	**Needs to be assessed*	**Needs to be assessed*	Damage to buildings (€), Time period of inability to use the building	**Entered by the designer*	**Entered by the designer*
	Fires	Increasing the intensity of fires that can endanger buildings	**Needs to be assessed*	**Needs to be assessed*	**Needs to be assessed*	Damage to buildings (€), Time period of inability to use the building	**Entered by the designer*	**Entered by the designer*
	Occurrence of landslides	Physical damage to the building	**Needs to be assessed*	**Needs to be assessed*	**Needs to be assessed*	Damage to buildings (€), Time period of inability to use the building	**Entered by the designer*	**Entered by the designer*

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