

SUPPORTING DISASTER RESILIENCE IN CROATIA



Building Seismic Resilience

A REVIEW OF THE CROATIAN REGULATORY FRAMEWORK
FOR SEISMIC RESILIENCE



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Abbreviations

ATU	Administrative territorial unit
BCR	benefit-cost ratio
CCEE	Croatian Center for Earthquake Engineering
CI	Critical infrastructure
DMAF	Disaster Mitigation and Adaptation Fund (Canada)
DRM	Earthquake prone buildings
EQC	disaster risk reduction
EU	European Union
GDP	Gross Domestic Product
GIS	Geographical Information System
IZIIS	Institute of Earthquake Engineering and Engineering Seismology (North Macedonia)
JRC	Joint Research Centre
KEUL	Key EU Laws
LTRS	Long-Term Strategy for National Building Stock Renovation
m²	Square meters
ML	Local magnitude (Richter scale)
Moi	Ministry of Interior
MoPPCSA	Ministry of Physical Planning, Construction, and State Assets
NECP	Integrated National Energy and Climate Plan
NLTRS	National Long-Term Renovation Strategy (Romania)
NRA	National Risk Assessment
NRRP	National Recovery and Resilience Plan (Croatia)
NSPP	National Seismic Prevention Plan (Croatia)
NDRMS	National Disaster Risk Management Strategy
NSRRS	National Seismic Risk Reduction Strategy (Romania)
nZEB	nearly zero-energy building
NZ	New Zealand
PML	Probable maximum loss
RC	reinforced concrete
RVS	Rapid visual screening
SDG	Sustainable Development Goal
SDI	Significant damage index
UCPM	Union Civil Protection Mechanism

Key terms

Benefit-cost ratio (BCR): Ratio used in benefit-cost analysis to summarize the relationship between overall relative benefits and costs of a project. A BCR lower than 1 means that the project's net benefits could be negative, i.e., benefits lower than costs.

Climate change adaptation: The process of adjusting to life in a changing climate and making efforts to reduce the risk from the harmful impact of current or expected climate change and climate-induced hazards.

Climate change mitigation: The effort to reduce climate change and decelerate global warming through the reduction of greenhouse gas emission into the atmosphere. Mitigation can be done by either reducing the sources of greenhouse gases or improving the carbon sinks on Earth, which store and absorb greenhouse gases.

Comprehensive (major) renovation: A level of renovation at which optimal measures are taken to improve the existing condition of buildings. The measures may include improvement of energy performance, fire safety, indoor climate conditions, and mechanical resistance and stability—in particular, to reduce risks related to earthquake loads. Comprehensive renovation may also include measures to improve the basic requirements for buildings.

Critical infrastructure: The body of assets, systems, and networks that is crucial for maintaining the functioning of a society and the economy. The destruction or disruption of CI will have a significant impact on people's physical, economic, and social well-being.

Damage: Total or partial destruction of physical assets existing in the affected area. Damage occurs during and after the disasters and is measured in physical units (that is, square meters of housing, kilometers of roads, and so on).

Losses: refer to indirectly quantifiable losses (declines in output or revenue, impact on wellbeing, disruptions to flow of goods and services in an economy), or additional operational costs associated with response and initial repairs.

Deep renovation: A level of renovation at which energy efficiency measures are taken for the envelope and technical systems of a building that reduce the annual consumption of heating (QH, nd) and primary energy (Eprim) [kWh/ (m² ·a)] by at least 50 percent from prerenovation consumption.

Disaster risk: The combination of the probability of an event and its negative consequences. Disaster risk refers to the likelihood over a specified time period of severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic, or environmental effects that

¹ Pursuant to Article 2 Directive 2010/31/EU on the energy performance of buildings, major renovation is defined as the renovation of a building where (a) the total cost of the renovation relating to the building envelope or the technical building systems is more than 25 percent of the value of the building, excluding the value of the land upon which the building is situated; or (b) more than 25 percent of the surface of the building envelope undergoes renovation. Member states may choose to apply option (a) or (b).

² World Bank (WB). 2021a.

³ Global Facility for Disaster Reduction and Recovery, website. [Link](#).

⁴ The proposed revision of Directive 2010/31 defines deep renovation as one that transforms a building or building unit (a) before January 1, 2030, into a nearly zero-energy building and (b) as of January 1, 2030, into a zero-emission building. See European Commission (EC). 2021. Proposal for a Directive of the European Parliament and of the Council on the energy performance of buildings. [Link](#).

require immediate emergency response to satisfy critical human needs and that may require external support for recovery.

Disaster risk management (DRM): Processes for designing, implementing, and evaluating strategies, policies, and measures to improve the understanding of disaster risk, foster disaster risk reduction and transfer, and promote continuous improvement in disaster preparedness, response, and recovery practices, all with the explicit purpose of increasing human security, well-being, quality of life, and sustainable development.

Disaster risk reduction: Denotes both a policy goal or objective, and the strategic and instrumental measures employed for anticipating future disaster risk, improving resilience, and reducing existing exposure, hazard, or vulnerability.

DRM investments: Investments in risk identification (risk assessments, etc.), risk reduction (prevention), early warning, emergency preparedness and response, public awareness, financial resilience (various instruments), and resilient recovery.

Energy performance of a building: The calculated or measured amount of energy needed to meet the demand associated with the typical use of a building. This includes, among other things, energy used for heating, cooling, ventilation, hot water, and lighting.

Exposure: The situation of people, infrastructure, housing, production capacities, and other tangible human assets located in hazard-prone areas.

Hazard: A potentially destructive physical phenomenon, such as a natural hazard (e.g., earthquake, wildfire).

Nearly zero-energy building: A building with very high energy performance, which cannot be lower than the 2023 cost-optimal level reported by Member States in accordance with Article 6(2) (proposed revision of Directive 2010/31) and where the nearly zero or very low amount of energy required is covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced onsite or nearby. It will remain the standard for new buildings until the application of the zero-emission building standard and is the level to be attained by a deep renovation by 2030.

Peak ground acceleration: Peak values of the ground motion parameters in an earthquake, or maximum acceleration of the ground caused by earthquakes.

Resilience: The ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through the preservation, restoration, or improvement of its essential basic structures and functions.

Retrofitting and reconstruction: Retrofitting refers to reinforcement or upgrading of infrastructure to improve safety levels and safety performance and to increase resistance and resilience to the damaging effects of hazards. Reconstruction refers to a process of demolishing and rebuilding (new structures).

Rehabilitation: The restoration of basic services and facilities for the functioning of a community or society affected by a disaster.

⁵ Definition of retrofitting is from UNISDR (2009, [Link.](#)).

Seismic exposure: Refers to the elements at risk, such as people, buildings, structures, lifelines, or other CI located in seismic hazard-prone areas. It has a permanent character (for fixed assets, such as the built environment) or a variable character (for people, etc.), depending on when the event occurs. For instance, more people may be exposed to nighttime earthquakes, given that during daytime more people may be outdoors rather than indoors within unsafe structures. Understanding exposure implies, at a basic level, storing and monitoring key data on people and the built environment they inhabit, use, or depend on.

Seismic hazard: An earthquake-related physical phenomenon that may produce adverse effects on life, human-related activities, and the built environment. Seismic hazard is determined by natural factors, such as faults and subduction zones, though it might also be induced by human activities (gas extraction, mining, large water management works). Hazard information serves different purposes: it substantiates building and planning regulations and feeds into seismic risk assessments. In light of this, a number of laws and regulations contain provisions with regard to hazard maps at national and local levels.

Seismic microzonation: An aspect informing local hazard maps to better indicate site-specific effects on ground motions. Local hazard maps capture amplification/de-amplifications as well as the frequency content modifications of the ground motions likely to occur due to local shallow geology or orography. These data also allow for a better refinement of building code requirements and planning regulations for areas where earthquake site amplification may occur.

Staged deep renovation: A deep renovation carried out in several steps, which are set out in a renovation passport in accordance with Article 10 (proposed revision of Directive 2010/31). Deep renovation is set as a gold standard for building renovation and “staged deep renovation” to ease its delivery.

Seismic risk assessment: Assessment that brings together hazard, exposure, and vulnerability information to develop probabilistic methods of assessing expected casualties and material losses in the aftermath of an earthquake. Such assessments are crucial for prioritizing scarce budgets across territories and typologies of buildings. They are also the baseline for effective planning of response actions.

Technical expertise/survey: The official process through which a building’s seismic vulnerability is assessed and general directions for seismic strengthening are indicated. It is conducted by a structural engineering expert who is certified by a government entity. A technical expertise/survey report is the result of the exercise.

Vulnerability: The characteristics and circumstances of the built environment and communities that make them susceptible to damaging impacts (or social vulnerability). Vulnerability factors include building construction type, socioeconomic context, and so on.

Zero-emission building: A building with a very high energy performance, where the very low amount of energy required is fully covered by energy from renewable sources generated onsite; from a renewable energy community, as defined by Directive (EU) 2018/2001 [amended RED]; or from a district heating and cooling system.

⁶ GFDRR 2014, [Link](#).

⁷ Ibid.

⁸ Ibid.



EXECUTIVE SUMMARY

Regulating seismic resilience is critical for Croatia because it can help save lives, limit physical damage and economic impacts, and provide opportunities for investments and broader development co-benefits. Although rare compared to other disasters, earthquakes pose considerable risk in Croatia.⁹ In 2020, the country was affected by a series of earthquakes, equivalent in magnitude to some of the strongest since 1880.¹⁰ The total cost of the March earthquake (magnitude 5.5), which affected the City of Zagreb, Zagreb County, and Krapina-Zagorje County is estimated at €11.301 billion.¹¹ The December earthquake, which affected Petrinja (magnitude 6.2) destroyed €4.8 billion in physical assets in Sisak-Moslavina County, Zagreb County, Karlovac County, Krapina-Zagorje County, and the City of Zagreb.¹² The two earthquakes, which were preceded and followed by shocks of varying magnitude, resulted in a total of eight deaths, left 41 people injured, and displaced 45,000—this during the COVID-19 pandemic.¹³

These recent earthquakes highlight the need for proactive seismic risk management. Croatia has a large stock of aging infrastructure, with only a small proportion of buildings (more than 10 percent) meeting modern codes, including the Eurocodes and those related to energy performance.¹⁴ One-third of existing buildings were constructed before 1964, when the first building code introduced seismic provisions, with little or no consideration of seismic shaking.¹⁵ Since the 1964 code, seismic codes were gradually introduced until 2008, when buildings were required to adhere to the Eurocodes (currently under revision). Furthermore, there has been some illegal construction across the country, meaning such buildings could be inadequate in ways that make them vulnerable to earthquakes and unsafe for occupants.

⁹ The level of earthquake risk is considered “unacceptable,” according to GoC. 2019a, Link.

¹⁰ Previous significant seismic events include the 1880 Zagreb earthquake (Richter local magnitude [ML] 6.2); the 1909 Pokuplje earthquake (surface-wave magnitude [MS] 5.8); the 1942 Imotski earthquake (ML 6.2); the 1962 Makarska earthquake (ML 6.1); the 1963 Skopje earthquake (ML 6.1); the 1969 Banja Luka earthquake (ML 6.4); the 1979 Montenegrin Coast earthquake (moment magnitude [Mw] 7.0); and the 1996 Ston earthquake (Mw 6.0).

¹¹ €10.66 billion in damage and €0.640 billion in loss; the housing sector sustained the most damage and loss (€7.2 billion), and reconstruction and recovery needs estimated at €9.1 billion (52 percent of the total needs). See GoC. 2020b, Link.

¹² €4.12 billion in damage and €714 million in loss; the housing sector sustained the most damage and loss (€2.6 billion), and reconstruction and recovery needs estimated at €4.76 billion (56 percent of all total needs). See GoC. 2020a, Link.

¹³ GoC 2020a, Link. ; GoC 2020b, Link.

¹⁴ WB and EC. 2024d. Link.

¹⁵ By comparison, around 40 percent of buildings in the European Union (EU) were constructed before the 1960s. See EC. iRESIST+ innovative seismic and energy retrofitting of the existing building stock. Link.

Legislative framework

While Croatia has made strides in implementing and updating seismic laws, gaps remain that limit opportunities for seismic risk reduction. The 2020 earthquakes, which tested the state of application of, and adherence to seismic building laws, showed that buildings with adequately implemented seismic safety standards generally sustained minor or no damage; damage was more likely among buildings that did not meet modern building codes or were built before their introduction. Moreover, physical infrastructure, including facilities that offer public services, such as public administration buildings, schools, hospitals, and emergency response buildings, are often housed in old buildings dating back to the period before the application of seismic codes, making them very seismically vulnerable. In addition, many facilities are also used in emergency situations have not been adequately assessed for exposure and vulnerability to earthquakes and other disasters.

Although public awareness of earthquake risk is growing, ongoing renovations to improve buildings' energy efficiency do not always comprehensively and systematically address seismic resilience. Moreover, while funds and legal regulation are available only for rehabilitating and reconstructing buildings damaged in the 2020 earthquakes, and many investments are ongoing, there is no programmatic, systematic, and proactive approach that targets and prioritizes all other seismically vulnerable types of public and private buildings (such as schools, hospitals, and emergency response buildings) for upgrading before the next earthquake strikes.

Croatia has an opportunity to take advantage of the existing momentum at the national and European Union (EU) levels to lay down a strong regulatory foundation for disaster resilience, including seismic resilience. In the past few years, Croatia has taken measures and instituted new policies to enhance its disaster resilience. In 2022, the government approved a Disaster Risk Management (DRM) Strategy, drawing on its 2019 National Risk Assessment (NRA). The NRA has been updated, reconfirming the country's high earthquake risk; and a more in-depth, localized seismic risk assessment is being conducted for Zagreb. Meanwhile, the EU Preparedness Union Strategy and the EU disaster resilience goals call on EU Member States to make investments that will help them withstand the impacts of future disasters and be better prepared to act before disasters strike. In December 2020, Croatia adopted a Long-Term Strategy for National Building Stock Renovation (LTRS), setting a path toward a long-term goal of decarbonizing buildings and reducing emissions by 80–95 percent by 2050 (the EU's target). Investments in disaster and climate resilience are also emphasized by the National Recovery and Resilience Plan (NRRP), funded by the EU.

To meet the challenges of disaster risk, Croatia needs to promote a holistic approach to resilience, one that includes a comprehensive regulatory framework and that focuses on public and private infrastructure exposed and vulnerable to different hazards. While the country has taken significant steps to build resilience to floods by investing in forecasting, early warning, and flood protection, earthquakes have received considerably less attention, and public awareness of risks and appropriate courses of action is still limited. Croatia could address these gaps by pursuing a holistic approach to disaster resilience. In particular, it needs to establish a framework for prevention and preparedness that facilitates the reduction of risk, avoids the creation of new risks, and enhances readiness to manage disaster impacts and recovery needs.

This knowledge note focuses on only one part of a holistic resilience framework: the regulatory framework for seismic risk reduction. It provides an overview of the existing framework related to seismic resilience and energy efficiency, with particular attention to adoption and enforcement of building codes that address Croatia's disaster profile. It highlights key challenges and opportunities and

¹⁶ EC 2023e, [Link](#).

¹⁷ GoC, 2020d, [Link](#).

considers the example of other countries, including Canada, Italy, Japan, New Zealand, Portugal, and Romania, which can serve as inspiration for Croatia's efforts. It also recognizes the importance of long-term efforts to strengthen disaster preparedness and readiness for recovery. For example, preserving earthquake awareness among future generations is crucial to foster a more resilient and disaster-ready society. The recommendations provided in this note can inform deeper analysis and enable alignment of decisions with long-term disaster and climate resilience goals at the national and EU levels.

Key challenges

The main challenge Croatia faces in implementing a comprehensive framework for reducing seismic risk is that the current laws regarding seismic risk reduction are not fully harmonized or consistent. The Reconstruction Law was a special regulation that applied only to damaged buildings in specific counties affected by the 2020 earthquakes; it thus leaves out high-risk buildings in other areas. The building code requires all buildings to adhere to Eurocode 8; but meeting these standards may not be possible or practical for older buildings in high-risk areas, especially cultural heritage structures. Finally, the Ordinance for Simple Buildings allows only minor changes, such as energy efficiency improvements, without permitting seismic interventions. These inconsistencies make it difficult to promote integrated solutions.

A further challenge is that decision-makers need better access to risk information and data. There are gaps in the mapping of seismic risk in Croatia, and microzonation studies—like the one the CRONOS project conducted in Sinj in 2023 as part of the city's microzonation effort—are generally missing. While examples of comprehensive risk assessments are available (notably for Zagreb), this methodology has not yet been rolled out nationwide. Data and evidence are needed in order to prioritize investments in specific areas or types of assets and to inform effective investment in both energy efficiency and seismic interventions. Croatia also currently lacks a sound understanding of the building portfolio and its multiple elements, such as building design, materials, and so on; this is true even for critical public infrastructure. The current laws also fail to consider high-risk areas or specific building types, which could help prioritize interventions. Builders are not obligated to document or prove the structural soundness of buildings undergoing energy efficiency interventions, and the resulting knowledge gap hinders the ability to enhance risk resilience at the same time.

Additional challenges include the need to strengthen broader compliance with and uptake of disaster-related laws—for example, by developing stakeholders' capacity and improving the skills needed to support the correct use of these laws. Training, knowledge, and awareness are required to support better practice among line ministries, local administrations, and professional communities (architects, engineers, project managers, and so on). Such measures may go hand in hand with enforcement. More broadly, bolstering disaster risk awareness may expand the application of risk management to include risk prevention, risk preparedness, and resilient recovery planning at various levels.

¹⁸ See also WB. 2025. Seismic Resilience: Experience and Lessons Learned from Japan: Knowledge Notes on Selected Topics. [Link](#).

¹⁹ The CRONOS Project undertakes the "investigation of seismically vulnerable areas in Croatia and seismic ground motion assessment." See website at [Link](#).

²⁰ WB and EC 2024. [Link](#).

Key recommendations

To more effectively reduce seismic risk, Croatia could adopt these key policy recommendations:

- Modernize the regulatory framework to meet short-, medium-, and long-term challenges related to seismic risk.
- Advance seismic risk reduction efforts to reflect the current scale of risk.
- Link energy efficiency and seismic resilience to enable smart, integrated, and efficient investments that strengthen disaster and climate resilience.

MODERNIZE THE REGULATORY FRAMEWORK

Establishing up-to-date laws, regulations, building codes, strategies, and processes is essential to ensure the safety of infrastructure during disasters and save lives. For Croatia, this involves addressing gaps within the country's legal framework related to the existing building stock and to construction processes and compliance. Two steps are essential: first, risk analysis of the building stock must be conducted to gain an understanding of its vulnerability and exposure to earthquakes and other hazards. Second, the current framework must be analyzed to bridge the gaps between regulations and compliance, particularly in relation to seismic and other disaster standards. It is particularly important to optimize processes for quality inspection and improve enforcement of legal standards for critical infrastructure. Notably, the current building code does not include provisions for the post-2020 earthquake reconstruction; this is governed instead by a special law, i.e., the Law on Reconstruction, which as indicated above applies only to specific areas affected by earthquakes—the City of Zagreb, Zagreb County, Krapinsko-Zagorska County, Karlovac County, and Sisak-Moslavina County. The implementation of the new Law on Critical Infrastructure (NN 89/25) also provides a good opportunity to start with risk screening and risk reduction for critical entities.

Disaster and climate risk information should be integrated into local and national laws, infrastructure plans, and strategies to ensure coherence among them. In parallel, institutional and market capacity, including at the local level, should be enhanced to increase compliance with the regulatory framework. The ultimate goal is to have an up-to-date regulatory framework that corresponds to challenges, establishes relevant methodologies, enables stakeholders to understand their responsibilities, and allows them to access the data and knowledge needed to address seismic and other challenges related to disasters and climate change.

To meet this goal, Croatia can take advantage of the knowledge and experience already attained by other earthquake-prone countries. For example:

- **Japan** regularly upgrades its regulations and codes, drawing on lessons from major earthquakes and exploiting the window of opportunity when awareness is high and the will to change is strong. Following the 2011 Great East Japan Earthquake and associated tsunami, for example, an Expert Committee on Earthquake and Tsunami Disaster Management was set up at the highest level to document lessons learned. Japan's partial reliance on the private sector to carry out inspections and confirm building code compliance has helped local governments with limited human resources to ensure the codes are applied. To prevent misuse of the system, the confirmation process is coupled with a robust penalty mechanism.
- **Italy** has made significant efforts since the 2009 L'Aquila earthquake and has integrated lessons learned from this event into its National Seismic Prevention Plan. Italy also invests in risk analytics, seeks to better understand types of infrastructural interventions necessary to strengthen its seismic resilience and reduce seismic risk, and has established various incentives for risk reduction.
- **Romania** has developed a National Seismic Risk Reduction Strategy and associated action plan, which provide a three-level approach to vulnerability assessment to guide investment decisions across key sectors.
- **New Zealand** has updated its regulatory framework to provide guidance on and incentives for investment in risk reduction. The relevant legislation engages both local and national authorities in evaluating vulnerable buildings, whose seismic risk status is made publicly available through a register.

²¹ GoC 2025, [Link](#).

Advance seismic risk reduction efforts

Croatia has an opportunity to establish a prioritized approach to risk reduction that is both effective and cost-efficient, and that takes into account risk and other socioeconomic and environmental information. Preventive investments in resilient infrastructure make economic sense and deliver many benefits by protecting lives and assets, avoiding disruption of services, and creating various developmental and climate change-related co-benefits. Croatia could consider establishing and financing dedicated programs for phased improvements in infrastructure at different administrative and societal levels, focusing initially on critical infrastructure and services (such as emergency response, health care, education, transportation, energy, and telecommunications) and addressing multiple hazards, including earthquakes, landslides, wildfires, and extreme heat. Such programs would also take into account the need to adapt to and mitigate climate change impacts. To mitigate current and future risks, it will be especially important to incentivize support for seismic resilience in high-risk areas. This step will require strong technical capacity and the development of skills through alliances across society, including academia and the private sector. Risk reduction must also be accompanied by efforts to enhance preparedness and by development of a robust knowledge base on seismic and other disaster risks, which will help to preserve risk awareness across future generations.

Several countries have made mitigating the earthquake risk of important public buildings a priority and have therefore sought to better understand the risk and to decrease vulnerability. For example:

- **Italy** has been implementing its National Seismic Prevention Plan, and Romania is also scaling up its national efforts.
- Research across **Europe** shows that earthquake prevention measures accompanied by investments in energy efficiency and building modernization provide the highest benefit-cost ratios and offer immediate benefits, even if a disaster does not occur. Investments at the national level can encourage private investment by building owners.
- Japan has several programs in place to upgrade infrastructure—such as housing or public infrastructure (including schools)—as part of proactive risk reduction efforts that are planned and implemented before events happen. The programs operate under a regulatory framework that includes specific arrangements and dedicated funding for local government efforts and subsidies to the public. To ensure program implementation is supported by the necessary financing and processes, Japan emphasizes strong coordination between the central and local levels of government.

Strengthen energy efficiency and seismic resilience

At both the EU and national levels, opportunities exist to maximize the benefits of integrating multi-hazard considerations in laws, infrastructure plans, and investments, and these are aligned with opportunities for investment. By taking advantage of these opportunities, Croatia can make great progress toward achieving its own disaster and climate objectives, as well as those of the EU and the rest of the world. Essential to this progress are legislation and policies establishing requirements and procedures for comprehensive retrofits, which incorporate energy efficiency and earthquake resistance while also addressing fire safety, inclusiveness, and other disaster-related issues. To enhance disaster preparedness and response, the laws should be supported by comprehensive and multifaceted DRM regulations.

²² ODI and WB 2015 [Link](#).

²³ WB and EC 2021b [Link](#).

²⁴ WB. 2025a. [Link](#).

It is equally important to ensure that there is institutional capacity and knowledge among officials at different levels, professional communities, and the broader public. These groups require capacity building, awareness raising, and technical training that draws on state-of-the-art research; these will enable them to implement green, resilient, and inclusive considerations swiftly and effectively, and to address infrastructural deficiencies (for example, aged buildings). To develop a more sustainable approach to earthquake resilience, one that combines energy efficiency with seismic and other disaster considerations, legislation must also address the challenge of institutional fragmentation and lack of interinstitutional coordination. Robust communication is necessary across all levels of society to raise awareness about relevant risks and to inform the public about the availability of funding opportunities. These efforts will facilitate the adoption of comprehensive regulations that take into account multi-hazard considerations on a large scale.

In seeking to strengthen energy efficiency and seismic resilience, Croatia can draw lessons from the efforts and experiences of other countries. For example:

- **Japan** takes an approach to seismic resilience that focuses on integrated retrofit but also pays attention to other upgrading needs, such as fire safety and functional modernization. This approach makes it possible to maximize the benefits derived from a single retrofitting opportunity and increases the cost-effectiveness of the intervention. Laws as well as programs are in place that enable this integrated approach.
- **Portugal** has requirements for energy-efficient and earthquake-resistant retrofits, and **Romania** has also incorporated such considerations into its national seismic risk reduction efforts.
- **Slovenia** integrates energy efficiency and earthquake resilience in retrofitting through the use of a “building cards” tool that promotes gradual, comprehensive renovation.
- Lessons can also be drawn from studies on energy efficiency and seismic risk reduction conducted in the **Western Balkans**, with infrastructure similar to Croatia’s.

Conclusion

In summary, Croatia can make public and private buildings less vulnerable to seismic and other disaster and climatic risks through smart, prioritized, and integrated rehabilitation and reconstruction efforts. These include combining seismic upgrades with energy efficiency improvements and other necessary enhancements for functional modernization. To accomplish the needed improvements, the current legal framework must be updated to address existing gaps and risk areas. Furthermore, investment planning and programs must be revised to enable and promote integrated interventions.

Croatia can support smarter ways to promote disaster and climate resilience, build alliances across society, and enable proactive investments to minimize the economic and human toll of disasters. In parallel, it can continue efforts to ensure a robust level of preparedness and emergency readiness across different administrative levels and sections of the society, in line with a holistic approach to disaster and climate resilience.



1. INTRODUCTION AND CONTEXT

This note provides an overview of Croatia’s regulatory framework for seismic resilience. This is not a comprehensive review; rather, the note highlights arrangements currently in place, key challenges, good practice examples, and opportunities going forward. The note also includes a set of international good practices and policy recommendations for national policy makers and practitioners seeking to improving seismic resilience regulations and moving toward a systematic reduction of earthquake risk.²⁵ This introductory chapter provides country and sectoral context, focusing specifically on seismic risk.

Accompanying this note are three knowledge notes on select topics that support the Government of Croatia in enhancing institutional capacity for resilient and green reconstruction, and in expanding the knowledge base for scaling up risk reduction, preparedness, and financial resilience against multiple hazards. The accompanying knowledge notes cover: (i) selected aspects of Japan’s approach to seismic resilience—including engineering, regulatory frameworks, risk reduction, and disaster risk finance²⁶; (ii) an overview and assessment of Croatia’s current disaster risk financing landscape, with recommendations for future action²⁷; and (iii) a review of Croatia’s regulatory framework for seismic resilience, highlighting existing arrangements, challenges, good practices, and opportunities for improvement.²⁸

²⁵ Ibid.

²⁶ Ibid.

²⁷ WB. 2025b. Link.

²⁸ WB. 2025 (forthcoming). Opportunities for Smart Investments in Resilience – Application of Prioritization Tools to Strengthen Disaster Resilience in Croatia, Knowledge Notes on Select Topics.

Country context: key highlights

Croatia's geographical location and climate make it susceptible to a wide variety of hazards. These include geological disasters (earthquakes), hydrometeorological and weather-related hazards (floods, extreme temperatures, strong winds, and droughts), and wildfires, all of which can significantly disrupt economic and social functions. According to the global disaster database EM-DAT, between 1990 and 2023, 36 disasters were recorded in Croatia. The 2019 NRA identified earthquakes, floods, and wildfires as priority hazards.

Climate change is expected to have major impacts in Croatia; the intensity and frequency of disaster events, along with hotter and drier summers, are predicted. Croatia's cumulative damage from extreme weather and climate events as a share of gross domestic product (GDP) is one of the highest in the European Union (EU). Croatia has experienced various extreme weather events; 2017 recorded the most intense, hottest, and driest summer season to date in Croatia. Since 2017, Croatia has broken many meteorological records. According to the Ministry of Interior (Mol), 2022 was the fifth warmest year recorded and saw an increase in the number of forest fires by 74 percent from 2021. In May 2023, torrential rainfall led to severe flooding (which broke 2014 records) and caused multiple landslides.

In the long term, the complexity of Croatia's climatic profile, coupled with sea-level rise, will have a significant impact on various critical sectors in the country as well as the economy. The World Bank and European Commission have estimated average annual losses to private and public buildings from flood damage at 0.29 percent of GDP (€147 million), while the Joint Research Centre puts them at 0.4 percent of GDP.

Earthquake risk

Croatia is located in a seismically active region, with a history of strong earthquakes. For example, in 1880, an earthquake (5.5 magnitude) struck near Zagreb, and in 1969, an earthquake (5.6 magnitude) struck near neighboring Banja Luka. Further, in the former Yugoslavia, the risk of earthquakes was quite high; notable events include the 1962 Makarska earthquake (6.1 magnitude) and the 1667 Dubrovnik earthquake (estimated at ± 7 magnitude). The most recent major events occurred in 2020, when a series of major earthquakes struck Zagreb (March 2020) and Sisak-Moslavina County (December 2020). The entire country is highly active seismically (Figure 1); about 30 percent of the country, an area that is home to about 60 percent of the population and that produces a large percentage of the country's GDP, is exposed to earthquakes. Populations in Zagreb, Split, Dubrovnik, and Rijeka are exposed to strong earthquakes that could have catastrophic consequences. Over half the residents in Zagreb City and Rijeka city (52 percent and 54 percent respectively) live in seismically vulnerable multifamily housing built before the year 2000.

²⁹ EM-DAT: The International Disaster Database, Université Catholique de Louvain–CRED (Centre for Research on the Epidemiology of Disasters), Brussels, Belgium, [Link](#).

³⁰ GoC 2019a, [Link](#).

³¹ European Environmental Agency 2017, [Link](#).

³² WB and EC 2021b, [Link](#).

³³ Dottori et al. 2020.

³⁴ Historical events include the 1667 Dubrovnik earthquake, which caused 5,000 casualties (around one-third of the city's population), and the 1880 Great Zagreb earthquake, which affected almost every building in Zagreb and destroyed 13 percent.

³⁵ See UN Office for Disaster Risk Reduction, "Dubrovnik–Croatia," [Link](#).

³⁶ On Zagreb earthquake, see University of Zagreb, 2020a, [Link](#). See also Markušić et al. 2020, [Link](#).

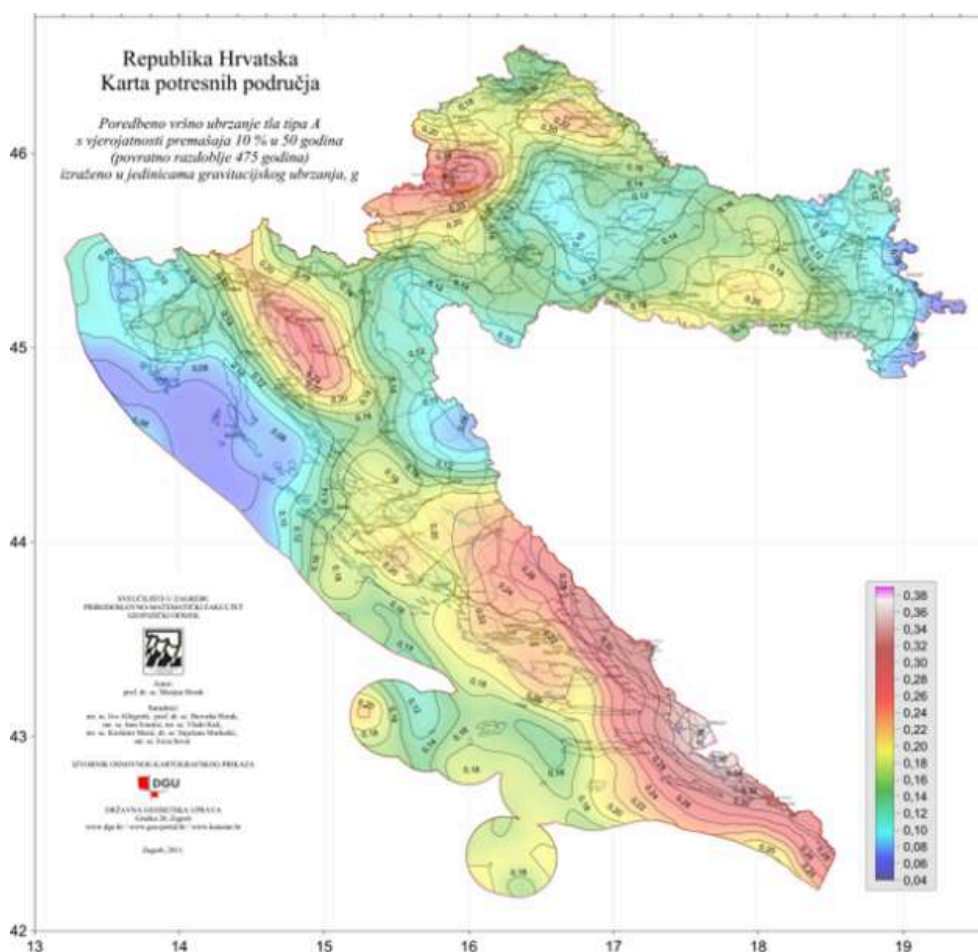
³⁷ See University of Zagreb. 2020b, [Link](#).

³⁸ GoC, "Disaster Risk Assessment for the Republic of Croatia" [Procjena rizika od katastrofa za Republiku Hrvatsku], [Link](#). See also GoC. 2019a, [Link](#).

³⁹ WB. 2021, [Link](#). Unreinforced masonry and reinforced concrete frame buildings pose the highest earthquake risk, expected to

Croatia's housing stock is vulnerable to the impacts of earthquakes. Almost a third was built before adopting any regulations that consider earthquake action. About half was built between 1964, when the first building code with seismic provisions was introduced, and 2013; for the buildings in this group that have been analyzed, the values of horizontal forces from seismic action are several times lower than those prescribed by current standards. A particular challenge is posed by dense urban areas, where some buildings come under special cultural protections and require special analysis. These areas also include public buildings designed to a seismic standard lower than today's Eurocode 8 standard. In addition, the majority of buildings in Croatia were constructed before 1987 and lack adequate thermal protection; up to 83 percent fail to meet the Technical Regulations from 1987, leading to substantial heat loss and an average energy consumption from heating of 150 to 200 kWh/m².

Figure 1. Seismic Hazard Map of Croatia



Source: Herak 2011, [Link](#).

Note: The key shows peak ground acceleration (PGA) of type soil A for a return period of 475 years (a probability of exceedance of 10 percent in 50 years) in units a_g (gravity acceleration).

The December 2020 earthquake ended an extraordinary year for Croatia, one that included the compounding effects of a major earthquake in March 2020, the COVID-19 pandemic, and associated economic challenges—all of which exposed Croatia's vulnerabilities to disaster events. The World Bank supported the Croatian government in conducting Rapid Damage and Needs Assessments (see [Box 1](#)), which estimated the damage and losses from both 2020 earthquakes at €16.1 billion (€11.3

cause the most fatalities. In Zagreb (home to some 20 percent of Croatia's population), over two-thirds of residents live in high-risk building types. In Rijeka (home to some 3 percent of the population), it is one-third of residents.

⁴⁰ GoC 2022b.

⁴¹ Ibid.

⁴² FZOEU. "ENU in building construction" [EnU u zgradarstvu]. [Link](#).

billion for Zagreb and €4.8 billion for Sisak-Moslavina County). Following the earthquakes, several laws were passed to simplify reconstruction procedures in earthquake-affected areas. These included the Reconstruction Act, passed in the Croatian Parliament, and the Program of Measures for the Reconstruction of Earthquake-Damaged Buildings, adopted on December 10, 2021, and detailing the processing of submitted applications for reconstruction. More information on these laws is included in the next chapter.

Following the 2020 earthquakes, Croatia received support for recovery and reconstruction from various international organizations. The European Union Solidarity Fund granted €1.1 billion—€684 million for the March earthquake and €319 million for December. Croatia was also allocated €5.8 billion in grants and €4.2 billion in loans from the NRRP, of which approximately 39 percent was designated for the green transition and €1,978 million for earthquake reconstruction (see Box 4). Through the €183.9 million (US\$200 million) Earthquake Recovery and Public Health Preparedness Project, the World Bank is supporting Croatia with earthquake reconstruction efforts in Zagreb and the surrounding areas, improving institutional capacity for reconstruction, and strengthening national systems for public health preparedness.

⁴³ Of the €11.3 billion, €10.661 billion is damage and €0.640 billion are losses; see GoC. 2020b, [Link](#).

⁴⁴ Of the €4.8 billion, €4.12 billion is damage and €714 million are losses; see GoC. 2020a, [Link](#).

⁴⁵ GoC 2023a, [Link](#).

⁴⁶ EC 2023c, [Link](#).

⁴⁷ Information on the Earthquake Recovery and Public Health Preparedness Project (P173998) is available at [Link](#).

Box 1. Findings of the 2020 Post-Earthquake Rapid Damage and Needs Assessments in Croatia

On March 22, 2020, Zagreb was hit by a magnitude 5.5 earthquake, the strongest earthquake recorded in 140 years. The event occurred in the middle of a nationwide lockdown due to the COVID-19 outbreak, and it affected COVID-19 testing centers and health facilities specializing in respiratory diseases. The earthquake affected large sections of the population in Zagreb and the surrounding area. There was one fatality and 26 people were injured (18 severely). According to Ministry of Interior data, 791,038 people were directly exposed to earthquake conditions of level-VII intensity. The earthquakes caused damage to 26,000 public and private buildings, including health and education infrastructure. Some 5,816 buildings were declared unusable (1,236 permanently unusable and 4,580 temporarily unusable), while 18,065 remained in usable condition. By the end of February 2021, following the December 2020 earthquakes, approximately 43,000 buildings were reported as damaged. Damage and losses by sector are summarized in [Table 1](#).

Table 1. March 2020 Earthquake: Damage and Losses by Sector

	Damage	Losses	Total
Housing	6,881	364	7245
Health	826	61	884
Education	1,071	9	1,080
Culture and Cultural Heritage	1,378	21	1,399
Business	505	184	689
Total	10,661	640	11,301

Source: GoC 2020b, [Link](#).

On December 29, 2020, Sisak-Moslavina County was hit by a 6.2 magnitude earthquake with the epicenter near the town of Petrinja. This earthquake was preceded by a strong 5.0 magnitude foreshock a day earlier. Numerous aftershocks followed the December 29 main shock. The earthquake resulted in seven fatalities; 15 persons sustained severe injuries, and dozens of minor injuries. Apart from Sisak-Moslavina, several other areas were affected, including Karlovac, Zagreb, and Krapina-Zagorje Counties and the City of Zagreb. In the immediate aftermath of the earthquake, it was estimated that the houses of almost 15,000 Sisak-Moslavina County residents were unusable or temporarily unusable.^a Some of the affected people were housed in evacuation centers and temporary shelters, some were displaced to other parts of Croatia, and some decided to stay near their homes and were eventually provided mobile homes or housing containers. Overall, the earthquake resulted in damage to about 40,000 buildings, predominantly in Sisak-Moslavina County but also in the other abovementioned counties. The total cost of the December earthquake across 13 sectors and five counties was estimated at €4.83 billion, of which €4.15 billion refers to destroyed physical assets and €687 million refers to losses. Most of the cost (80 percent) refers to Sisak-Moslavina County, followed by Zagreb County (10 percent), Karlovac County (6 percent), Krapina-Zagorje County (2 percent), and the City of Zagreb (2 percent). Overall, a total area of more than 11.2 million m² was affected by the Petrinja earthquake. By sector, most of the damage was to housing (73 percent), followed by the business sector, agriculture, education, and others. Damage and losses by sector are summarized in [Table 2](#).

Table 2. December 2020 Earthquake: Damage and Losses by Sector

All sectors		Damage			Losses			Total		
		Public	Private	Total	Public	Private	Total	Public	Private	Total
Social	Housing	56	2,433	2,489	2	107	109	58	2,540	2,598
	Health	123	2	125	42	0.05	42	165	2	167
	Education	153	1	154	20	0.10	20	173	1	174
	Social Protection	21	14	35	58	1	59	79	15	94
	Culture and cultural heritage	62	410	147	24	14	39	86	424	510
Productive	Business	0	322	322	0	359	359	0	681	681
	Agriculture	0	84	84	0	18	18	0	102	102
Infrastructure	Water and flood protection	76	0	76	2	0	2	78	0	78
	Energy	19	0	19	2	0	2	21	0	21
	Public administration and community infrastructure	159	0	159	9	0	9	168	0	168
	Transport and communications	87	2	89	22	1	22	109	2	111
Cross-cutting	DRR and civil protection	23	0	23	13	0	13	35	0	35
	Geology and land stability	47	30	77	1	1	2	48	31	79
Total		824	3,298	4,122	196	500	696	1,020	3,798	4,818

Sources: GoC 2020a ; GoC 2020b .

This estimation is from Ministry of Interior data and is cited in the Program of Measures for the Reconstruction of Buildings Damaged by Earthquakes for the Areas of the City of Zagreb, Krapina-Zagorje County, Zagreb County, Sisak-Moslavina County, and Karlovac County, dated February 19, 2021. According to the MoI, on January 12, 2021, there were a total of 2,214 unusable and 3,548 temporarily unusable buildings, in which an estimated 4,438 and 10,059 people lived, respectively.



Disaster risk management framework and seismic risk

Over the past decades, the DRM system in Croatia has evolved from focusing mostly on disaster response to taking a more comprehensive approach that emphasizes reducing, preventing, or preparing for disaster risks. The elaboration and strengthening of Croatia's DRM system upon joining the EU and the Union Civil Protection Mechanism (UCPM) has several drivers, including the legal requirements imposed by the EU (such as the preparation of an NRA) and the opportunities for knowledge exchange and international cooperation facilitated by the UCPM.

At the core of the country's DRM legal and institutional framework is the Act on the Civil Protection System. The law stipulates the adoption of a National Disaster Risk Reduction Strategy, a Strategy for the Development of the Civil Protection System, and the State Civil Protection Action Plan, based on the development of the National Risk Assessment. Croatia's DRM strategic documents are in line with the relevant national and EU regulations. A summary of the legal framework for regulating earthquake and disaster resilience can be found in Annex 1 ([Table 7](#) and [Table 9](#)).

The institutional framework involves policy makers at three levels: national, regional (all counties and the City of Zagreb), and local (local self-government units), as set out by the Civil Protection Act. The MoI, and its Civil Protection Directorate, aim to minimize risks, prevent consequences of risks, organize activities related to DRM, oversee the civil protection operational forces, and ensure smooth coordination among all the participants of the civil protection system. The Croatian Platform for Disaster Risk Reduction was set up in 2009 in order to provide a link between the political, operational, and scientific levels. The key tasks of the platform are fostering knowledge transfer, providing solutions, and developing and implementing various planning documents to reduce disaster risk. Actors involved in the Disaster Risk Reduction Platform include various ministries, scientific institutions, units of local and regional self-administration, the private sector, and citizens. It should also be noted that within the platform, a working group is dedicated to multi-hazard considerations (flood and earthquake). There are also volunteers and research organizations, including the Croatian Center for Earthquake Engineering, which raise the level of knowledge and awareness of earthquake risk.

The first NRA was adopted in 2015 and was updated in 2019. In 2022, as the country prepared for the next update of the NRA, the MoI developed a draft of new guidelines for disaster risk assessment. The initial and updated NRAs consider the country's seismic risk as "unacceptable" under various earthquake-related scenarios. The NRA included a scenario on ground shaking in the City of Zagreb caused by an earthquake whose return period aligned with the regulations for earthquake resistance design; it also included a multi-risk scenario that assessed an earthquake and a flood in Zagreb. The NRA recognized that awareness of the potential threat of earthquakes in Croatia is limited; that the

⁴⁸ See Sigmund, Radujković, and Atalić. 2022, [Link](#).

⁴⁹ See EC. 2023f, [Link](#).

⁵⁰ GoC 2022a, [Link](#).

⁵¹ For relevant laws, see GoC. 2023b, [Link](#). For strategic and planning documents, see GoC. 2023c, [Link](#).

⁵² For more information on disaster risk governance in Croatia, see Holcinger and Šimac 2021, [Link](#).

⁵³ See GoC, "Croatian Platform for Disaster Risk Reduction" [Hrvatska platforma za smanjenje rizika od katastrofa], [Link](#).

⁵⁴ See Croatian Center for Earthquake Engineering [Hrvatski centar za potresno inženjerstvo (HCPI)], website [Link](#).

⁵⁵ In line with Decision No. 1313/2013/EU of the European Parliament and of the Council of 17 December 2013 on the Union Civil Protection Mechanism and EU Decision 2019/420 of the European Parliament and of the Council of 13 March 2019 amending Decision No. 1313/2013/EU, with the obligation to provide risk data in accordance with the recommended Guidelines of the EC SEC(2010) 1626. See Atalić, J., Hak, S. 2014. See Atalić, J., M. Šavor Novak, and M. Uroš. 2018.

⁵⁶ GoC 2019a, [Link](#).

⁵⁷ MoI 2022.

existing system to address this risk is relatively neglected; and that there is no dedicated organization that consistently works toward mitigating the impact of earthquakes.

The DRM Strategy until 2030 was developed based on the results of the NRA and was adopted in 2023 with the accompanying Disaster Risk Action Plan for the period 2021–2024. The strategy addresses the risks labeled "unacceptable" and "tolerated" by the NRA. It seeks to achieve comprehensive, sustainable, and long-term justified DRM, which will further contribute to the fulfilment of obligations arising from international agreements—i.e., the Sendai Framework for Disaster Risk Reduction 2015–2030, the United Nations Sustainable Development Goals 2015 (Agenda 2030), and the Paris Agreement on Climate Change in 2015. Some existing regulations already outline sector-specific Disaster Risk Reduction measures, such as the Water Act, the Civil Protection System Act, and the Act on Protecting Forests against Fires.

The DRM Strategy covers several issues related to seismic risk management and highlights key needs/priorities going forward. The strategy recognizes that seismic risk was not considered in aged buildings and notes that the functionality and vulnerability of buildings at risk should be assessed. Spatial plans should also integrate new knowledge and analysis of earthquake resistance as well as analyses of the building stock. Related to prevention and risk reduction, the strategy notes comprehensive renovation of buildings should be encouraged, and it calls for optimal measures in addition to energy renovation to improve buildings' existing condition, including measures to increase safety in case of fire, measures to ensure healthy indoor climate conditions, and measures to improve the mechanical resistance and stability of the building. Related to preparedness, the strategy calls for strengthening of seismological station networks. Related to post-disaster response and recovery, the strategy highlights the need to strengthen the operational forces of the civil protection system for search and rescue, to involve more experts in activities defined by earthquake risk needs, and to undertake seismic strengthening of structures and comprehensive renovation of buildings. Related to overall operational readiness and awareness, the strategy calls for increasing professional capacities and equipment for earthquake risk management, and for forming intervention teams and teams of experts to eliminate consequences/damage, raise awareness, and educate the population about behavioral procedures before, during, and after the earthquake. It also calls for establishing an interdisciplinary and cross-sectoral earthquake relief center and for developing and modernizing seismological affairs. Various projects related to earthquake risk are proposed under the strategy, including the development/fostering of a national platform for the Croatian Center for Earthquake Engineering, as noted above.

The national DRM Strategy is in line with the National Development Strategy until 2030, approved in 2021. The development strategy serves as a comprehensive strategic planning act to guide development of society and the economy in the long term. The strategy highlights the risk of disasters as a security challenge. One of the four development directions is to strengthen resilience to crises, and one of the 13 strategic goals is security for stable development. One part of this goal is to strengthen resilience to disaster risks and improve the civil protection system. The National Development Strategy emphasizes measures to mitigate the risk of disasters caused by natural threats, especially the risk of fires, floods, and earthquakes, and calls for strengthening institutional capacities and the Croatian Platform for Disaster Risk Reduction.

Although there is no specific seismic risk management strategy, seismic risk priorities are included in various documents, such as the NDRMS, the NRRP, and the NRAs. DRM in Croatia is governed by the DRM Strategy, which outlines key priorities for future action, alongside other relevant

⁵⁸ GoC 2019b, [Link](#).

⁵⁹ For the DRM Strategy, see GoC 2022b. The strategy was drafted in line with the Act on the System of Strategic Planning and Development Management of the Republic of Croatia (Official Gazette, 123/17).

laws and legislation. Several projects related to earthquake risk are proposed, including the development of a national platform for the Croatian Center for Earthquake Engineering (CCEE). The establishment of the CCEE was realized in 2021 after the 2020 earthquakes, as part of the University of Zagreb's Faculty of Civil Engineering. The CCEE supports authorities in disaster preparedness, reduces seismic vulnerability, and enhances response capacity. It provides expert technical assistance for disaster response and risk mitigation activities. Over time, the CCEE is expected to expand its role, aligning with the civil protection system's needs, and become a center of excellence in seismic risk reduction. During the response phase in 2020, CCEE's Intervention Service (CCEE-IS) conducts damage assessments, supervised disaster response facilities, and collaborates with the Civil Protection Headquarters. It also provides its data and platforms to relevant institutions for risk management and mitigation activities. Beyond operational tasks, CCEE-IS works to raise public awareness of earthquakes and other risks, connecting experts in earthquake engineering to enhance the profession through unified methodologies, knowledge sharing, and digitalization. The benefits of integrating expertise are already evident in new developments, where the government plans to introduce a seismic certificate, as the CCEE is helping create a database of building structures and monitoring infrastructure in Zagreb and Sisak-Moslavina County. The proposal is to introduce a seismic certificate to assess the mechanical stability and resistance of public buildings, similar to the existing energy certificate, as part of the new Construction Act expected 2025-2026.

Climate change agenda

Croatia is making efforts to address the impact of climate change. The Act on Climate Change and the Protection of the Ozone Layer, was approved in 2025, and the Climate Change Adaptation Strategy in 2020. The institutional framework for climate change adaptation/energy efficiency is similar to the DRM institutional framework. The main institutions include the government, regional and local stakeholders, and representatives of various scientific, educational, and other institutions, such as non-governmental organizations. Under the NRRP, €1,978 million has been allocated for energy efficiency and post-earthquake reconstruction of buildings (Box 4). Croatia has also taken several steps specifically related to ensuring energy efficiency, which have been reflected in the policy and legal framework, as described in Chapter 3. The climate-proofing of infrastructure is at a very early stage of implementation, however, and further technical capacities, data, and multidisciplinary collaboration will be required to include it in building codes and spatial plans.

⁶⁰ GoC 2024. [Link](#).

⁶¹ GoC 2020a, [Link](#). . The National Recovery and Resilience Plan is discussed further in section 3.2 (Box 5).

⁶² EC 2023c, [Link](#).



2. SEISMIC REGULATION IN CROATIA

This chapter provides an overview of national and EU-level regulation related to seismic risk. It identifies key challenges and opportunities to improve the framework with several international examples.

2.1. Overview of the framework

The legal system for seismic structures in Croatia (as the country is known today) has its foundations in the legal system of the former Yugoslavia, whose seismic risk was quite high. Prominent in the current building code was the 1963 magnitude 6.1 earthquake that occurred in Skopje in present-day North Macedonia. Following the 1963 earthquake, decision-makers, academics, and engineers in the former Yugoslavia and globally took measures that recognized the devastating and complex impact of earthquakes. As in Japan, reinforced concrete (RC) became the norm. As of the 1970s, the former Yugoslavia mandated that all buildings be built with RC, among others. This law was put to the test by the 2020 earthquakes in Croatia, where buildings built before the post-1963 standards did not withstand the earthquake, while buildings built according to the standards had considerably less damage.

Despite the moderate to high seismicity of Croatia, no seismic codes for the design and construction of buildings were in place until 1948, when the Provisional Technical Regulations for Building Loading were passed. However, the first seismic code (National Provisional Technical Regulations for Construction in Seismic Regions) appeared in 1964 after the devastating 1963 Skopje earthquake. The evolution of the application of various seismic codes, along with the general features of the buildings built in the specific periods, is shown in [Table 3](#). Nowadays, as in most European Union (EU) countries, Eurocode standards are applied to the structural and geotechnical design of buildings and infrastructures, and their obligatory use is implemented through the Technical Regulation for Building Structures passed in March 2017. [Table 3](#) also provides the estimated seismic lateral load in relation to the current (Eurocode 8) seismic loads.

⁶³ For older-generation rules for the design of earthquake-resistant constructions, see Croatian Center for Earthquake Engineering (HCPI), “Seismological Maps (Separate Area of Central Croatia)” [Seizmološke Karte (Izdvojeno Područje Središnje Hrvatske)], [Link](#).

⁶⁴ See Shendova, Apostolska, and Sesov (2023, [Link](#)).

⁶⁵ For an example from Australia, see Sinadinovski and McCue. 2013, [Link](#).

⁶⁶ Government of Yugoslavia (GoY) 1948, GoY 1964, GoY 1981 [ORL reference list].

Table 3. Overview of Seismic Codes with Description and Specific Characteristics

	Until 1948	1948–1964	1965–1981
Description of standards	Without standards	Provisional Technical Regulations for Building Loading	National Provisional Technical Regulations for Construction in Seismic Regions
Motivation for change of the previous standards			1963 Skopje earthquake
Seismic resistance of buildings (rough division according to structural type and analysis method)	Buildings with an initial level of seismic resistance (mainly masonry buildings with wooden floor systems, introduction of RC floors since 1920)	Buildings with a minimal level of seismic resistance (mainly RC floors, masonry without confinement, etc.)	Buildings with a low level of seismic resistance (confined masonry buildings, RC residential buildings, etc.)
Structural analysis (lateral load)	Earthquake was not taken into account as a load, but horizontal wind load was taken into account	Earthquake was taken into account by simplified methods (e.g., force on the top of the building)	First regulations for earthquake resistance design (seismic map from 1964)
Seismic load	Up to 5% of the relevant load	Up to 10% of the relevant load	30–50% of the relevant load
Identified deficiencies	Aging of materials, events throughout history (earthquakes, fires, etc.), insufficient initial resistance, exceedance of the designed life of 50 years, poor maintenance, particularly endangered	Structures not adapted for resisting horizontal forces, poor construction quality, bad details, questionable calculations	Structures designed for a much lower earthquake force, damage much greater than predicted (possible collapse), poor quality of materials, poor details, incomplete calculations, etc.

1982–1998	1998–2012	2013–today
Technical Regulations for Building Construction in Seismic Regions	Transitional period: gradual introduction of ENV regulations (Eurocode 8)	Current regulation EN (Eurocode 8)
1979 Montenegro coast earthquake		
Buildings with a medium level of seismic resistance (buildings with confined masonry, RC frame structures, etc.)	Buildings with a high level of seismic resistance (masonry, concrete, steel, wood, etc.)	
Regulations, amendments, and annexes to regulations for earthquake resistance design (simple rules, preliminary seismic map from 1981, and seismic map from 1988)	Development and gradual introduction of modern regulations for earthquake resistance design (simple rules, complex calculation), increase in design load	European Standards for Seismic Resistance Design (complex calculation), map of seismic areas from 2011
30–50% of the relevant load	75–100% of the relevant load	100% optimal
Structures designed for a lower earthquake force, damage greater than expected, illegally constructed buildings, modifications of residential spaces (storefronts), unprofessional additions and reconstruction (additional floors), bad details etc.	Structures mostly designed for a lower earthquake force, damage greater than expected, illegally constructed buildings	Complex, poorly designed buildings

Source: Šavor Novak et al. 2021 . Note: RC = reinforced concrete.

2.2. National framework

Legal framework

In Croatia, the legislation related to construction consists of legal rules that govern construction and building activities. Such laws are divided into public laws, which address relations between legal and natural persons and state or legal entities with public power, and private laws, which address natural and legal persons, in accordance with the principle of equality. The relevant building and construction regulations at national and EU level can be found in Annex 1. The key regulations are in [Box 2](#).

Box 2. List of Key Seismic Regulations in Croatia

- Croatian Building Code [Zakon o gradnji] (Official Gazette [153/13](#), [20/17](#), [39/19](#), [125/19](#), [145/24](#))
- Technical Regulation on Amendments to the Technical Regulation for Building Structures (Official Gazette NN 7/2022)
- Law on Reconstruction of Earthquake-Damaged Buildings in the City of Zagreb, Krapina-Zagorje County, Zagreb County, Sisak-Moslavina County and Karlovac County (Official Gazette [102/20](#), [10/21](#), [117/21](#), [21/23](#))
- Program of Measures for the Reconstruction of Earthquake-Damaged Buildings in the City of Zagreb, Krapina-Zagorje County, Zagreb County, Sisak-Moslavina County and Karlovac County (Official Gazette [28/23](#))

Source: Authors.

Croatian Building Code

The Croatian Building Code (Zakon o gradnji) regulates all construction in the territory of Croatia, excluding structures and facilities (such as those related to mining or the military) that fall under special regulations. The building code serves as the framework for construction law and its enforcement in the country, and it sets forth the minimum requirements for structural design and construction. According to the code, all designs must adhere to Eurocode 8 (described in the subsequent section referring to the EU framework). Since any changes made to a structure are considered modifications to the Basic Building Requirements, as stated in Article 6, upgrading the structure following an earthquake requires obtaining a new building permit. This, in turn, necessitates compliance with Eurocode 8. In Croatia, nearly 90 percent of the existing building stock needs significant changes to achieve compliance. The building code links to the Long-Term Strategy for National Building Stock Renovation by 2050, which includes analysis of policies and measures to improve fire and earthquake resilience for buildings undergoing major renovations. The building code also transposes EU laws relevant to construction and energy efficiency, including, among others, Directive 2010/31/EU on the energy performance of buildings and Directive 2021/27/EU on energy efficiency. The law further provides for other provisions, including inclusivity considerations.

⁶⁷ GoC, 2019a, [Link](#).

⁶⁸ GoC, 2020d, [Link](#)

⁶⁹ GoC, 2019a, [Link](#).

⁷⁰ See GoC, 2019b, [Link](#).

The Law on the Reconstruction of Earthquake Damaged Buildings

After 2020, the Croatian community and the authorities became more aware of the earthquake risk, and a series of new laws on post-earthquake reconstruction was enacted. Following the March 2020 earthquake near Zagreb, Croatia introduced a new legal and institutional framework for reconstruction. The Law on the Reconstruction of Earthquake-Damaged Buildings in the City of Zagreb, Krapina-Zagorje County, and Zagreb County was adopted in September 2020; the law was extended to Sisak-Moslavina County and Karlovac County in January 2021, following the December 2020 earthquakes (Official Gazette 102/20, 10/21). The currently valid Act on Reconstruction of Earthquake-Damaged Buildings in the City of Zagreb, Krapina-Zagorje County, Zagreb County, Sisak-Moslavina County, and Karlovac County was passed in February 2023 (Official Gazette 21/23). In addition, the Program of Measures for the Reconstruction of Earthquake-Damaged Buildings was passed in order to facilitate the implementation of the act; it established the method and procedure for the restoration or removal of buildings damaged or destroyed during the 2020 earthquake. Several formal decisions and ordinances passed by the authorities also aimed at regulating the reconstruction process.

The law covers the rehabilitation and reconstruction of both public and private buildings and contains assessment categories for renovation of earthquake-affected buildings in relation to mechanical (structural) resistance and stability for areas of the City of Zagreb, Krapina-Zagorje County, Zagreb County, Sisak-Moslavina County, and Karlovac County. Four levels of rehabilitation and reconstruction are established under the law: (i) repair of nonstructural building elements required for legal use and occupancy of a building, (ii) repair of structural elements, (iii) upgrade of structural elements, and (iv) full rehabilitation and reconstruction. The most important objective of the law is to simplify and speed up the procedures for construction and reconstruction of buildings and thus facilitate the rehabilitation/ reconstruction of damaged buildings, i.e., ensure that citizens can return to their homes as soon as possible. It should also be noted that this law is not applicable to the buildings in Zagreb and the surrounding counties that have been marked with a green label (meaning that the building is usable); only the Building Code or the Ordinance for Simple Buildings can be used with green label buildings.

Technical Building Regulation (Official Gazette 17/17, 75/20, 7/22)

The Technical Regulation for Building Structure (Official Gazette 17/17, 75/20, 7/22) is part of the framework for fulfilling the basic requirements for construction. It prescribes the technical properties for construction of structures; the requirements for design, execution, maintenance, and removal of building structures; the properties that building products must have in relation to their essential features; and other requirements for building products intended for installation in building structures. The Technical Regulation for Building Structures was amended twice after the 2020 earthquakes in order to include the post-earthquake retrofitting of structures. The post-earthquake retrofitting was defined through four levels. The lowest one considers only the repair of nonstructural elements. The second level refers to repair of building structures in order to restore the level of seismic resistance that a structure had before the earthquake, or to increase the level with local reinforcements of critical load-bearing elements (and exceptional addition of new load-bearing vertical elements). The third level is aimed at strengthening of structures, while the fourth level requires a structure to be strengthened so that it is able to resist seismic loads in accordance with valid seismic standards (as already mentioned, the Eurocode 8 is applied for the design of structures for earthquake resistance; the standard Eurocode 8-3 is therefore applied for the assessment and retrofitting of buildings in Croatia). The minimum significant damage index (SDI), defined as the ratio of the design seismic resistance to the

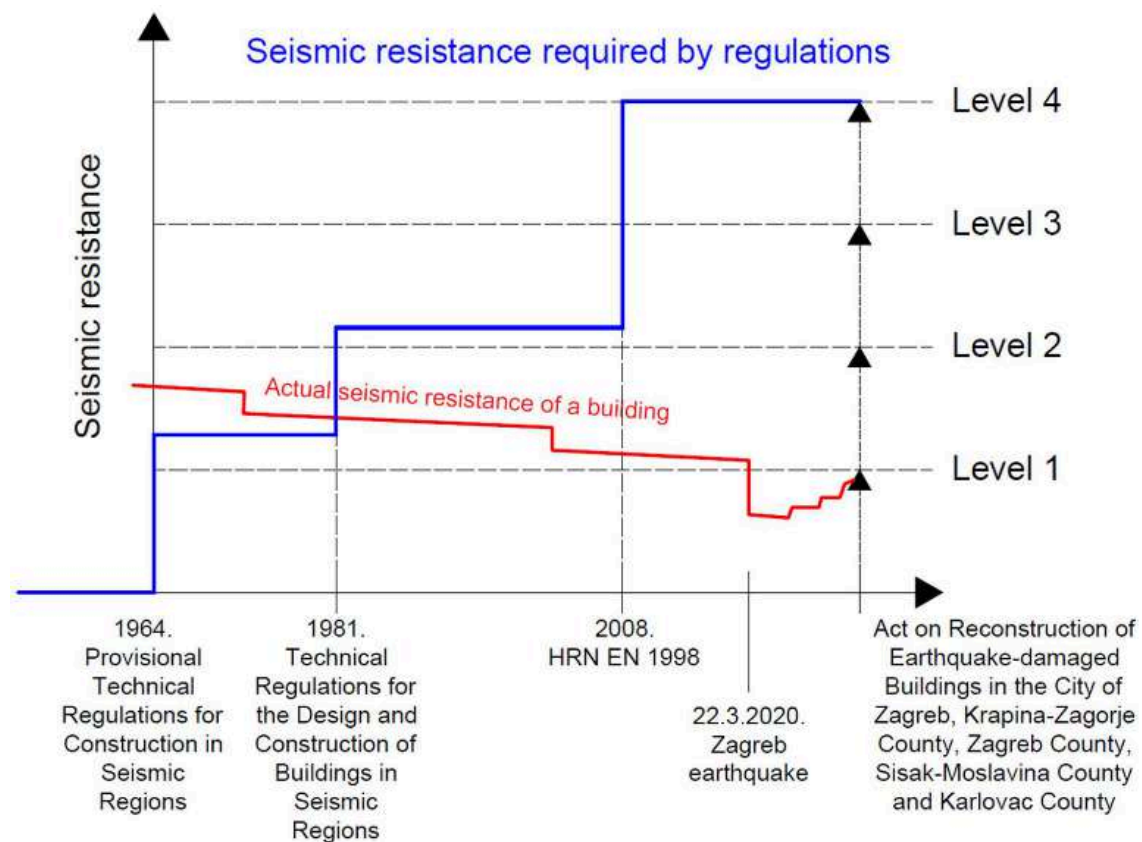
⁷¹ The Ministry of Physical Planning, Construction, and State Assets, the Fund for Reconstruction, and the Center State Office for Reconstruction and Housing are the three leading institutions for earthquake reconstruction.

⁷² GoC 2021c, [Link](#).

⁷³ The law includes provisions for independent peer review of designs by certified professionals.

structural requirement for the limit state of significant damage, is specified for level 2 ($SDI_{min} = 0.5$), level 3 ($SDI_{min} = 0.75$), and level 4 ($SDI_{min} = 1.0$). Figure 2 schematically presents the retrofitting levels in relation to the actual level of the building's seismic resistance.

Figure 2. Schematic Representation of the Retrofitting Levels in Relation to the Actual Level of the Building's Seismic Resistance



Source: Salaman et al. 2022, [Link](#).

Related to critical infrastructure, Croatia has taken the first step in transposing Directive (EU) 2022/2557 on the resilience of critical by adopting the Law on Critical Infrastructure (Official Gazette NN 89/2025-1232). In line with the provisions of this law, additional steps remain to be taken by the Government to ensure full alignment and effective implementation. Critical infrastructure is defined as “an asset, facility, equipment, network or system, or part of an asset, facility, equipment, network or system, that is necessary for the provision of an essential service.”

2.3. EU framework

Given the susceptibility of the EU and its Member States to earthquakes, in particular Italy, Greece, Romania, and Croatia, the EU regulates seismic resilience through different instruments. Croatia has transposed EU laws, including all relevant EU building laws, but faces challenges for buildings that were built before EU laws were transposed. During the 2020 earthquakes, buildings that were newly built in accordance with EU laws and building codes in force since 1964 suffered little to no damage.

The EU has developed a number of directives that set out requirements for the construction, performance, and energy efficiency of residential buildings. These directives aim to improve the quality and sustainability of residential buildings and to reduce the environmental impact of the construction sector. Relevant EU laws related to energy efficiency are described below.

⁷⁴ GoC 2025, [Link](#).

Eurocodes

The Eurocodes are a set of standards related to construction; they apply to the structural design of buildings and other civil engineering works and include geotechnical aspects, structural fire design, situations including earthquakes, execution, and temporary structures (Figure 3).

Pursuant to Article 42 of Directive 2014/24/EC, a contracting authority may not reject a tender for works, products, or services that comply with a national standard transposing a European standard. It should be noted that the European Commission is in the process of revising and preparing the second generation of the Eurocodes, to be published by 2026.

Figure 3. The Eurocodes and the European Standardization System



Sources: Left chart: European Commission, “EN Eurocodes and Related Standards,” [Link](#) ; right chart: JRC 2008, [Link](#) .

⁷⁵ For EN Eurocodes, see: “Recommendation Related to the EN Eurocodes,” [Link](#); “Construction Products Regulation,” [Link](#); the Directive on public procurement, available at [Link](#); the Directive on services, [Link](#); Directive on the provision of information in the field of technical standards and regulations, available at [Link](#).

⁷⁶ EU 2014, [Link](#). [KEUL reference list].

⁷⁷ EC, “Eurocodes: Building the Future. 2nd Generation,” [Link](#).

Eurocode 8 (EN 1998): Design of structures for earthquake resistance

Eurocode 8 provides standards for the design of structures for earthquake resistance. It applies to the design and construction of buildings and other civil engineering works in seismic regions. Its purpose is to ensure that, in the event of earthquakes, human lives are protected, damage is limited, and structures important for civil protection remain operational. Eurocode 8 consists of six parts: (i) EN 1998-1:2004: general rules, seismic actions and rules for buildings; (ii) EN 1998-2:2005: bridges; (iii) EN 1998-3:2005: assessment and retrofitting of buildings; (iv) EN 1998-4:2006: silos, tanks, and pipelines; (v) EN 1998-5:2004: foundations, retaining structures, and geotechnical; and (vi) EN 1998-6:2005: towers, masts, and chimneys.

Protection of CI

The EU adopts an all-hazards approach in order to increase the resilience of CI and reduce countries' vulnerabilities. This approach relies on regulations that aim to ensure an adequate level of protection and to limit disruptions to CI as much as possible. The basis for the protection of CI at EU level was the former Directive 2008/114 on European critical infrastructure. But the 2019 evaluation found that operations using CI were increasingly interconnected and cross-border in nature, and that protection of individual assets alone was insufficient to prevent all disruptions from taking place.

In 2022, Directive 2008/114 was repealed by Directive 2022/2557 on the resilience of critical entities, which aims to reduce the vulnerabilities and strengthen the physical resilience of CI. EU Member States are responsible for transposing the directive, and the subsequent legal rules and measures, into national law, and for adopting a strategy for strengthening the resilience of critical entities. The Critical Entities Directive 2022/2557 specifies obligations for Member States and critical entities to ensure that essential services—those that are vital for societal functions and economic activities—are unobstructed in the internal market. Member States are required to identify critical entities and support them in meeting their obligations to enhance their resilience and their ability to provide services. Directive 2022/2557 establishes rules for the supervision and enforcement of critical entities and for the identification of critical entities of European significance. It also establishes common procedures for cooperation and reporting. Its overall goal is to achieve a high level of resilience for critical entities in order to ensure the provision of essential services and improve the functioning of the internal market.

⁷⁸ Special structures, such as nuclear power plants, offshore structures, and large dams, are beyond the scope of EN 1998. EN 1998 contains only provisions that, in addition to the provisions of the other relevant EN Eurocodes, must be observed for the design of structures in seismic regions.

⁷⁹ EC 2022c, [Link](#).

⁸⁰ See EU, 2008, [Link](#). [KEUL reference list].

⁸¹ See EU, 2022, [Link](#). [KEUL reference list].



2.4. Key challenges

Gaps in risk knowledge

Before the 2020 earthquakes caused extensive damage to buildings in the public sector, Croatia had done little to address the risk to public buildings and to improve the models needed for reliable earthquake risk assessment. Before the 2020 earthquakes, there were only small-scale initiatives that made minor contributions to knowledge about seismic risk assessment, e.g., the microzonation of the northern part of Zagreb and analysis of characteristic types of buildings in Zagreb. In other parts of Croatia, the few individual initiatives (e.g., Split, Osijek) lack a comprehensive/systematic approach. But the 2020 earthquakes pushed the implementation of a pilot project, Seismic Risk Assessment of the City of Zagreb, which is expected to make a major contribution to seismic risk knowledge in Croatia. The project processes all available data about hazard and envisages the creation of an exposure database (on buildings). Finally, state-of-the-art risk calculations will be made available (at the end of 2023), and the results could form the basis for strategic decisions, dimensioning of intervention forces, and strengthening of key buildings.

Croatia is also beginning efforts to address gaps in knowledge about CI. Currently, Croatia does not have a defined list of CI buildings, though one is being prepared by the MoI as part of implementation of the new Law on Critical Infrastructure. This step, along with seismic risk analyses, is critical to make strategic decisions and prioritize rebuilding efforts. Given these knowledge gaps and the importance of CI buildings, the Croatian Center for Earthquake Engineering, which was formed after the 2020 events, is advocating for a national strategic project to analyze CI buildings and propose targeted (optimal) strengthening.

Lack of harmonized laws

The current laws related to seismic risk reduction in buildings are not harmonized nor adequate for handling earthquake upgrades:

- The Reconstruction Law relates only to damaged buildings in specific counties (namely, those affected by the 2020 series of earthquakes). Furthermore, buildings without yellow or red usability labels are not eligible for seismic upgrading. As a result, high-risk buildings—for example, in Dubrovnik—cannot be rehabilitated or reconstructed through this law. Similarly, a building owner who wishes to conduct an earthquake upgrade, say, in Split, needs to follow the standard building permit procedure, which is complex, expensive, and time consuming. Lightly damaged buildings in Zagreb are similarly limited. Considering the seismic hazard map displayed in [Figure 1](#), there is a gap in the legal framework to address areas of high earthquake risk, portrayed in red.
- The building code mandates that all buildings adhere to Eurocode 8. Since older buildings in highly risky areas, especially cultural heritage buildings, may not be able to meet the standards set by Eurocode 8 for new buildings, upgrading them may not be practical. Even if interest exists in rehabilitating or reconstructing these buildings, doing so may not be feasible unless they have already been damaged.
- The Ordinance for Simple Buildings permits only minor modifications, such as energy efficiency improvements, interior changes, backyard modifications, and installation of solar panels. This rules out a comprehensive solution that includes seismic or fire safety interventions at the same time a building is undergoing energy efficiency upgrades. For any such additional modifications, the building owner needs to follow the process outlined in the Croatian Building Code. In practice, this means an owner making energy efficiency improvements can avoid making the other upgrades by utilizing the Simple Buildings Ordinance to streamline the process and avoid unnecessary bureaucracy.

- For energy efficiency interventions, builders are currently under no obligation to provide documentation or proof that a building is structurally sound or compliant with building standards, such as the Eurocode standards for new buildings or other standards for older buildings. As a result, similarly, in practice, building owners tend to prioritize energy efficiency upgrades.

The overall result of this regulatory inconsistency is a lot of missed opportunity to invest in seismic risk reduction.

Gaps in legal framework

While the Croatian legal system has learned from disasters, the breadth of international experience must inform the legal system as well. In general, changes and improvements to regulations are being made at the EU and global level, but promptly adapting these at the national level can be challenging. Experience showed that structures built in the 1970s, after the Skopje earthquake, were able to better withstand the 2020 earthquakes than earlier structures. Nonetheless, there are still gaps in the legislation related to seismic resilience, and these should be addressed to ensure a more resilient Croatia. Enforcement of the laws remains a problem. For example, laws requiring the inspection of buildings and use of reinforced concrete are sometimes ignored. This situation makes buildings more hazardous.

The regulatory framework should also facilitate seismic assessment of existing buildings and be clearer about what they entail. The seismic assessment of existing buildings almost inevitably implies extensive investigative work (in situ inspections). This work can be very difficult to carry out given its many requirements and its high cost. As a result, in situ inspections are often avoided. But the lack of knowledge of a building's properties ultimately increases the cost of any retrofit, because the designer resorts to making decisions "on the safe side" (insuring against liability), rather than based on specific knowledge of what is needed.

The 2020 earthquakes exposed various legal barriers to and gaps in post-disaster response. Following the earthquakes, Croatia needed to pass various laws in order to commence the recovery and reconstruction process. There is a need to ensure the availability of public funds and public procurement plans. The need for legislation resulted in a stalemate, particularly in earthquake-affected areas, where the way forward was uncertain for local authorities and communities. The provision of public services in Croatia is fragmented and greatly affected by the lack of adequate financial and administrative capacities in local governments, leading to significant disparities in public service delivery. Disaster preparedness should include legal planning so that aid can be quickly and efficiently disbursed in the event of a disaster. A current gap in the law is the failure to define if engineers can legally enter a building, what data they are allowed to collect, and how these data should be handled in the subsequent assessment/recovery planning processes.

Ensuring compliance with seismic and other disaster-related standards in infrastructure has been identified as a challenge. In Croatia, for instance, independent supervision services are supposed to be mandatory for all types of construction projects during the construction phase, with a technical examination to be conducted at the end of the process to ensure everything has been done according to the design, building permit, and applicable standards. Compliance with these provisions has been inconsistent, however, because of lack of enforcement. Although the Croatian Ministry of Planning is responsible for overseeing the quality of works through laws, standards, and regulations, no specific agency is currently designated to conduct the necessary quality control checks.

Ensuring inclusivity and accessibility in new buildings is mandatory, while for existing buildings, particularly older and public ones, accessibility and disaster resilience improvements are less consistently required and can be complex, with evolving regulations set to enhance standards by 2025. The accessibility of buildings for persons with disabilities is regulated by the Building Code and

the Ordinance on Ensuring Accessibility of Buildings for Persons with Disabilities and Reduced Mobility, which outlines obligations for both new constructions and the adaptation of existing buildings during their reconstruction. In new buildings, compliance with the Ordinance for Disabled Persons is mandatory for all designer's, ensuring accessibility is embedded within the design framework, with issues typically arising only from design errors. For existing buildings undergoing upgrades, accessibility improvements are usually not included in the scope, even when installing elevators, and overall accessibility is not guaranteed. However, specific provisions exist to ensure uninterrupted access, movement, and use of public and business buildings by individuals with disabilities, with minimal disruption to the building's function, and often without the need for a building permit. In cases where existing buildings, particularly public ones, sustain earthquake damage, accessibility upgrades are generally not required unless the building undergoes *Cjelovita obnova* (comprehensive/overall reconstruction), where such upgrades may be considered but are not mandatory. Ensuring accessibility in older or public buildings can be complex, expensive, and sometimes infeasible, depending on the specific circumstances and the scope of the works. As of January 2023, a new Technical Regulation on Accessibility was introduced to align with EU Directive 2019/882, which will come into effect in June 2025, replacing the current Ordinance. It is suggested that for public buildings, accessibility, particularly for evacuation, should be a mandatory consideration during reconstruction or upgrades.

Gaps in housing stock and land register

The reconstruction and recovery program launched after the March 2020 earthquake and adapted after the December 2020 earthquake also revealed challenges with the housing stock and land register. The program found that some structures had been built without the necessary building approvals/permits. The Act on Proceeding with Illegally Built Buildings (Official Gazette 86/12, 143/13, 65/17, 14/19) had legalized a large number of such buildings, without considering stability and earthquake resistance. A potential solution for this permitting issue is to allow buildings to be built without a permit, but in accordance with the building code, a finite period of time to legalize their development properly and thus gain access to reconstruction funds. The Ministry of Justice and Public Administration and the State Geodetic Administration have introduced the Joint Information System, which contains harmonized land data (registry/cadaster) now linked with five government databases, making land and other geospatial data more widely and easily accessible.

Another problem identified by the reconstruction program concerns ownership. Under the current inheritance law, it is not always possible to identify a "full" owner; in some cases, ownership is divided—for example, it could be split between siblings after the passing of a parent. In this case, agreement is needed from all owners to conduct renovation works.

The housing challenges that arose after the 2020 earthquakes have also had effects on the real estate market, which was already dealing with rising prices and lack of affordability. Because a significant portion of the available housing stock is not earthquake resistant—a crucial consideration for many home buyers when deciding on a purchase—the European Commission 2023 Country Report found that sales had declined.

Awareness among decision-makers

Experience shows that it is sometimes difficult to make seismic resilience a national priority. For example, EU countries at high earthquake risk have struggled to highlight earthquakes as an important element of the system, i.e., to raise awareness of earthquakes among Member States whose risk of earthquakes is low. It took a series of devastating earthquakes with catastrophic consequences to raise

⁸² GoC. 2013. [Link](#).

⁸³ GoC. 2023. [Link](#).

⁸⁴ EC 2023a, [Link](#).

awareness significantly and broadly; but this appears to be a common process that is repeated over and over again. Croatia is an example of a smaller country with limited capacities that has to carefully allocate funds when preparing the state budget (choosing from a number of priorities) and that depends on financial resources from the EU. For this reason, a broad awareness of earthquake risk is very important to Croatia.

Croatia has no authoritative institution to provide expert oversight of seismic improvement processes at the state level. The Institute of Earthquake Engineering and Engineering Seismology in North Macedonia takes care of all processes related to earthquakes and continually contributes to improvements in the system. As part of the eligibility check for energy efficiency investments under a World Bank-financed project entitled the Public Sector Energy Efficiency Project in North Macedonia, IZIS was responsible for the seismic screening of buildings. In the former Yugoslavia, IZIS was also responsible for the territory of Croatia. When the Croatian state was established, authorities failed to create such an institution, and in the course of time authorities "forgot" about earthquakes. It is crucial to have such an institution to ensure that decision-makers become aware of the risk and take responsibility for its mitigation.

Public awareness and incentives for actions

Given the level of awareness about seismic risk and the financial capacities of the state, it is crucial to encourage citizens to invest in seismic strengthening as part of other processes encouraged by the state. In the absence of tax incentives at the state level, new incentives are needed to motivate citizens. These incentives can be included as part of the tender for energy renovation—that is, including seismic renovation activities that could improve the evaluation score that forms the basis for obtaining financing. Considering that major renovations show long returns with over 40 years—over 60 years in some cases in Croatia—highlights the need to develop a sustainable program and financing instrument. Currently, seismic renovation is only recommended rather than required; but if it becomes a state priority, it will be necessary to clearly evaluate (score) the activities that increase the seismic resistance of buildings.

Training of experts related to existing/historic buildings

There is a great need to close technical gaps in Croatia by improving the technical education and training of engineers and designers related to older buildings (especially historic or traditional ones). In general, regulations for new buildings are well known by practicing engineers, supported by programs at civil engineering faculties, and generally followed on construction sites. However, there are many significant differences between existing buildings, especially historic ones, and modern buildings, and these must be considered when designing, reconstructing, rehabilitating, or retrofitting buildings. The vast majority of the building stock in Croatia consists of older buildings; new buildings represent less than 10 percent of the building stock. Yet the curriculum at the civil engineering faculties focuses almost solely on new buildings—older buildings are not a focus of the civil engineering program and indeed are rarely mentioned. This omission has created several challenges in the post-2020 earthquake context.

In conducting post-2020 earthquake field inspections to determine building damage and usability, engineers did not properly recognize the structural (load bearing) system/elements. Because of this gap in training, ad hoc efforts to train experts had to be quickly undertaken. For practical purpose, as part of Rapid Damage and Needs Assessments, a safety level assessment was conducted in line with the Post-earthquake Damage and Safety Assessment and Short-Term Countermeasures (AeDES) methodology.

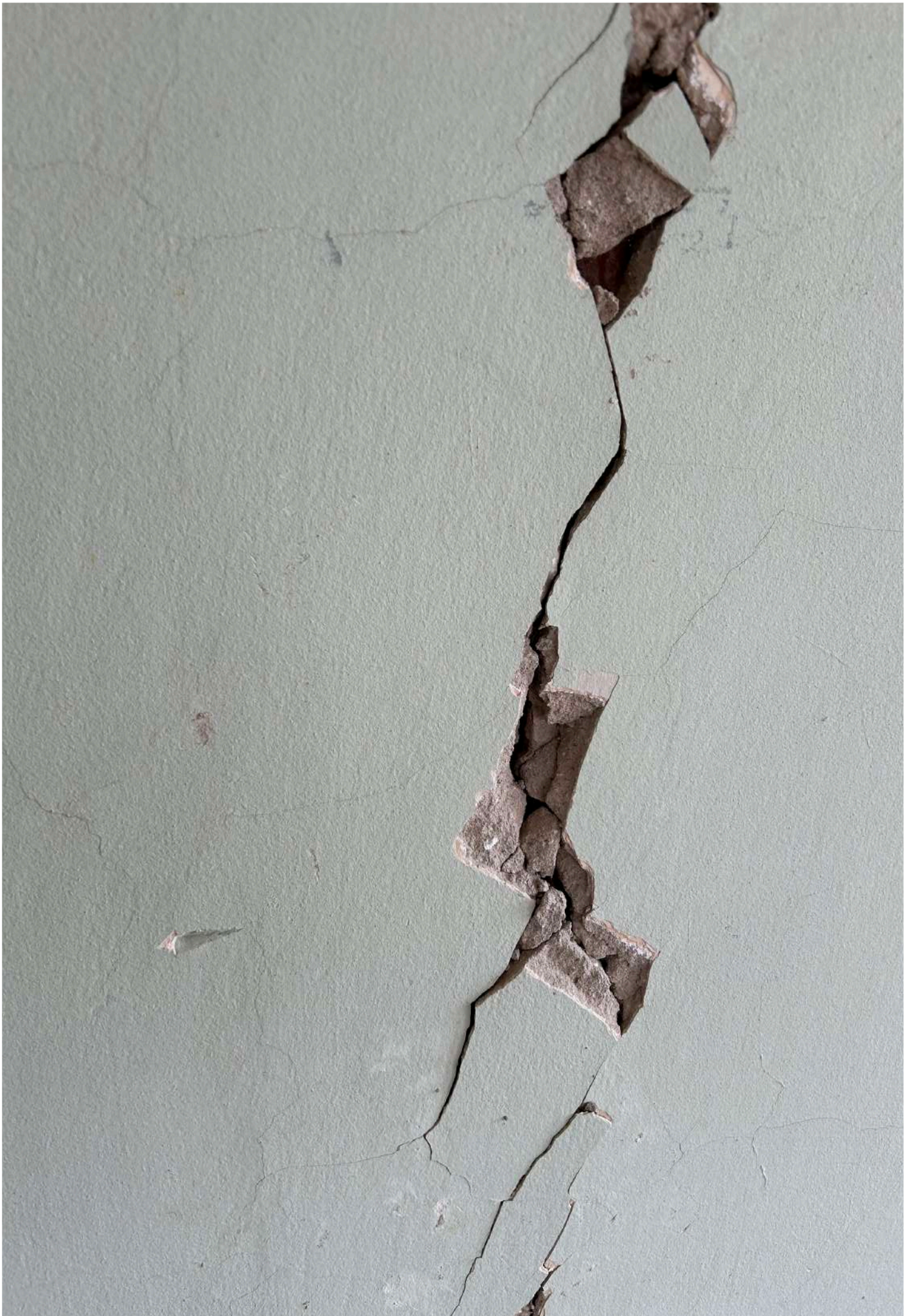
⁸⁵ See Taucer and Pinto Vieira. 2007, [Link](#).

Moreover, the regulations for assessing and retrofitting buildings have become more complex and have not caught on in practice. After the 2020 earthquakes, most construction market demand was for the retrofitting and reconstruction of structures, and the capacity among engineers was low. A campaign was launched to train engineers so they could participate in the retrofitting of buildings. The aforementioned shortcomings in the regulation of seismic resilience should be addressed with the ongoing legislative revision and the new Eurocodes, which will adopt good practice and lessons learned from Italy's experience with reconstruction after earthquakes. However, as new regulations are transposed into Croatian national law, the application of the updated Eurocode will require additional capacity building for practicing engineers, because it will contain many new/different approaches.

The retrofitting of historic buildings is especially complicated. After the Zagreb 2020 earthquake, for example, some designers made the error of interpreting "partition walls" (walls of lesser thickness) as referring to non-load bearing (nonstructural) walls, although they play an important role in ensuring the stability of buildings. A different approach to retrofitting such buildings is needed, including adjustments on the part of designers, who must be open to acquiring new knowledge. Historic buildings, for instance, often require nonlinear analyses, which had not been common practice in Croatia and only began to be used with any frequency after the 2020 earthquakes. Technical training on this topic is crucial for professionals involved in retrofitting, including architects, civil engineers, and experts in heritage protection. Involving the Ministry of Culture in the process and the training is also essential, as challenges related to the protection of cultural heritage have been impeding the earthquake reconstruction process. Without such expertise and proactive measures, any earthquake reconstruction (for example, in Split or Dubrovnik) is impossible, because the structural systems of historic buildings often differ significantly from those of modern structures. In the EU, countries such as **Italy** and **Portugal** have instituted programs that specialize in dealing with historic buildings, and Croatia should follow suit.

The lack of (adequate) documentation, valid designs, or input data for analyses is a problem in Croatia. Because of this deficit, structural analyses—such as those performed in the initial phase of reconstruction—are often flawed (based on numerous assumptions); hence the need in the execution phase to make continual adjustments because of "newly discovered" facts (e.g., undocumented past reconstruction). Designers are then forced to make difficult engineering decisions, often based on unreliable data; this situation is especially challenging if engineers have not received adequate training. A similar challenge is presented by cultural heritage buildings, as standards and guidelines for their renovation are lacking. Projects are often left to the individual interpretation and opinions of the evaluation expert, which leads to inconsistencies in the solutions implemented and significantly prolongs the process.

Linked to this issue is a gap in the certification of seismic professionals. Given the importance of mitigating seismic risks, a certification process for professionals involved in quality assurance is essential. Currently, certified engineers and architects who specialize in seismic protection for buildings and civil infrastructure are few, and the insufficient capacity in this area has been a matter for concern. It is worth noting that while Croatia has certified engineers and architects who specialize in building and infrastructure design, no specific branch within the civil engineering or architectural profession is certified solely for seismic protection. Additionally, an effective mechanism is needed to suspend the professional licenses of certified professionals who fail to comply with the provisions of the law and normative documents related to construction.



2.5. Global good practices and lessons learned

Preventive investments in resilient infrastructure make clear economic sense and deliver multiple benefits by protecting lives and assets, avoiding disruption of services, and creating various developmental co-benefits. Many countries in seismically active areas of the world have prioritized mitigating the earthquake risk of important public buildings through improved understanding of seismic risk and efforts to decrease seismic vulnerability.

Example from Italy

LINKING RISK INFORMATION AND FINANCING RISK REDUCTION

As one of the European countries impacted by devastating earthquakes in recent decades, Italy has been investing in improved analytics and seismic risk reduction. Following the destructive 2009 L'Aquila earthquake, Italy launched a National Seismic Prevention Plan (NSPP) that aimed to reduce human losses during earthquakes and to incentivize private owners and administrators to reduce seismic risk. The NSPP focuses on three areas: (i) seismic microzonation studies and analysis of the limit condition for emergency to support territorial governance and emergency planning; (ii) seismic retrofit and reconstruction of public buildings and infrastructure of strategic interest or infrastructure deemed critical given the consequence of its collapse; and (iii) seismic upgrading and reconstruction of private buildings.

As part of the effort to improve knowledge of seismic risk, studies were carried out on urban and emergency planning to ensure that civil protection plans accounted for the vulnerability of the strategic elements and the interconnection routes. Numerous research studies were also carried out by top research centers and networks, such as RELUIS and EUCENTRE, in cooperation with the civil protection authorities. Data on damage from earthquakes was collected and systematized in the DaDO database, allowing researchers to calibrate their vulnerability models and validate them based on real data. The development of centers of excellence, especially the RELUIS consortium, provided the opportunity to involve a large number of researchers in earthquake vulnerability and risk research as the basis for a harmonized and advanced earthquake risk assessment of Italy. Based on numerous studies, Italy has launched WebGIS (geographical information system) platforms for earthquake risk assessments of different building types.

In terms of risk reduction investments, interventions affecting more than 1,000 buildings have been financed through Italy's NSPP. Seismic retrofit intervention types include local strengthening, seismic upgrading, and demolition and reconstruction; work takes place in compliance with the Italian National Technical Standards for Construction, issued in 2008 and updated in 2018. Importantly, the NSPP allocated financial resources to higher-risk municipalities—that is, those where the 475-year return period peak ground acceleration on stiff soil exceeds 0.125 g. Regarding renovation of private buildings, a number of incentives are available to private owners; the Sismabonus incentive, for example, offers a tax deduction equal to the expenses incurred in strengthening buildings in seismic zones 1–3.

⁸⁶ ODI and WB 2015, [Link](#).

⁸⁷ Microzonation studies are aimed at understanding the geological, geotechnical, geophysical, and geometrical characteristics of areas to provide reliable maps of seismic ground shaking parameters and induced hazards, such as liquefaction and landslides.

⁸⁸ Dolce et al. 2019; Moscatelli et al. 2020.

⁸⁹ Dolce 2012; Sabetta; Dolce et al. 2021.

⁹⁰ EUCENTRE, “WebGIS Platforms for the Assessment of Seismic Risk,” [Link](#).

⁹¹ Dolce et al. 2021, [Link](#).

⁹² Peak ground acceleration refers to the largest ground acceleration recorded during an earthquake event.

An evaluation of the costs and the benefits of the 2010–2016 NSPP, found that the NSPP investments for seismic upgrading, demolition and reconstruction, and local strengthening of public buildings yielded benefit-cost ratios of 1.65, 1.66, and 3.5, respectively. Benefits varied across public building types. The results show that in the case of a large earthquake, the benefits exceed the strengthening costs for all types of interventions across all sectors. Local strengthening seems to be the most effective investment; however, the benefits from demolition and reconstruction are likely underestimated, since the analysis does not account for the benefits associated with functional improvements, including improved use of space and energy efficiency. Public buildings showed a greater benefit-cost ratio than private buildings, which was related to higher occupancy (and hence a lower concentration of risk).

FOCUS ON TRANSPORT SECTOR

The INFRARISK project in Italy conducted scenario-based criticality analysis using the analytic hierarchy process (AHP). As part of the project, a stress test was performed that modeled the effect of low-probability, high-consequence seismic hazard events and the associated earthquake-triggered landslides; this helped to identify the network elements that were most affected by the hazards and that should be prioritized when implementing seismic risk reduction measures. The stress test considered both the vulnerability of network bridges and tunnels to earthquakes and the vulnerability of road networks to landslides. This was done by assigning fragility functions to individual network elements according to their structural characteristics. The impact of the earthquake scenarios was measured in both direct costs (the network repair costs) and indirect losses (the disruptions to the transportation system and network users, with traffic analyses conducted through the use of NEXTA traffic simulation software). The case study provided an integrated approach to assessing rare low-frequency hazard events that could have significant impacts on CI, and thus need to be carefully modeled and analyzed.

Italy carried out another risk-based criticality analysis in the transport sector within the frame of the SYNER-G project. A connectivity analysis prioritizing main road segments and bridges collected data at suburb level. The data reduction process removed irrelevant elements at regional level and established a concise road network that included 2,861 nodes, 5,970 edges, and 2,089 active landslide areas. The analysis measured both simple connectivity loss and weighted connectivity loss. Among affected infrastructures within the network regions, health care facilities were prioritized. Hence, the analysis modeled and quantified the travel disruption and increase in minimum travel time to hospitals due to seismic hazards. The methodology and the data reduction process used in the study provide a prioritization framework for analyzing complex transportation systems (a combination of roads, highways, bridges, etc.), which may be applicable to major road networks and intra-system infrastructures at country or international levels.

Example from Romania

USING RAPID METHODS TO INFORM DECISIONS ON RISK REDUCTION

Romania has been taking steps toward a proactive and comprehensive approach to DRM. An extensive cross-sectoral multistakeholder consultation—involving public institutions, the private sector, and civil society—led to the preparation of the draft National Disaster Risk Reduction Strategy (NDRRS) and corresponding three-year Action Plan. The strategy aims to form an umbrella for the many actions being undertaken and planned by stakeholders with formal or informal DRM roles across different hazards (including seismic) and cross-cutting topics. The National Disaster Risk Reduction Strategy also draws on and complements other government strategies and programs, including the National Seismic Risk Reduction Strategy (NSRRS).

⁹³ WB and EC 2021a, [Link](#).

⁹⁴ This method uses math and psychology for organizing and analyzing complex decisions.

⁹⁵ Clarke et al. 2016, [Link](#).

⁹⁶ SYNER-G 2013, [Link](#).

A rapid analysis to screen the infrastructure buildings of first responders (civil protection) and to prioritize investments based on a portfolio-wide assessment of seismic risk in the country, combined with the criticality of each building. The framework considered costs and benefits, including those of integrating energy efficiency measures as part of a “smart” package of investments. Based on this analysis, a prioritized list of more than 67 critical emergency response facilities owned by the Ministry of Interior will be retrofitted or reconstructed with modernized emergency infrastructure to provide 3,000 first responders with disaster-resilient, energy-efficient, gender-sensitive, and disability-friendly facilities that meet modern response requirements. Millions of citizens are expected to benefit from the improved emergency services. The investments in the resilience of emergency response buildings are expected to yield benefits up to twice the costs. It is expected that the benefits are underestimated given the challenges associated with quantifying the second and third dividends of the “triple dividend of resilience.”

In 2022, Romania adopted a NSRRS the first strategic document to provide a long-term vision on retrofitting Romania's built environment. The strategy proposes a complex approach to seismic risk assessment in Romania, with a three-level approach to assessing vulnerability that aims to guide investment decisions on large-scale interventions. The Level 1 assessment is a probabilistic assessment carried out at national level that aims to determine the impact of earthquakes at the level of each administrative territorial unit (ATU) in Romania. The Level 2 assessment consists of a city-wide rapid visual screening that classifies buildings at ATU level according to their seismic vulnerability to determine the buildings with high seismic risk. The rapid visual assessment is carried out from the outside of the building, and it collects and processes key building data using a standard digital form. In most cases, access to the interior of the building is not required. The Level 3 assessment consists of technical surveys and expertise (that is, technical expertise followed by the documentation for approving intervention works). This approach allows Romania to allocate funds based on the risk level and direct them toward the priority areas and buildings, where the largest number of people can be placed safely in the shortest time.

In line with this strategy and three-level approach, Romania started implementing its National Program for the Consolidation of High Seismic Risk Buildings (i.e., buildings classified in seismic risk class I or II). The program finances the design and execution of intervention works for two types of high-seismic-risk buildings: (i) multistory residential buildings; and (ii) buildings of public interest and utility that are owned or managed by central or local authorities. The buildings included in the national program are selected based on a set of criteria, including the peak ground acceleration (PGA), the number of floors and apartments (for multistory residential buildings), and their importance (for public interest/utility buildings). These investments serve as models for further modernization through national or EU funds.

Example from Japan:

A HOLISTIC APPROACH TO RESILIENCE

Over the decades, Japan has adopted a proactive stance toward national seismic risk by leveraging and implementing robust building codes and regulations aimed at mitigating the impact of earthquakes. Over time, Japan's framework has undergone continuous refinement and improvement, incorporating various programs dedicated to enhancing resilience. Japan has also established a

⁹⁷ See Strengthening Disaster Risk Management Project (P166302), [Link.](#); the Improving Resilience and Emergency Response Project (P168119), [Link.](#); and the Strengthening Preparedness and Critical Emergency Infrastructure Project (P168120), [Link.](#)

⁹⁸ As in ODI and WB (2015, [Link.](#)) : “Investing in disaster resilience [...] can yield a ‘triple dividend’ by (1) avoiding losses when disasters strike; (2) unlocking development potential by stimulating innovation and bolstering economic activity in a context of reduced disaster-related background risk for investment; and (3) through the synergies of the social, environment and economic co-benefits of disaster risk management investments even if a disaster does not happen for many years.”

⁹⁹ WB. 2025a. [Link.](#)

rigorous system for regularly inspecting and verifying compliance with its laws, ensuring their effectiveness in promoting seismic safety. Japan offers three key lessons: first, it is important to plan for disasters before they strike; second, DRM cannot be addressed by either the public or private sector alone but is most effective when it is shared among many stakeholders; and third, it is important to institutionalize the culture of continuous enhancement of resilience. Japan also recognizes the limitations of structural risk reduction measures and prioritizes actions to strengthen preparedness through nonstructural interventions; as part of this approach, all stakeholders play a significant role based on the principles of “self-help,” “mutual support,” and “public help.” More information is provided in a separate note on Japanese good practice.

Example from New Zealand

THE IMPORTANCE OF A STRONG ENABLING ENVIRONMENT

New Zealand’s approach to seismic resilience is underpinned by strong enabling legislation, including the 2002 Civil Defence Emergency Management (CDEM) Act, 2004 Building Act, 1991 Resource Management Act, and 1993 Earthquake Commission Act 1993, and by land use planning. The Building Act regulates building work, provides for the licensing regime for building practitioners, and sets the performance standards for buildings. All these are essential in New Zealand, where there are varying environmental conditions, exposures to seismic risk, coastal hazards, and so on. The act provides for the management of hazards in relation to the construction and modification of buildings and allows varying standards in different areas.

New Zealand’s system is risk based, informed by the scientific research of the Crown Research Institutes and universities, and funded through a set of contestable grants. New Zealand seeks to quantify risk through scientific research, understand risk’s consequences, and then undertake mitigation of risk. The New Zealand government aims to encourage relevant research through grants such as the National Seismic Hazard Model project, which informs the New Zealand Building Act. Funded by the National Emergency Management Agency (NEMA), the project modeled peak ground acceleration over a defined period. Under this model, buildings need to meet a higher standard in certain areas depending on the level of ground shaking expected.

Based on the lessons learned from global and national experience, New Zealand adopted the Building (Earthquake-prone Buildings) Amendment Act 2016, which regulates the identification and management of earthquake-prone buildings. The country is divided into high-, medium-, and low-seismic-risk areas, allowing local authorities to determine the time frame for identifying, assessing, and conducting seismic work on buildings using the earthquake-prone buildings (EPB) methodology. Building Performance, an entity of the New Zealand government, defines an earthquake-prone building as one that would exceed its capacity in a moderate earthquake and collapse in a way that could cause harm or damage to people or property. Such buildings are issued an EPB notice that must be displayed prominently. Information about the seismic risk status of buildings is available to the public through the EPB register.

Moreover, New Zealand provides an enabling environment by supplementing private insurance with publicly funded insurance through the Toka Tū Ake Earthquake Commission (EQC). The EQC insurance coverage is tied to private insurance—that is, it is not available to homeowners without private insurance. Insured New Zealand homeowners who suffer a loss are covered up to \$NZ300,000 by

¹⁰⁰ Takemoto, Shibuya, and Sakoda 2021, [Link](#).

¹⁰¹ See GNS Science. 2020, [Link](#).

¹⁰² Government of New Zealand 2016, [Link](#).

¹⁰³ Building Performance 2017, [Link](#).

¹⁰⁴ Toka Tū Ake EQC, “About Toka Tū Ake EQC,” [Link](#).

the EQC. This is sufficient to cover most damage to residential housing and represents about two-thirds of the total rebuild costs for a fully destroyed house. The remaining one-third would then be met by the private insurer. Thus, private insurers are not exposed to all the smaller damages. The EQC also delivers public information related to preparedness and funds relevant hazard research in New Zealand. It acts as one of the risk reduction pillars for the government.

Lastly, the Residential Earthquake-Prone Building Financial Assistance Scheme, established in 2020, helps owner-occupiers living in earthquake-prone buildings in areas of high seismic risk for whom earthquake-strengthening costs present a hardship. Eligible applicants can apply for a low-interest deferred-repayment loan of up to \$NZ250,000. To make sure the scheme is targeted to those most in need of support, a range of eligibility criteria exist. Loans are made only for seismic retrofit to achieve seismic performance of up to 100 percent of the new building standard. Loans are secured by a mortgage, charge, or other security against the unit's record of title (or equivalent).

¹⁰⁵ The EQC cap was raised from \$NZ150,000 to \$NZ300,000 for each claim. See Toka Tū Ake EQC, "Building Cover," [Link](#).

¹⁰⁶ Kāinga Ora—Homes and Communities 2023, [Link](#).



3. REGULATIONS FOR ENERGY-EFFICIENT BUILDING CONSTRUCTIONS AND RETROFITTING IN CROATIA

This chapter provides a short summary of the national and EU-level regulations related to energy efficiency, including key challenges—specifically those related to seismic risk—and opportunities. Several examples of good practice are included.

3.1. Overview of the framework

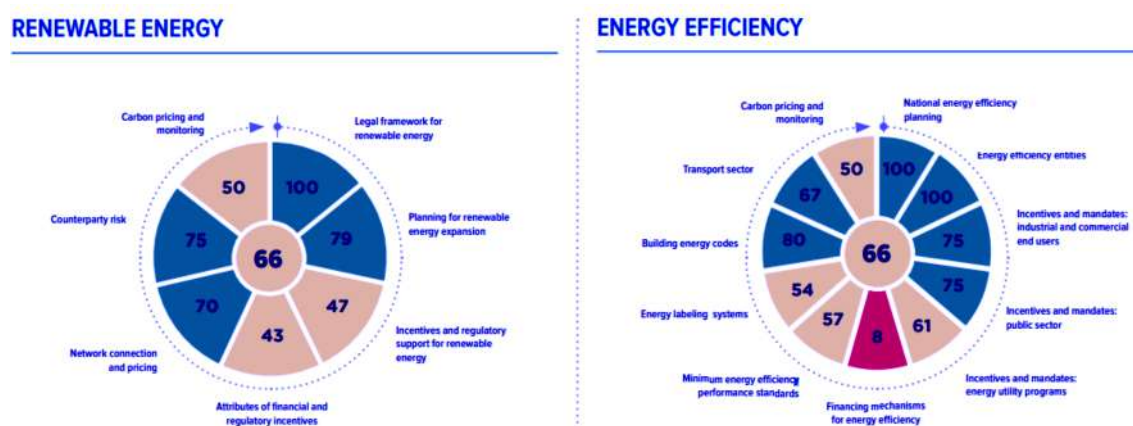
Ensuring that infrastructure and buildings are energy efficient is a key policy priority at national, European Union (EU), and global level and part of commitments on climate change. It is also the focus of Sustainable Development Goal (SDG) 7, Affordable and Clean Energy. Croatia's progress toward SDG 7 has been evaluated by the Regulatory Indicators for Sustainable Energy (RISE), a set of indicators developed by the World Bank and ESMAP (Energy Sector Management Assistance Program). As shown in Figure 4, Croatia received an overall score of 77 out of 100 for energy efficiency. For building energy codes—the codes governing energy efficiency—Croatia received a score of 80 out of 100, but it received a score of just 8 for financing mechanisms that support energy efficiency (Figure 5). The European Commission's 2023 Country Report found that while Croatia's contribution to the EU's 2030 energy efficiency targets was low, investment in renovating both public and private buildings had increased, and the country was aiming to renovate all buildings by 2050. Under the LTRS, the strategic objective is to raise the renovation rate of buildings from the current 0.7 percent (1.35 million square meters) per year to 3 percent by 2030; to 3.5 percent from 2031 to 2040; and to 4 percent from 2041 and 2050.

Figure 4. Croatia's RISE Scores for Energy Efficiency (out of 100)



Source: RISE (Regulatory Indicators for Sustainable Energy), "Croatia," [Link](#).

Figure 5. Croatia's RISE Scores (out of 100) per Pillar in 2021



Source: RISE (Regulatory Indicators for Sustainable Energy), "Country Profiles," [Link](#).

3.2. National framework

Legal framework: Building Code, Law on Energy Efficiency, and other legislation

In Croatia, the overarching laws on energy efficiency are the Croatian Building Code (Official Gazette 153/13, 20/17, 39/19, 125/19), the Law on Energy Efficiency (Official Gazette 127/14, 116/18, 25/20, 32/21, 41/21), and the Ordinance on Simple Buildings (Official Gazette.

- The Croatian Building Code regulates the design, construction, use, and maintenance of all buildings and prescribes legal measures for both their structural safety and energy efficiency (see [Box 3](#) for new developments), while the Law on Energy Efficiency regulates the following areas, among others: efficient energy use; the adoption and implementation of plans at the local, regional (area), and national levels to improve energy efficiency; energy efficiency measures; energy efficiency obligations; the determination of energy savings; and consumer rights in the application of energy efficiency measures. The Building Code notes that the Long-Term Strategy for the Renovation of the National Fund of Buildings until 2050 “contains an analysis of policies and measures that, during the building's energy renovation, contribute to increasing fire protection and protection against risks associated with earthquakes, which affect the life of the building, and provides recommendations for improving healthy indoor climate conditions, fire protection and risks associated with earthquake action for buildings undergoing significant renovation.”
- The Law on Energy Efficiency determines the framework of measures for the promotion of energy efficiency to ensure the achievement of the national framework goals for energy efficiency for 2020 and 2030. Article 1 of the law regulates the following: the area of efficient use of energy; adoption and implementation of plans on local, regional, and national level to improve energy efficiency; energy efficiency measures; energy efficiency obligations; obligations of the energy regulatory body, transmission system operator, operator distribution system, and energy market operators in connection with transmission (i.e., transport and energy distribution); obligations of energy distributors and energy and/or water suppliers, especially the energy service activity; determination of energy savings; and consumer rights in application of energy efficiency measures.
- The Ordinance on Simple Buildings defines buildings and other works that can be built without a building permit and buildings that can be demolished. This ordinance applies to procedures for energy efficiency upgrades, as they often involve minor changes in building layouts. Additionally, architectural teams typically coordinate the mechanical, electrical, and physical aspects of the building.

Key secondary legislation on the energy performance of buildings includes the Technical Regulation on the Rational Use of Energy and Thermal Insulation in Buildings (Official Gazette 128/15, 70/18, 73/18, 86/18, 102/20). This regulation provides information on the energy performance of both new and existing buildings, taking into account the climate zone and the building's functions. It requires the designer of a significant renovation—defined as a renovation or reconstruction where more than 25 percent of the surface of the building's envelope undergoes renovation—to analyze the existing condition of the building; provide an overview of the measures to improve the existing condition, based on an assessment of healthy internal climatic conditions, fire protection, and earthquake risks; and include a summary of the analysis in the main design.

¹⁰⁸ See GoC. 2021b, [Link](#). (under “Key Croatian legislation” on reference list”).

¹⁰⁹ See GoC. 2022c, [Link](#). (under “Key Croatian legislation” on reference list”).

¹¹⁰ GoC. 2020e, [Link](#). (under “Key Croatian legislation” on reference list”).

Box 3. Implementation of Nearly Zero-Energy Buildings (nZEB)

Under the Building Code, one of the key developments is the implementation of nZEB, which are defined in full by the Technical Regulation on the Rational Use of Energy and Thermal Insulation in Buildings.^a Pursuant to Article 21 of the Building Code, all new buildings must be nZEB from December 31, 2020,^b and must have an energy certificate. (For all buildings over 250 m², the energy certificate must be publicly displayed, according to Article 25).

Under the technical regulation, the main design of a building must be prepared in accordance with the provisions for nZEBs laid down in the regulation and enclosed with the application for a building permit. These obligations do not pertain to buildings that applied for planning permission or a building permit before December 31, 2019, or to buildings used by public authorities as building owners if the application for a planning permission or building permit was submitted before December 31, 2017.

All energy certificates are given through the Information System of Energy Certificates and are valid for 10 years (Article 23). Under the Ordinance on building energy audits and energy certification (Official Gazette 88/17, 90/20, 1/21, 45/21),^c and according to the 2021 Methodology for conducting energy audits of buildings, from July 1, 2021, the energy certificate must include a calculation of the required specific annual thermal energy for heating and cooling/air conditioning of the building for reference climate data, a calculation of specific annual primary energy, specific annual delivered energy, and specific annual carbon dioxide emissions.^d

In Croatia, compliance with the nZEB standard is checked at the time the application for a building permit is submitted, that is, at the design stage, rather than after construction and receipt of the certificate of occupancy. The performance of nZEBs is determined based on the characteristics of the building stock used to define reference buildings, including the optimization of the building geometry in order to achieve the lowest possible level of energy required to meet buildings' energy needs. In Croatia, the nZEB definition applies to family buildings, apartment buildings with multiple units, office buildings, educational buildings, (wholesale and retail) trade services buildings, hotel and restaurant buildings, hospital buildings, and sports hall buildings.

^a Notably, for permits issued after March 10, 2021, the Building Code also includes provisions for promoting electromobility (i.e., electric vehicle charging stations) in new and existing buildings.

^b An nZEB is defined by the amount of primary energy consumed for heating, cooling, ventilation, DHW (domestic hot water) generation, and lighting; it also includes a minimum 30 percent share of renewable energy sources in the delivered energy required to meet its energy needs. The Technical Regulation on the Rational Use of Energy and Thermal Insulation in Buildings lays down limits on the annual amount of thermal energy used for heating per unit of the useful floor area of a building Q_{th} , in [kWh/(m²·a)], and on the primary energy E_{prim} , which includes energy for heating, cooling, ventilation, DHW generation, and (in the case of nonresidential buildings) lighting for each building type by purpose.

^c GoC 2021e, [Link](#) . See also GoC (2021d, [Link](#)) .

^d GoC 2021d, [Link](#) .

With regard to energy, the Energy Act (Official Gazette 120/12, 14/14, 95/15, 102/15, 68/18) regulates measures for safe and reliable energy supply and its efficient production and use, implementation of energy policy and energy development planning, performance of energy activities, and basic issues of performing energy activities. The subsequent Integrated National Energy and Climate Plan (NECP), which is currently being updated, and the Energy Development Strategy of Croatia until 2023 reflect the vision of reaching climate neutrality. The relevant building and construction regulations, as well as energy efficiency regulations at national and EU level, can be found in Annex 1.

Such measures may also be linked to health and safety renovations required under the Occupational Health and Safety Act (Official Gazette, no. 71/14, 118/14, 94/18 and 96/18). The act provides measures for protection against fire and explosion and immediate and significant risks and for evacuation and rescue. Article 12 imposes obligations on the employer related to the prevention of fire and explosion, to ensuring the mechanical resistance and stability of the building, and to protection from harmful atmospheric and climatic influences.

Transposing EU law

In addition to the laws described above, there are several relevant regulations and decisions by the government, defined in accordance with the EU policies. These include the Long-term Strategy for National Building Stock Renovation by 2050 (Official Gazette 140/20), the Decision on the adoption of the program of energy renovation of multi-apartment buildings for the period until 2030 (Official Gazette 143/21) and the Decision on the adoption of the program of energy renovation of buildings with the status of cultural property for the period until 2030 (Official Gazette 143/21).

Croatia's Long-term Strategy for the Reconstruction of the National Building Stock by 2050 supports the long-term EU goal of decreasing CO² emissions from the building sector by 80–95 percent by 2050. It is aligned with the draft updated NECP for the period 2021 to 2030 (draft update submitted to EC in June 2023) and with the Strategy for Energy Development until 2030 with a view to 2050 (approved in 2020). It comprises the following: overview of the national building stock; determination of a cost-effective approach to renovation depending on the type of building and climate zone; policies and measures to promote cost-effective thorough renovation of buildings; a review of policies and measures targeting the worst-performing segments of the national building stock, the dilemmas posed by conflicting landlord and tenant interests, and market imperfections; a description of relevant national policies that help alleviate energy poverty; policies and measures for all public sector buildings; an overview of national initiatives to promote smart technologies, well-connected buildings and communities, and skills and training in construction and energy efficiency; an evidence-based assessment of expected energy savings and wider benefits, such as associated health, safety, and air quality benefits; and an assessment of the expected energy savings and broader benefits of systematically investing in the holistic energy retrofit of the national building stock.

According to the Long-Term Strategy for the Reconstruction of the National Building Stock (LTRS) by 2050, the highest priority during energy efficiency renovation is the renovation of the external envelope of heated space. Under the LTRS, cost projections take into account that some portions of

¹¹¹ GoC 2018a, [Link](#).

¹¹² GoC 2020c, [Link](#).

¹¹³ GoC 2023, [Link](#). The discussion of building renovation under the energy efficiency dimension of the NECP refers to the Long-term Strategy for National Building Stock Renovation by 2050 and states that during the 2021–2030 period, the average building renovation rate “is growing from the current 1.0% per year to 3% per year in 2030, and rises to 3.5% in the period until 2040 and 4% by 2050”. Per the NECP, “the average final energy consumption in the residential sector will be 30 kWh/m² for newly built and renovated buildings, and it is expected with no significant variations for the non-residential sector.”

¹¹⁴ GoC 2020b, [Link](#).

¹¹⁵ GoC 2018b, [Link](#).

buildings will undergo major renovation—that is, renovation inclusive of other energy efficiency and seismic measures. Furthermore, it should be noted that the Program of Energy Renovation of Multi-apartment Buildings for the Period until 2030 addresses elements of a comprehensive renovation, which includes earthquake resilience.

Spatial plans serve as the key instrument to plan and implement green urban infrastructure, manage land use changes, and conserve green areas, while general urban plans for cities are also important to ensure effective oversight and evaluation of these initiatives. The Green Infrastructure Development Program in Urban Areas 2021–2030 aims to establish sustainable, resilient, safe, livable, and well-organized cities and municipalities in Croatia as prerequisites for better quality of life and health of people and to contribute to sustainable social, economic, and spatial development. The Program for the Circular Management of Space and Buildings 2021–2030 was created with the aim of developing sustainable, inclusive, safe, and resilient cities by encouraging circularity measures in the planning of new buildings, defining construction guidelines based on circular economy principles, encouraging the reuse of buildings and spaces, increasing the durability of existing spaces and buildings, and encouraging measures to reduce construction waste, increase energy efficiency, and increase the use of renewable energy sources and the reuse of existing construction products and materials.

To unify and facilitate assessments of the existing buildings by practicing engineers, the Ministry of Physical Planning, Construction and State Assets (MoPPCSA) issued guidelines for the analysis of the existing state of buildings with a proposal of measures and assessment of investments related to healthy indoor climate conditions, mechanical resistance and stability, and fire safety. This preliminary analysis represents only initial information and a rough assessment of the possibilities/needs of renovating existing buildings. For a more detailed assessment and implementation of the measures for upgrading, it is necessary to create project documentation in accordance with current regulations. Concerning healthy indoor climate conditions, the guidelines state that measures for improving the building energy performance should not be aimed only at the envelope of the building but should include all relevant elements and technical systems in the building, such as passive elements and techniques whose goal is to reduce energy needs for heating, cooling, lighting, and ventilation. The guidelines tackle the internal comfort conditions of the space, air temperature, surface temperature, relative air humidity, air flow speed, volatile organic compounds (VOC), radioactivity, dust, microorganisms, carbon dioxide, insolation of rooms, natural lighting, noise protection, sound insulation, acoustic quality, and moisture of structural parts.

Guidelines related to mechanical resistance and stability facilitate the implementation of the visual survey of the existing building and help determine whether there is a need for seismic strengthening. If there is a need, the guidelines specify which interventions are necessary and estimate the cost of those interventions. The guidelines describe the main factors contributing to earthquake resistance (seismic hazard, period of construction, and structural type) and identify the main deficiencies of various structural types built in different time periods, as well as the main interventions aimed at enhancing earthquake resistance. The guidelines also propose recommendations for assessment of seismic resistance and required strengthening measures, associated cost estimations, and recommendations regarding repairs.

Concerning fire safety, the guidelines discuss problems related to the use of permits, legalized and older buildings, and the criteria, as well as the relevant regulations. The guidelines describe what methodological approach is used and how to verify the analysis of an existing building's fire safety. They call for analyzing and assessing fire access to the building as well as the distance to and equipment of

¹¹⁶ GoC 2021g, [Link](#).

¹¹⁷ GoC 2021a, [Link](#).

¹¹⁸ GoC 2021f, [Link](#).

the nearest fire department. They also call for analyzing and assessing the structure's resistance to fire; the number and characteristics of building users (mobility); the characteristics of evacuation routes from the building; and the technical systems that are important in terms of fire protection, such as electrical installations, mechanical installations, automatic shutdown systems (if any), and water supply and sewerage). They call for understanding the fire load and fire separation inside the building, combustibility (reaction to fire) of building materials, and prevention of fire transmission to and from neighboring buildings or structures. The reference law on fire protection is the Fire Protection Act (Official Gazette 92/10, 114/22), and the reference regulation—which determines the level of protection from fire—is the Ordinance on resistance to fire and other requirements that buildings must satisfy in case of fire (Official Gazette 29/13, 87/15).

The comprehensive list of the Croatian programs for energy renovations and their results may be found in a recent publication issued by the Joint Research Centre (JRC). It is emphasized that Croatia is one of a few countries that rely on grants and subsidies for upgrading energy efficiency in the building sector; it does not make use of soft loans, tax incentives, or additional tax exemption schemes. Croatia's NRRP includes several reforms and investments related to energy efficiency of buildings, including €542 million invested in supporting businesses for green transition and energy efficiency as well as €658 million invested in low-carbon energy transition through modernizing energy infrastructure. The NRRP Renovation of Buildings Initiative supports the renovation of existing residential and nonresidential buildings for private or public use (see [Box 4](#)). Special attention is given to the renovation of buildings of public interest that serve health and educational purposes. Specific to the restoration, reconstruction, and revitalization of earthquake-affected areas, “the goal is not only to restore the original condition, but a full transformation in building construction with earthquake strengthening and energy efficiency of buildings.” Efforts will be made to reduce energy poverty through programs for the energy renovation of the housing sector. Special attention will be paid to the energy renovation of buildings with the status of cultural assets, which are not included in the energy renovation programs for cofinancing with European funds in Croatia. Funding opportunities related to energy efficiency are available, including the Fund for Environmental Protection and Energy Efficiency (FZOEU).

¹¹⁹ See GoC. 2015. .

¹²⁰ Butenweg et al. 2022, [Link](#).

¹²¹ The 2023 Country Report notes that private investments in addition to grants and subsidies are needed to improve the energy efficiency in the building sector and achieve the 2030 energy efficiency targets. See EC 2023a, [Link](#).

¹²² EC 2023c, [Link](#).

¹²³ Recovery Plan, “Initiative: Renovation of Buildings” [Inicijativa: Obnova zgrada], [Link](#).

¹²⁴ See the organization's website at [Link](#).

Box 4. Croatia's Renovation of Buildings Initiative

Programs under the **Renovation of Buildings Initiative** “will encourage comprehensive building renovation and high-performance alternative systems. Special attention will be paid to ensuring healthy indoor climate conditions, fire protection, and risks associated with increased seismic activity. The goal of this initiative is to contribute to the wave of building renovation, which implies transformation into a highly energy-efficient and decarbonized building stock. The renovation will include residential and nonresidential buildings, as well as public purpose buildings, while respecting the importance of public interest for health and educational buildings. Investments under the Recovery and Resilience Plan will contribute to more effective post-earthquake reconstruction and seismic safety of buildings.”¹²⁵ Other measures include improving efficiency and digitizing the reconstruction process; modernizing seismic data integration for reconstruction and infrastructure planning; and establishing systematic energy management and a new financing model. Also included are procedures for conducting energy renovations in both earthquake-damaged and culturally significant buildings.

The NRRP will finance the post-earthquake reconstruction and energy upgrade of buildings damaged in the devastating earthquakes that hit Croatia in 2020. The plan is to renovate 45,000 m² of private buildings and 274,000 m² of public buildings in the City of Zagreb, Krapina-Zagorje County, Zagreb County, Sisak-Moslavina County, and Karlovac County. Besides increasing buildings' seismic resilience (under the build back better principle), the plan also seeks at least 30 percent energy savings for all buildings compared to their pre-renovation state, thereby contributing to a cleaner and safer environment.¹²⁶

The NRRP includes the following planned reforms and measures with respect to building renovation: energy renovation of buildings (€133 million);¹²⁷ disaster risk reduction program (€158 million);¹²⁸ seismological data network development (€11 million);¹²⁹ introduction of a new model of green urban renewal strategies and the implementation of a pilot project for the development of green infrastructure and circular management of space and buildings (€2.1 million);¹³⁰ and introduction of vouchers for developing green and digital skills (€40 million for programs related to green skills, including development of a framework for skills necessary to green jobs in post-earthquake reconstruction).¹³¹

¹²⁵ Recovery Plan, “Initiative: Renovation of Buildings” [Inicijativa: Obnova zgrada], Link.

¹²⁶ GoC 2021, Link.

¹²⁷ EC, “Energy Renovation of Buildings,” Link.

¹²⁸ EC, “Disaster Risk Reduction Program,” Link.

¹²⁹ EC, “Seismological Data Network Development,” Link.

¹³⁰ GoC, “Pilot Project for the Development of Green Infrastructure and/or Circular Management of Space and Buildings” [Pilot projekt razvoja zelene infrastrukture i/ili kružnog gospodarenja prostorom i zgradama], Link. A manual was also developed for the implementation of green urban renewal strategies of cities and municipalities in Croatia.

¹³¹ EC, “Introduction of Vouchers for Developing Green and Digital Skills,” Link.

Croatia has introduced various programs to address energy poverty and promote efficiency in different sectors: Multi-Apartment Buildings: These programs focus on energy renovation, including buildings damaged in the earthquake, energy efficiency loans, and other measures. Single Family Houses: Programs target energy efficiency for both single-family houses and those at risk of energy poverty. Public Buildings: These programs focus on energy renovation, including the energy renovation of earthquake-damaged buildings, as well as those with cultural heritage status. Business: Entrepreneurs can benefit from energy efficiency programs.

3.3. EU framework

The field of energy efficiency has gained much attention among Croatian decision-makers in recent years, especially after Croatia joined the European Union. One of the EU's key priorities is the renovation of its building stock. The European Green Deal (COM (2019)640) highlights the need for a Renovation Wave (COM (2020)662) for buildings, supported by the establishment of a New European Bauhaus (COM (2021)573), to achieve ambitious energy and greenhouse gas reduction targets by 2030 and a climate-neutral society by 2050. Among the key principles of the Renovation Wave are high health and environmental standards to ensure high air quality, good water management, disaster prevention and protection against climate-related hazards, removal of and protection against harmful substances such as asbestos and radon, fire and seismic safety, and accessibility. These principles will be jointly implemented with the principles of a clean and circular economy, such as those outlined in the context of the New Circular Economy Action Plan (Communication 2020/98).

In addition to setting construction standards, the EU is in the process of strengthening resilience through different instruments and strategies. The EU has also adopted a number of directives and initiatives related to energy efficiency and energy performance of buildings. Overall, these directives aim to improve the energy efficiency and sustainability of residential (and other) buildings in the EU, thereby contributing to the reduction of greenhouse gas emissions and the transition to a low-carbon economy. Likewise, in 2023, the European Commission updated the EU industrial strategy for a more resilient, green, and digital construction ecosystem.

Energy Efficiency Directive (2023/1791)

The Energy Efficiency Directive establishes energy efficiency targets for the EU and requires Member States to take measures to improve the energy efficiency of buildings, transportation, and industry. The 2023 revision of the directive set a more ambitious target—11.7 percent—for reduction in energy consumption by 2030 (Article 4), and it doubled the annual energy saving obligation: 1.3 percent for 2024–25, 1.5 percent for 2026–27, and 1.9 percent for 2028–30 (Article 8). The new directive also revised the target savings to be compared to the 2020 EU reference scenario and introduced the determination of specific national contributions based on country key indicators, such as

¹³² A more detailed analysis of energy efficiency under the Renovation Wave is being conducted through the WB-implemented Croatia Technical Assistance Facility to Support the Renovation Wave in EU Member States (P177061).

¹³³ EC 2020, [Link](#).

¹³⁴ EC 2023b, [Link](#).

¹³⁵ See EU (2018c, [Link](#).) [KEUL reference list]. See generally EC (2022a, [Link](#).)

¹³⁶ EU 2023, [Link](#). [KEUL reference list].

energy intensity, GDP per capita, and so on. The directive gives legal standing to the principle “energy efficiency first,” which requires all EU Member States to consider energy efficiency in all relevant policy and major investment decisions. According to the directive, buildings are responsible for about 40 percent of the EU’s total energy consumption and for 36 percent of its greenhouse gas emissions from energy.

Renewable Energy Directive (2018/2001)

The Renewable Energy Directive sets out targets for the use of renewable energy in the EU and promotes the development and deployment of renewable energy technologies.

Energy Performance of Buildings Directive (2010/31)

The Energy Performance of Buildings Directive (EPBD) establishes minimum energy performance requirements for new and existing buildings and requires Member States to set up building energy performance certification systems. EU Member States are required to set up programs to improve the energy performance of existing buildings and to promote the use of renewable energy sources in the building sector. According to a revision of the directive expected in 2024, Member States should encourage high-efficiency alternative systems in buildings undergoing renovation, insofar as this is technically, functionally, and economically feasible. They should also address the issues of healthy indoor climate conditions, fire safety, and earthquake risks (Article 7).

The revised directive further aims to increase the rate of renovation for poorly performing buildings in each country, while promoting better air quality, digitalization of energy systems, and sustainable mobility infrastructure. It allows governments to decide on renovation measures based on their specific national contexts and provides exemptions for certain types of buildings. Additionally, it facilitates targeted financing for building sector investments, supports vulnerable consumers, and ensures safeguards for tenants. The revision also introduces various new measures, such as energy performance standards, national trajectories for energy reduction, enhanced standards for new buildings, and the promotion of solar-ready buildings. Finally, it includes the phase-out of fossil fuel-powered boilers, one-stop-shops for energy renovations, and the modernization of building systems for better energy integration.

Construction Products Regulation (305/2011)

The Construction Products Regulation sets out requirements for the performance and labeling of construction products used in the construction of buildings, including requirements for the energy efficiency of these products. The regulation aims to ensure that construction products used in the EU meet certain performance standards and to provide information to consumers and professionals about the characteristics and performance of these products.

Eco-Design Directive for Energy-Related Products (2009/125)

The Eco-Design Directive for Energy-Related Products establishes minimum energy performance requirements for a range of energy-using products in residential buildings, including heating and ventilation systems and lighting products.

¹³⁷ EU 2018b, [Link](#). [KEUL reference list]; see also EU (2018a, [Link](#).) [KEUL reference list].

¹³⁸ EU 2010, [Link](#). [KEUL reference list]. See also EU (2018d, [Link](#). [KEUL reference list]; EU (2021, [Link](#). [KEUL reference list]; EC 2022b, [Link](#).

¹³⁹ EC 2022b, [Link](#).

¹⁴⁰ EU 2011b, [Link](#). [KEUL reference list]; see also EU (2011a, [Link](#). [KEUL reference list]. See also EC, “Construction Products Regulation (CPR),” [Link](#).

¹⁴¹ EU 2009b, [Link](#). [KEUL reference list]; see also EU (2009a, [Link](#). [KEUL reference list].

3.4. Key challenges

Linking seismic and energy retrofitting efforts in practice: Lack of rationale and incentives

Joint/combined energy and seismic retrofitting is not common practice in Croatia. Prior to the 2020 earthquakes, upgrading efforts exclusively focused on the process of energy renovation and did not include seismic improvements. Awareness of earthquake risk was low, and retrofitting processes did not take this risk into account.

In the past, Croatia did not have funds for investments in both seismic and energy upgrading of structures, and the seismic upgrading was not included in the EU funding available (under the 2014–2020 multiannual financial framework, i.e., the Program on Competitiveness and Cohesion). Mitigation of seismic risk was not adequately recognized as a priority at the EU level, and countries like Croatia were not able to support the processes with their own funds. With the aim of maximizing the use of funds, the decision was made to undertake only energy renovation; the concern was that parallel seismic upgrading would slow down the process, complicate implementation, and jeopardize the implementation of EU funding. Existing investments in energy efficiency rely on grants and subsidies, an arrangement that limits private investments toward the achievement of the 2030 energy efficiency targets.

Issues with framework and its application

Past opportunities to link the legal frameworks for seismic and energy efficiency retrofitting were not acted upon. An opportunity to promote seismic retrofitting of buildings came with the revised Directive on the energy performance of buildings (Directive 2010/31) and the Directive on energy efficiency (Directive 2018/844) in 2018. Directive 2010/31 emphasized the need to improve the resilience of buildings in earthquake-prone areas. However, although Croatia officially implemented this new directive in its legislation, energy renovation of buildings did not change to include seismic retrofitting.

The experience of earthquakes in 2020 and changes at the EU level have created a valuable opportunity for Croatia to strengthen its energy renovation legislation by implementing more robust regulations that incorporate multi-risk considerations, especially in high hazard areas such as those prone to earthquakes. Since seismic retrofitting is often recommended, not required, it has not been included in several past tenders and is unlikely to be carried out except at a fairly minimal level. The main issue is a need for additional funding to expand the scope of work and, if necessary, relocate occupants during it. Renovations are expected to continue focusing on energy performance, especially since funding for this has been secured. For example, according to the technical regulation on the rational use of energy and thermal protection in buildings, before the major renovation of a building, an analysis of the existing condition of the building should be made, as well as a presentation of measures for improvement of the existing condition of the entire building including: an assessment of the investment in terms of health internal climate conditions, fire protection and risks associated with earthquakes, a summary of the analysis is presented in the main project.

Opportunities also exist to develop technical guidance that integrates climate-proofing measures with risk reduction measures. The European Commission's technical guidance on the climate-proofing of infrastructure in 2021–27 could be a valuable tool for achieving climate change mitigation and adaptation, with many benefits. Its effective utilization in conjunction with seismic guidance is crucial, however. Croatia, currently in the early stages of implementing this guidance, has an opportunity to consider the long-term resilience of buildings and infrastructure in the country. Technical assistance

¹⁴² GoC. 2020e. [Link](#).

¹⁴³ EC. 2021. [Link](#).

and data are needed to support this process, which could serve as the basis for a capacity-building program. At a minimum, it is important to initiate a dialogue with the government and national authorities, as well as engineers, experts, planners, designers, and other professionals.

Croatia missed earlier opportunities to improve energy security and affordability, with wider implications for integrating seismic and other disaster considerations in these areas. According to the 2023 European Commission Country Report, for example, Croatia had not mounted awareness campaigns on energy saving, had not required reductions in energy consumption, and had not taken ambitious actions to address energy efficiency structurally. A complex legislative framework and administrative procedures had led to low uptake of measures such as photovoltaic installations. Given Croatia's susceptibility to earthquakes and other hazards, undertaking such efforts could be highly beneficial. Several challenges still need to be addressed—for instance, at the policy level and within the framework of the LTRS. One is the presence of barriers to energy efficiency updates, which are also relevant to earthquake retrofitting. Additionally, it is worth noting that most of the set targets have not been met. The update of the LTRS in 2025 may provide opportunities to address these challenges and improve outcomes.

Finally, the renovation of cultural heritage buildings shows similar challenges. the 2020 earthquakes, along with the energy renovation process, highlighted the challenges associated with renovating cultural heritage buildings. An important one is the absence of established standards and guidelines for the renovation of such buildings, which often leaves such projects subject to individual interpretation and the opinions of evaluation experts, leading to inconsistencies in the solutions implemented and causing significant delays in the renovation process. Notably, most protected buildings in earthquake-prone areas of Croatia require seismic upgrading.

A dangerous legacy and limited proactive action

The 2020 earthquakes showed that investments in energy renovation that do not consider seismic resistance can be wasted investments that create a dangerous legacy. While some laws include elements that integrate energy renovation with seismic resistance, this problem was not emphasized enough following the earthquakes, and energy renovation continued with minimal seismic upgrading, sometimes making the lack of resilience even more of a hazard. Upgrading energy performance by covering walls with new layers, for example, hides cracks, which ultimately makes it difficult to inspect damaged buildings after an earthquake and to retrofit them. While awareness of earthquake risk has changed, the existing retrofitting processes are very difficult to change; moreover, investment cycles do not wait for adjustments, so that most of the houses being rebuilt are not incorporating serious seismic retrofitting.

A failure to focus on comprehensive solutions

Experience shows that after a disaster; it may be complex to foster comprehensive building back better efforts. Given the urgency to act and possible funding constraints (related, for example, to the European Union Solidarity Fund), there is a focus on rapid renovation/construction, and perhaps on single building features (such as seismic resistance), while activities that could easily and cheaply be performed in parallel are neglected. Before the 2020 earthquakes, investments focused only on energy renovation; after the 2020 earthquakes, they focused on seismic upgrading; and if in the future there is another renovation process (perhaps for increasing fire safety), then the buildings will once again have to undergo significant interventions (including all the finishes, layers of insulation, etc.). To avoid this scenario requires a systematic understanding of the building stock's characteristics before a disaster event. This would allow a targeted and comprehensive effort to build back better, would avoid uncoor-

¹⁴⁴ EC 2023a, [Link](#).

minated individual investments in the essential characteristics of buildings, and would use funds more efficiently.

In addition, appropriate financing instruments that could support such a comprehensive approach are lacking (see [Figure 5](#)). An allocation under the NRRP that targets energy renovation and seismic strengthening is a positive initial step. It may not be adequate, however, in terms of scale, and a sustainable solution is needed that can address long-term needs. The increase in renovation costs can be attributed, in part, to an unsuitable programming and financing approach that leads to market distortions.

A lack of green skills

Croatia's 2023 Country Report found that the lack of relevant green skills created bottlenecks in the reconstruction and renovation process following the 2020 earthquakes, and more generally in the transition to a net-zero economy. According to the report, Croatia is facing labor shortages, particularly in 31 green transition-related occupations, causing constraints in the industry and construction sectors. Construction and manufacturing experienced a shortage of professional and skilled workers, and the construction sector performed below the EU average. Croatia is investing in developing green skills through the European Social Fund (2.6 percent contributes to green skills and jobs) and through the Just Transition Fund. The latter is focused on the two most affected counties, Sisak-Moslavina, which suffered significant damage following the 2020 earthquakes, and Istria. The NRRP is also seeking to develop green skills by introducing vouchers that finance participation in relevant educational programs, which are based on the Croatian Qualifications Framework (CROQF) and are implemented through accredited institutions in accordance with the new Adult Education Act.

Further barriers to development of green skills include high regulatory restrictions for some relevant occupations, such as engineering. The 2023 Country Report found that competitiveness across engineering professions is restricted by a combination of challenges.

A missed opportunity on certification

Croatia did not take advantage of an opportunity to link ongoing activities related to the energy retrofitting and certification of buildings with seismic retrofitting efforts. It introduced an energy certificate, which contributed to greater awareness among citizens about the benefits of energy efficiency and the importance of investing in it. The certificate faced several challenges, however, related to its low quality, acceptance, and uptake in the market and peak demands in a very short period of time. As seismic retrofitting was carried out as part of the post-earthquake recovery, it did not insist that complete renovation of buildings should also include energy renovation. In the first recovery phase, many religious buildings and buildings under cultural protection were renovated; and though the application of energy renovation is limited in these cases, Croatia could have tried to direct the activities into a comprehensive/holistic/build back better process. Following the experience with the energy certificate, a seismic certificate was also proposed, with the aim of maintaining awareness of earthquake threats and communicating the level of seismic resistance of buildings. The introduction of the seismic certificate was mentioned in the first version of the Law on Reconstruction, but the methodology for the seismic certificate is still being developed, and it will be a special challenge to fit it into the existing laws/regulations, since a wide impact is expected.

¹⁴⁵ Ibid.

¹⁴⁶ EC 2022d, [Link](#).

¹⁴⁷ EC 2023d, [Link](#); ; GoC 2023d, [Link](#).

¹⁴⁸ Croatia is one of the most restrictive EU countries in terms of access to and exercise of the profession of engineering. EC. 2021, [Link](#).

¹⁴⁹ EC. 2023a, [Link](#).

Similarly, the 2023 Country Report found that, despite Croatia's positive performance in uptake of renewable electricity, its permitting procedures for renewable energy face significant administrative barriers, take longer than the EU average, and hamper investment. The report found that delays are often due to the confusing and complex legal framework, lack of process overviews, unclear process steps, and shortage of skilled staff in the competent authorities.

3.5. Global good practices and lessons learned

Regional insights on linking energy efficiency and seismic upgrading

According to a 2022 JRC report that reviews policy measures for seismic and energy upgrading of buildings in 16 EU Member States, the majority of implementation measures relate to energy renovation; significantly fewer measures relate to seismic strengthening and even fewer to both. The report found just a few examples of combined seismic and energy retrofit measures. For instance, the Ecosisma bonus is a tax relief scheme in Italy that combines the previous incentives (the Ecobonus and the Sismabonus). It lists measures for improving the seismic and energy performance of buildings in 16 EU Member States that included seismic risk in their National Risk Assessments in 2015: Austria, Bulgaria, Croatia, Cyprus, France, Germany, Greece, Hungary, Italy, Malta, Portugal, Romania, Slovakia, Slovenia, Spain, and Sweden. The report is one of the products of the EU-funded Integrated Techniques for the Seismic Strengthening and Energy Efficiency of Existing Buildings project, which aims to define technical solutions that can reduce seismic vulnerability and increase energy efficiency of existing buildings at the same time and in the least invasive way.

Examples of legislative action across Europe

Seismic regulation in Portugal takes a holistic approach to retrofitting existing buildings and sets requirements for energy efficiency and earthquake resistance that consider fire safety, acoustics, and accessibility, as well. In this way, it offers the opportunity to develop solutions that meet all requirements at the same time. The regulation establishes the fundamental principles that must be satisfied by all retrofits that guarantee the best possible link between building performance (relative to current expectations of comfort and safety) on the one hand and the protection and value of the existing structure, environmental sustainability, and proportionate and progressive improvement of each of the technical requirements on the other. Regarding seismic safety, the regulation defines situations in which the retrofitting of buildings is subject to the preparation of a seismic vulnerability assessment report and the possible strengthening of buildings. This helps ensure the interventions will guarantee structural safety. A seismic vulnerability assessment report is required when there is clear evidence of deterioration of the building structure; when the intervention involves structural changes or changes of use; and for all large-scale interventions (including demolitions and extensions)—that is, interventions exceeding 25 percent of the building's gross construction area and whose construction costs exceed 25 percent of those of an equivalent new building. A seismic vulnerability report is also required for buildings of high importance if any of the above conditions are met, but the latter two requirements (the intervention area and construction costs) are reduced to 15 percent. If the report shows the building does not meet the safety requirements equivalent to 90 percent of the measures provided by NP EN 1998-3 (2017), further seismic retrofitting is required.

¹⁵⁰ Ibid.

¹⁵¹ Butenweg et al. 2022, [Link](#).

¹⁵² Government of Portugal 2019, [Link](#).

¹⁵³ Butenweg et al. 2022, [Link](#).

In 2022, Romania approved its first NSRRS, which also considers an integrated approach to energy efficiency. Among the measures proposed by the NSRRS are (i) establishing coherent prioritization criteria for interventions to reduce seismic risk and increase energy efficiency, ensuring that investment programs target both earthquake and climate resilience; and (ii) funding research and carrying out research projects and studies on scalable and integrated solutions that combine a building's seismic performance with its energy performance. Notably, the NSRRS is also aligned with Romania's National Long-Term Renovation Strategy (NLTRS). The aim is to address not only aspects related to seismic consolidation, but also the transition to a green built environment, thereby ensuring an increase in the energy performance of buildings. Romania's NLTRS includes three complementary measures to integrate seismic risk into energy efficiency investments:

- Structural surveys and technical inspections carried out at the building level, in order to determine the relevant measures for ensuring the structural safety of buildings prior to any major energy efficiency renovations
- Benefit-cost analysis for vulnerable buildings that compares at least two mandatory alternatives: (i) either nZEB renovation with measures to increase seismic safety, or (ii) demolition and construction of a new building as a viable alternative in seismic risk reduction programs, as per nZEB requirements
- Mandatory measures to increase seismic safety of buildings based on the results of the benefit-cost analysis

In Slovenia, as part of a JRC pilot project, there is a plan to introduce the "building cards" tool by 2024, which will provide guidance on recommended and required measures to promote gradual, more comprehensive renovation that includes energy, fire, and seismic aspects. The JRC project proposes a simplified method for assessing the combined upgrading, and applies it to “case studies of both residential and non-residential representative building typologies retrofitted with the investigated upgrading technologies.” It has identified three categories of integrated solutions for combined seismic and energy retrofit technologies in existing buildings: (i) exoskeleton solutions, including shell-grid and shell-exoskeleton solutions (e.g., simple steel braces with solar shading, steel diagrids with thermal panels, insulated RC walls and RC frames with thermal insulation panels); (ii) interventions on the building envelope, such as textile reinforced mortars with thermal insulation, integrated prefabricated panels, and cross-laminated timber panels; and (iii) interventions on horizontal elements of masonry buildings, such as roofs and floors.

Understanding the benefits of linking energy efficiency and seismic action

Between 2020 and 2021, the World Bank and European Commission developed a series of analytical reports that aimed to deepen the knowledge base on Europe's exposure to key risks and on actions to strengthen prevention and preparedness. These reports have provided evidence to policy makers and practitioners seeking smart investments in disaster and climate resilience that also deliver high social, economic, and environmental benefits, and that can be linked with efforts to increase financial resilience and institutional capacity.

Achieving energy savings and the concomitant reduction in greenhouse gas emissions is not possible if existing seismically vulnerable buildings are not structurally strengthened. The World Bank/European Commission benefit-cost analysis of structural strengthening of existing buildings found BCRs of 1.8 for public buildings and 5 for private buildings under probable maximum loss (PML) analysis. Earthquake prevention measures that are accompanied by investments in energy efficiency

¹⁵⁴ The development of the NSRRS was supported by WB reimbursable advisory services.

¹⁵⁵ Negro and Romano 2022, [Link](#).

¹⁵⁶ Negro and Romano 2022, [Link](#).

and building modernization provided the greatest BCRs and were found to offer immediate benefit to beneficiaries even if a disaster does not occur. See [Box 5](#) for details.

Box 5. Integrating Energy Efficiency and Structural Strengthening

Beyond achieving ambitious climate goals, the integration of structural strengthening and energy efficiency brings other benefits, including (i) reduction in total cost through shared labor and complementary concurrent investments; (ii) improved sustainability of energy efficiency improvements through the building lifetime and payback period by ensuring investment in earthquake-resistant buildings; (iii) functional upgrades such as autonomous energy (e.g., solar panels), which are crucial to ensure energy supply and continuity of service in the aftermath of an earthquake, when energy service can be disrupted for days or weeks; (iv) upgrade to roofs associated with energy efficiency, which can increase the performance of buildings during an earthquake (e.g., minimize damage to nonstructural elements) and in storm events; (v) assessment of the full economic case for building improvement versus demolishing and rebuilding; and (vi) minimization of disruption to building occupants and government services.”

World Bank technical report “Reducing earthquake risk in large panel multifamily buildings” in Bulgaria indicated that over 50 percent of the cost for the energy efficiency improvements relates to labor. Such a cost can be shared and further optimized if integrated with seismic strengthening.

The Energy Efficiency in Public Buildings (EEPEP) project in Turkey,¹⁵⁸ supported by World Bank financing, will target a minimum energy savings of 20 percent, with a maximum simple payback period of 12 years. Considering the high frequency of damaging earthquakes in Turkey (one event every 1.5 years on average), seismic events are likely to occur during that period, even more so during the life cycle of the buildings. Therefore, adequate seismic performance of structures is crucial to justify the long-term return on investment for energy efficiency works.

Source: World Bank and European Commission 2021b, [Link](#).

¹⁵⁸ WB. 2025c. Türkiye Energy Efficiency in Public Buildings - Audited Financial Statement. [Link](#).

Example of the education sector

In 2021, the World Bank and European Commission conducted benefit-cost analysis of hypothetical investments in seismic strengthening and energy efficiency for pre-tertiary and tertiary education facilities in earthquake-prone countries in Europe. Using the Triple Dividend of Resilience methodology found that prioritizing the most vulnerable buildings and implementing seismic strengthening with energy efficiency measures yielded higher BCRs, but nonetheless found a range of 0.63 to 2.18 for all countries. This means that investments to both strengthen and improve the energy efficiency of education facilities yield positive returns in the majority of the countries analyzed, considering both design life and PML benefits. Benefits differ across countries depending on their seismic risk, climate, and energy profile. The results for Croatia are found in Table 4. This finding aligns with analysis conducted for the retrofitting and reconstruction of 350 schools in Türkiye, which yielded a BCR of 1.53. Earthquake prevention measures that were accompanied by investments in energy efficiency and building modernization yielded the greatest BCRs while also providing immediate benefit to beneficiaries even if a disaster does not occur.

Table 4. Benefit-Cost Analysis for Schools in Croatia: Probable Maximum Loss Analysis (475-year return period)

Dividend 1		Dividend 2		Costs	
Avoided injuries	€5.2M	Energy savings	€139.9M	Seismic retrofit costs	€60.9M
Avoided fatalities	€50.6M	CO ₂ savings	€47.6M	EE improvement costs	€165.8M
Decrease in repair cost	€ 6.1M	Total dividend 3	€187.5M	Total costs	€226.7M
Total dividend 1	€62.0M	Total benefits	€249.5M	Benefit-cost ratio	1.10
				Net present value	€22.8M
				External rate of return	10.1%

Source: World Bank and European Commission, 2021b, [Link](#).

Example from the Western Balkans

Recently, analysis on integrating energy efficiency into seismic strengthening was conducted for the Western Balkan region. The study reviewed legislation and ongoing energy efficiency programs across Bosnia and Herzegovina, Kosovo, Montenegro, and North Macedonia; it found that while in general selection criteria for retrofit include “structural soundness,” there is inconsistent guidance across the region, leading to gaps in application of such programs. The study identified several opportunities to better coordinate integration of seismic risk into energy efficiency programs: (i) justify the “structural soundness” criterion, and target buildings for energy efficiency retrofit that have long remaining lives; (ii) screen and inspect buildings for energy efficiency and seismic resilience in parallel; (iii) carry out energy efficiency and seismic retrofit in parallel to minimize overall disruption; and (iv) look for retrofit options that target both energy efficiency and seismic resilience. The study proposed a framework for integrating seismic considerations into an energy efficiency program (shown in Figure 6).

¹⁵⁹ WB and EC 2021b, [Link](#).

¹⁶⁰ There are three types of Triple Dividend of Resilience that DRM investments can yield: (1) Avoiding losses when disasters strike; (2) Stimulating economic activity thanks to reduced disaster risk; and (3) Development co-benefits, or uses, of a specific DRM investment. See (WB, 2015). [Link](#). ; (WB, 2024). [Link](#).

¹⁶¹ Grant and Hulme 2020.

It also provided some general recommendation for policy makers: (i) incorporate seismic integration at the project concept design stage; (ii) allow time in the program for permitting processes; (iii) engage disaster risk stakeholders early; (iv) use high-level screening to filter buildings before detailed assessment; (v) apply seismic safety improvements to nonstructural installations; and (vi) engage the right skills in seismic engineering, and build capacity using pilot programs.

Figure 6. Framework for Integrating Seismic Considerations into an Energy Efficiency

	Level 1 - High Level Screening			
	Low risk buildings	Buildings which may be relatively low risk	Medium risk buildings or limited information	High risk buildings Retrofit unlikely to be cost effective
Energy Efficiency Building Selection Stage				
Review findings		Simple buildings	Complex buildings	Exclude from EE Refer findings to DRR department
Energy Efficiency Audit Stage	Structural visual survey only. (Optional FEMA E74 check)	Level 2a Deficiency-Based Assessment	Level 2b Detailed Assessment	
Review findings		Review Costs and risks		
	Risk is acceptable without intervention	Interventions are within budget	Interventions are not viable within budget	
			Exclude from EE Refer findings to DRR department	
Energy Efficiency Detailed Design and Construction	Proceed with EE detailed design and coconstruction	Incorporate seismic interventions into detailed design and implementation		

Program

Source: Adapted from Grant and Hulme 2020 .

Note: DRR = disaster risk reduction; EE= energy efficiency; FEMA = US Federal Emergency Management Agency.



4. KEY RECOMMENDATIONS AND OPPORTUNITIES GOING FORWARD

This chapter summarizes key recommendations drawing on the above chapters, especially the challenges and opportunities associated with three priorities:

- Modernize the regulatory framework to meet short-, medium-, and long-term challenges related to seismic risk
- Advance seismic risk reduction efforts to reflect the current scale of risk
- Link energy efficiency and seismic resilience to enable smart, integrated, and efficient investments contributing to strengthening disaster and climate resilience

Example from Canada: Investing in resilient critical infrastructure

Canada has prioritized the resilience of CI through a comprehensive all-hazards DRM approach.

The National Strategy and Action Plan for Critical Infrastructure aims to build a safer, more secure, and more resilient Canada by strengthening the resiliency of CI against current and emerging hazards. The fundamental concepts and principles outlined in the strategy set out a collaborative approach for federal, provincial, and territorial emergency management initiatives. Consistent with this framework, and recognizing the interconnected nature of CI, the strategy fosters partnerships among federal, provincial, and territorial governments and CI sectors; it also advances an all-hazards risk management approach and sets out measures to improve information sharing and protection.

Canada has also made funding available for strategic investments in resilience. Funding sources include the following:

- **Canada Community-Building Fund:** The Canada Community-Building Fund is a permanent source of funding provided up front, twice a year, to provinces and territories, which in turn channel this funding to their municipalities to support local infrastructure priorities. Municipalities can pool, bank, and borrow against this funding, so it provides them with significant financial flexibility. The Canada Community Building Fund delivers over CAN\$2 billion every year to 3,600 communities across the country. In recent years the funding has supported approximately 4,000 projects each year. Communities select how best to direct the funds and have the flexibility to make strategic investments, including in disaster mitigation.
- **Disaster Mitigation and Adaptation Fund:** In 2018, the Government of Canada launched the Disaster Mitigation and Adaptation Fund (DMAF), committing Can\$2 billion over 10 years for structural and natural infrastructure projects that would increase the resilience of communities impacted by climate change-related natural disasters. As announced in the 2021 budget, an additional Can\$1.375 billion in federal funding over 12 years was provided to renew the DMAF. A minimum of Can\$138 million of this funding is allocated to Indigenous recipients. As outlined in the Government of Canada Adaptation Action Plan, the Government of Canada will invest up to an additional Can\$489.1 million over 10 years through the DMAF to help communities increase their resiliency against the effects of climate change. More than Can\$1 billion in funding is available in the current DMAF.

¹⁶² Government of Canada 2022, [Link](#).

¹⁶³ Government of Canada 2023b, [Link](#).

¹⁶⁴ Government of Canada 2023a, [Link](#).

4.1. Modernize the regulatory framework to meet short-, medium-, and long-term challenges related to seismic risk

► **Pursue urgent actions for preparedness and risk avoidance (no-regret actions).**

ADDRESSING GAPS IN RISK KNOWLEDGE

Adequate risk analysis of the building stock is crucial to understanding its vulnerability and exposure to disasters and must be done before updating laws or creating programs. With only 10 percent of current building stock built under modern laws, it is essential to have a solid understanding of the vulnerabilities of the remaining 90 percent. Successful programs in **Italy** and **Portugal** provide valuable lessons on how to conduct and implement such analyses. Such assessments can also be integrated into legislation, taking inspiration from **New Zealand's** earthquake-prone building methodology outlined in the Building (Earthquake-prone Buildings) Amendment Act 2016. Data collection can start even when limited information is available and can be gradually improved with further information.

Rapid initial assessments of infrastructure that can guide future analytics. Adopting a rapid visual screening (RVS) and leveraging the registry of engineers under CCEE for pre- and post-earthquake RVS to prioritize buildings at need for intervention could be considered. Leveraging the registry of engineers for pre- and post-earthquake RVS could aim for (i) exposure data collection and consequently seismic risk assessments and prioritization for retrofitting or reconstruction, and (ii) a quick response for the damage and usability assessment of buildings after an earthquake. This information could feed into an integrated seismic risk management database.

In Croatia, such an approach could be potentially linked to previous discussions in 2023 on seismic certification of buildings, but also other envisioned governance reforms related to construction, physical planning, and EE planned by the MoPPCSA for 2024-2028. These all should be complimented by training and deployment for practical experience. Such information can also feed into regulations to discourage the occupancy of buildings that are deemed unsafe in terms of earthquake risk.

ADDRESSING GAPS IN THE LEGAL FRAMEWORK

To better respond to disasters, the existing laws regarding seismic risk reduction in buildings should be harmonized since this regulatory inconsistency results in many missed opportunities to invest in seismic risk reduction. Currently, the key legislation includes the Reconstruction Law, the Building Code, the Ordinance for Simple Buildings, and the Energy Efficiency Interventions. Each serves a different purpose, which makes it harder to incentivize integrated efficient solutions to reduce seismic risk. Therefore, to mitigate risk derived from seismic events, Croatia should work on the harmonization of existing laws that could be applied during pre- and post-seismic events. Envisioned reforms related to construction, physical planning, and EE planned by the MoPPCSA under its Program for 2024-2028 could also be a practical opportunity to improve the governance framework on seismic risk reduction. The LTRS provides an opportunity to integrate comprehensive building renovations that go beyond EE

¹⁶⁵ GoC. 2024, [Link](#).

¹⁶⁶ See WB. 2023. Building Code Checklist for Fire Safety. [Link](#).; WB. 2023. Building Code Checklist for Green Buildings. [Link](#).; WB. 2024. Building Code Checklist for Structural Resilience. [Link](#).; WB. 2025. Building Code Checklist for Universal Accessibility. [Link](#).

¹⁶⁷ GoC. 2024, [Link](#).

to include seismic safety improvements. This includes enhancing fire safety, ensuring healthy indoor environments, and improving mechanical stability. Seismic retrofitting efforts should focus on upgrading critical entities, eliminating hazards from gas installations and chimneys, and promoting earthquake-resilient energy solutions

The legal status of buildings should be addressed, with more flexibility in the permitting process to provide clarity on the building stock. Excessive administrative barriers can be a deterrent to such efforts. To provide relevant stakeholders with more data, Croatia could enhance and make available data efforts by the Ministry of Justice and Public Administration, the State Geodetic Administration, and the like. The Ministry of Culture should also be involved, as almost all of the protected buildings require earthquake upgrades, and its role in future reconstruction procedures and projects will be crucial. In general, synchronization is needed of available databases that were created through several different processes, such as the legalization of illegally constructed buildings, the energy certification procedure, the collection of archival material, and so on.

The gap between regulations and infrastructure compliance needs to be bridged. Efforts should be made to facilitate the application of regulations and discourage avoidance. The experience it has gained from earthquakes in the last decades, for example, has led **Italy** to create a regulation that is better adapted and much more applicable to its situation than the corresponding one in the Eurocode. The complexity of Eurocode 8, the current version of the code that is also being implemented in Croatia, often confuses experts and practicing engineers. As a result, they frequently simplify their calculations with approaches that are not in accordance with the regulations yet closer to the (known) practice. To improve the seismic resilience of structures, the next generation of the regulations will need to address practical problems in the field. A synchronized approach—like Italy’s, which links its National Seismic Prevention Plan and National Technical Standards for Construction—should be pursued that combines the research and professional communities and continually seeks to raise the level of knowledge. This could eventually bridge the gap and facilitate the application of the regulations (and reduce their avoidance). In addition, such efforts will contribute to Croatia’s efforts to transpose the revised Eurocodes once adopted.

Furthermore, defining decision criteria for rehabilitation or reconstruction, such as structural-integrity thresholds, heritage value, life-cycle cost analysis, and projected climate risk, either by enshrining them in the building law or by issuing binding technical guidance, so owners and authorities can readily decide when full reconstruction or targeted rehabilitation is the sounder option. At the same time, such efforts would require continuous professional training for engineers and inspectors to apply these criteria consistently and steer stakeholders toward the most resilient, cost-effective solution.

ENSURING COMPLIANCE WITH SEISMIC AND OTHER DISASTER-RELATED STANDARDS ACROSS INFRASTRUCTURE

Compliance needs to be ensured with seismic and other disaster-related standards for CI, such as emergency response buildings, schools, and hospitals, and for other infrastructure in Croatia. The ongoing reforms under the NRRP may be an opportunity to pursue this. Based on a portfolio analysis of civil protection infrastructure, for example, **Romania** was able to create a prioritized list of more than 67 critical emergency response facilities, which also offered additional benefits, providing 3,000 first responders with disaster-resilient, energy-efficient, gender-sensitive, and disability-friendly facilities that meet modern response requirements. Compliance can also be promoted through enforcement campaigns, similar to successful initiatives in **Japan**, as part of the continuing process of reconstruction following the 2020 earthquakes.

Processes for quality inspection should be optimized and law enforcement improved. In Croatia, the building codes are based on scientific research and changes in neighboring countries or at EU level,

but enforcement of the laws and regulations is often a problem. Most commonly, a lack of control over the building process allows construction firms to deviate from approved designs and recent laws and regulations. Before the recent earthquakes, builders often ignored the regulations for concrete elements in favor of using traditional methods or to cut costs. The establishment of an agency, entity, or ministry, similar to those in **Italy**, **North Macedonia**, and **Japan**, to certify professionals involved in the construction quality assurance process would help enhance the capacity for quality inspection and enforcement. Prioritizing such inspections and organized consultations with experienced experts in the reconstruction efforts would also help address the lack of specialized construction firms for work on traditional masonry buildings, which sustained the most damage in the 2020 earthquakes, and put a stop to the significant deviations from the current regulations that were noted during the recovery process. Identifying deficiencies in advance of any earthquake or other hazard event is always preferable to having the event expose them.

► **Enhance capacities for short- to medium-term reconstruction, revitalization, and disaster response.**

INVESTING IN CAPACITY BUILDING TO ENSURE COMPLIANCE

To ensure compliance with the regulatory framework, investments should be made in capacity building and funding provided to relevant stakeholders. As the regulatory framework evolves—for example, with the adoption of the DRM Strategy and upcoming action in line with the Act on Critical Infrastructure—responsible entities need to be able to implement and apply the newly proposed measures. Considering the age and vulnerability of buildings of special importance (including CI), it is essential to increase the capacity of experts or of specialized institutions that can act in accordance with the regulatory needs.

To improve inspections and enforce the law, the capacity of local government staff needs to be strengthened. Government, academia, and the private sector should be engaged in multistakeholder collaboration to ensure regulatory compliance with resilience standards. In **Japan**, private-sector actors carry out inspections to ensure buildings conform to the building code. Such private-sector participation extends enforcement beyond the capacity of the local government.

MAINSTREAMING MULTI-HAZARD DISASTER AND SEISMIC CONSIDERATIONS AT ALL LEVELS

A culture of continual strengthening of resilience needs to be institutionalized. Before the 2020 earthquakes, earthquake risk was largely overlooked in the creation of laws, regulations, and strategies. In the future, multi-hazard disaster and seismic considerations must be integrated into all relevant national and subnational laws, infrastructure plans, and urban strategies. Such laws, plans, and strategies should incorporate information on risk, structural reinforcement, maintenance, and so on. To achieve this goal, the process should ensure the involvement of experts or institutions specializing in seismic risk (for example, from **Italy** or **North Macedonia**) that would continually implement relevant good practice.

Furthermore, climate-proofing measures should be introduced by revising building codes and incorporating climate considerations into urban planning. Calculations of the energy performance of buildings during the design phase should account for an increase of at least 2.2 degrees in the average temperature of the hottest month, based on the Croatian Meteorological and Hydrological Service's climate model for the period 2041–70.

A DRM policy framework needs to be developed at both national and local levels to ensure coherence between them. Local governments, such as municipalities or prefectures, could prepare ex-ante plans to facilitate immediate reconstruction efforts in case of a disaster. The national and local plans should be aligned, with a clear distribution of roles and responsibilities between them.

► **Address medium- to long-term regulatory, financial, and sustainability issues.**

CREATING A SEISMIC-RESILIENT LEGAL FRAMEWORK

The legislative framework needs to be updated to improve planning before the next earthquake strikes. It is important to define the legal framework, procedures, and emergency plans for response and immediate recovery ahead of the disaster.

- The first step is to develop clear procedures, define stakeholders' responsibilities, and outline a methodology for assessing damage and the usability of buildings, which was lacking before the 2020 earthquake response. In addition, protocols and procedures for immediate recovery and reconstruction should be developed, reviewed, and included in planning, with enough flexibility to integrate and follow up on the damage assessments conducted. Responsibilities of institutions and associations, as well as citizens, should also be clearly defined.
- In the preparedness phase, state-of-the-art procedures should be developed for CI for the collection of initial data, risk assessments, prioritizations, maintenance, and strengthening activities. These should replace existing procedures, which are either not implemented or outdated.
- A prerequisite for other activities is collecting data about existing infrastructure and buildings as a foundation for strategic decisions (and for inclusion in a database). Data might relate to building approvals and permits, the strengthening of buildings, and applicable disaster-risk financing and insurance.
- Adoption of a prioritization approach similar to **New Zealand's** Building (Earthquake-prone Buildings) Amendment Act 2016, which divides the country into high, medium, and low seismic risk areas, would be useful. This is particularly relevant for Croatia's seismic framework, as the country (as shown in [Figure 1](#)) has three regions classified as high seismic risk areas, while the remaining regions are at lower risk.

An “earthquake law” should be passed to address any perceived deficiencies in the system (for example, in building inspection procedures). The primary objective of the proposed law is to bring together and harmonize various fragmented and well-defined elements (such as the Eurocode) and then cover any gaps that are otherwise not regulated. In an effort to address gaps in risk knowledge, **New Zealand** adopted the Building (Earthquake-prone Buildings) Amendment Act, and in turn, the EPB methodology, through which information about the seismic risk status of buildings is available and public. Something similar may be considered in Croatia for the specific typology of buildings.

Beyond seismic risk reduction and prevention, the legal framework should ensure systems are ready and can be utilized in the event of a disaster. **Italy**, for example, conducted studies on urban and emergency planning to ensure civil protection plans accounted for the vulnerability of strategic elements and interconnection routes. To ensure a timely and effective response to disasters, regulations and guidelines that specify arrangements for the aftermath, including safe places to shelter, aid distribution, post-disaster assessments (including processes for surveying engineers), and post-disaster financing, are essential.

WORKING TOGETHER AND BUILDING ALLIANCES ACROSS THE SOCIETY

Research should be integrated into prevention and preparedness policies and investments. The successful collaboration between the research and professional communities following the 2020 earthquakes demonstrated the importance of a synchronized approach. Continuously raising the level of knowledge will eventually bridge the regulatory and compliance gap, encourage the application of regulations, and discourage efforts to avoid their application. Coordination with research institutions and academia can also support the development of cost-effective approaches to scaling up investments in risk reduction and prevention, in part through better targeting of investments and better use of limited resources. Also of value would be a national center of excellence, like those in **Italy** and **New Zealand**, to analyze seismic risk and suggest mitigation measures that can support awareness activities, knowledge creation, and knowledge transfer – such as the CCEE.

Regulations and codes should be upgraded regularly, based on evidence and lessons learned. Croatia could consider implementing a framework that integrates hazard-specific and multi-hazard scientific research findings and lessons learned into legislation. This approach would ensure regulations remain up-to-date and effective in addressing potential risks and hazards.

4.2. Advancing seismic risk reduction efforts to reflect the current scale of seismic risk

► **Pursue urgent actions for preparedness and risk avoidance (no-regret actions).**

PRIORITIZING SEISMIC RISK REDUCTION FOR CRITICAL INFRASTRUCTURE

Earthquake risk reduction needs to be prioritized for CI, including public buildings. Examples in Europe and beyond include **Italy**, **Romania**, and **Japan**. Promoting the seismic strengthening of CI buildings and networks, some of which may be operated by the private sector, is particularly important. Since CI is usually designed to be more resistant to earthquakes than other buildings, it is unlikely to be threatened by minor earthquakes, but in major events, all systems could fail simultaneously. Such a failure represents one of the biggest dangers to Croatia. Analysis and prioritization are key for strategic actions in this area. Croatia could optimize the resilience benefits of retrofitting opportunities by adopting comprehensive measures that address multiple risks and integrate seismic and other hazard-related standards with renewable energy standards.

Preparedness should be strengthened by complementing ex ante structural risk reduction measures with ex ante nonstructural measures. This approach combines comprehensive legal and policy reforms and structural investments through the development of plans, strategies, and other strategic documents to guide the process and ensure comprehensive management. An integrated approach also means a multistakeholder approach that integrates the principles of “self-help,” “mutual support,” and “public help.”

► **Enhance capacities for short- to medium-term reconstruction, revitalization, and disaster response.**

IMPROVING THE TECHNICAL KNOWLEDGE OF ENGINEERS RELATED TO EXISTING (INCLUDING HISTORIC) BUILDINGS

Croatia should establish and empower a stakeholder institution that is responsible for all processes related to earthquakes and that continually contributes to improvements in the system.

Such an institution should be empowered to meet the necessary scale and technical needs. In Croatia, this may include a designated program by the Faculty of Construction or through CCEE. **Italy**, for example, has created a center of excellence to analyze seismic risk and suggest mitigation measures.

Experts should be trained on a continuing basis and should regularly participate in knowledge exchange on best practices and the existing building stock. This training should address the aging building stock, as well as assessment before and after a disaster. Creating a database of trained engineers can ensure that assessments are led by experts with the same training, which in turn will improve the overall effectiveness of response efforts.

WORKING TOGETHER AND BUILDING ALLIANCES ACROSS THE SOCIETY

A range of stakeholders in seismic resilience should be engaged from both the broader public and the private sector. Citizens must be encouraged to invest in seismic strengthening as part of other processes promoted by the state. **Several countries** provide incentives, such as property tax breaks, to citizens and private-sector actors to invest in buildings. For such initiatives, clear communication of what activities and responsibilities are expected after a disaster is essential.

Reducing seismic vulnerability requires a multistakeholder effort, including cooperation by various academics and researchers. To achieve a whole-of-society resilience in **Italy** and **Romania**, the preparation of seismic plans was informed by academic studies and multiple consultations. Italy's development of a center of excellence to harmonize research on earthquake vulnerability resulted in a Web GIS (geographic information system) program, demonstrating the effectiveness of such efforts.

► **Address medium- to long-term regulatory, financial, and sustainability issues.**

DEVELOPING A STRONG KNOWLEDGE BASE ON SEISMIC AND OTHER DISASTER RISKS TO PRESERVE EARTHQUAKE AWARENESS AMONG FUTURE GENERATIONS

Efforts should be intensified to enhance awareness of and preparedness for disasters, preserving knowledge about earthquakes for future generations. Long-term efforts for disaster recovery and preparedness should be prioritized, and good communication with local communities should be maintained during reconstruction to strengthen disaster resilience. Good practices for promoting social cohesion in the face of frequent natural disasters include recognizing that the cost of reconstruction must be borne by all.

To ensure effective DRM, development of a strong knowledge base on seismic and other disaster risks should be prioritized and a culture of preparedness fostered to minimize the loss of life and property. **Japan**, for example, has been developing a strong knowledge base through investment in seismic hazard monitoring and assessment, including detailed studies of seismic activity, fault lines, and ground motion characteristics, which are useful for building seismically strong structures. In addition, it invests in knowledge sharing through public education and awareness raising, including regular drills, educational campaigns, and dissemination of information, which help raise public awareness about earthquake safety measures, evacuation procedures, and response protocols.

To make DRM efforts more efficient, data systems, the use of GIS, and the application of innovative information and communication technology should be improved. The reconstruction and recovery program launched after the March 2020 earthquake and adapted after the December 2020 earthquake revealed challenges with the housing stock and land register, including a need for improved data management and systems. The processes of damage assessment and reconstruction and rehabilitation offer a unique opportunity to create a comprehensive database of buildings that could be the foundation for building maintenance, the enforcement of seismic certificates, and many other strategic processes. **Japan** systematically updates technical standards based on new data from disaster events. Following a review of the impact of the 2011 Great East Japan Earthquake, for example, the specifications for highway bridges were updated with revisions to correction factors and motion levels.

PROVIDING INCENTIVE FOR SEISMIC RESILIENCE

Suitable financing instruments are needed that effectively facilitate a comprehensive approach. A program should be developed, for example, that combines grants and financing instruments to enable the funding of seismic improvements through grants with longer payback periods, while the energy efficiency component can be supported by sustainable financing instruments. This approach would ensure the availability of necessary funding for seismic renovations and promote energy efficiency measures.

Incentives to support the seismic renovation of buildings in areas of high earthquake risk are essential. The experience of **Italy** shows the importance of working continually on this issue and motivating citizens to invest in improving the seismic resilience of their own buildings (for example, through property tax incentives). Italy's "Sismabonus," which allows a tax deduction equal to the expenses incurred in strengthening a building, is an example of a successful incentive program. Such incentives can encourage building owners to take necessary steps to reduce seismic vulnerability, ultimately improving overall resilience to disasters.

4.3. Linking energy efficiency and seismic resilience to enable smart, integrated, and efficient investments contributing to strengthening disaster and climate resilience

► **Pursue urgent actions for preparedness and risk avoidance (no-regret actions).**

PRIORITIZING AND LINKING INVESTMENTS IN ENERGY EFFICIENCY AND SEISMIC STRENGTHENING

The linking of energy efficiency to seismic retrofitting should be prioritized to achieve the national, EU, and global disaster and climate objectives. Investments in the energy renovation of buildings that do not include sufficient seismic resistance can be wasted money, so programmatic screening should consider these aspects (or make it mandatory to combine them).

Legislation that sets requirements for multiple priorities for building upgrades, including energy efficiency and earthquake resistance, should be enacted. The 2020 earthquakes damaged many recently energy-renovated buildings and destroyed the investments. At the EU level, this issue and the related need for joint investment have been recognized, especially by countries, like **Italy**, that are endangered by earthquakes. Despite its recent earthquakes, Croatia has not included obligatory

seismic intervention in regulations; initial interest was followed by seismic resistance being raised only minimally or not at all. The absence of such requirements represents a missed opportunity during ongoing waves of energy efficiency renovations. Legislation must also consider that climate change threatens to worsen the impacts of disasters, which have already increased in intensity and frequency. Requirements should be set to improve overall resilience to hazards prevalent in the region. **Portugal's** legislation, for instance, sets requirements for energy efficiency and earthquake resistance. Likewise, in **Japan**, programs to provide incentives for integrated building upgrades address many urgent issues at once, including seismic resilience, energy efficiency, and renovations to cater to the needs of elderly residents or families with children.

Linked to this, policies and procedures should be developed and implemented that prioritize and/or oblige seismic retrofitting with energy renovation. These policies should encourage joint measures for energy and seismic retrofitting in buildings, and they should provide incentives for citizens to invest in seismic strengthening as part of other processes encouraged by the state.

Critical infrastructure and public buildings should be prioritized for seismic retrofitting and upgrading of their energy performance. Such policies make good economic sense; they promote the seismic strengthening of CI buildings and avoid compromises or individual actions on the essential requirements for the structures.

Croatia should take the opportunity provided by the 2025 review of the Long-Term Renovation Strategy to establish a stronger connection between the requirements for energy efficiency and seismic renovation. The country could ensure the policy framework effectively integrates and aligns the objectives of both by incorporating specific guidelines, targets, and incentives within the updated LTRS to promote and prioritize their combination in building projects. This would simultaneously enhance resilience to seismic events, improve energy efficiency, and contribute to national, EU, and global disaster and climate objectives.

To encourage more comprehensive retrofitting that includes energy and seismic aspects, the method for assessing the combined upgrading of buildings needs to be simplified. The assessment could, for example, include the evaluation and scoring of activities that increase the seismic resistance of buildings as part of the tender for energy renovation. It is also important to communicate clearly which seismic interventions are the most important (which is almost necessary under the current regulations), as well as to articulate which buildings should not undergo energy renovation (for example, those with structural systems extremely unfavorable for seismic loads). The “building cards” tool developed by **Slovenia**, for example, can provide guidance on what measures should be recommended or required to promote gradual, more comprehensive renovation that includes energy, fire, and seismic aspects.

Lastly, technical experts, climate scientists, building designers, urban planners, and policy makers (local, regional, and national government) must engage in open dialogue on climate-proofing steps, data gaps, analytical tools to use, and measures to take. Interdisciplinary collaboration, learning, and capacity building should be enhanced at all levels—planning, design, and implementation.

► **Enhance capacities for short- to medium-term reconstruction, revitalization, and disaster response.**

IMPROVING TRAINING AND TECHNICAL SKILLS IN THE CONSTRUCTION MARKET

State-of-the-art research and practice should be applied to continual education and training, through green upskilling, to build capacity for energy-efficient and resilient construction. Such

education could be made part of the standard curriculum at universities, and additional training and certification should be made available or mandated. Currently, building residents often receive inadequate, incomplete, or deficient information about the advantages and disadvantages of certain interventions and may decide against them as a result. They may, for example, be told that the retrofit requires them to move out of the apartment when, in fact, many significant interventions can be done with the residents remaining in place.

The education and training of practicing engineers needs to be improved so they can assess, design, and implement the rehabilitation and seismic strengthening of older historic buildings, as well as combine rehabilitation and strengthening actions with energy efficiency measures based on state-of-the-art research and practice – or reconstruction, where applicable. Engineers in Croatia lack some of the technical training they need to work on existing (old and/or historic) buildings; almost all academic curricula focus on modern (post-1960) buildings, which are constructed in accordance with current regulations. During post-earthquake field inspections of building damage and usability in 2020, for example, engineers did not properly recognize the structural (load bearing) systems and elements in older buildings. This deficit not only posed problems in the immediate post-earthquake period; it continues to have implications for recovery and reconstruction, as a large market demand for expertise in the rehabilitation and reconstruction of old buildings is going unmet. Also needed is greater capacity to link seismic strengthening with energy efficiency and other types of necessary upgrades, such as fire safety, and to combine them with heritage protection requests. All such changes directly affect buildings of cultural heritage significance, as well as their protected elements—specifically, the facades (including ornaments) and openings. **Japan's** Agency for Cultural Affairs, recognizing that they require unique knowledge and approaches for seismic retrofitting, has commissioned an expert panel to develop a guide to seismic resilience measures for specific types of traditional buildings.

RAISING AWARENESS FOR ACTION

Strong media campaigns must be mounted and new funding schemes, such as those in Italy, should be developed to give private citizens incentive to invest their own funds in the energy and seismic upgrading of their buildings. Such programs should be linked with the ongoing reconstruction and rehabilitation process, as well as integrated into future policy and legislative revisions.

The risk awareness of citizens should be increased and the multiple benefits of integrating energy efficiency upgrading with seismic retrofitting communicated to them. Initiatives, such as the introduction of the seismic certificate, should be supported as an efficient way to communicate risk to citizens.

Targeted support should be considered for groups that may need it to integrate seismic and energy efficiency standards into retrofitting. This step could increase the uptake of such upgrades while also alleviating the burden on such groups. Lessons from **Japan** indicate the value of providing targeted support to small and medium enterprises and groups that need special approaches and standards, such as owners of cultural properties.

► **Address medium- to long-term regulatory, financial, and sustainability issues.**

TAKING A COMPREHENSIVE POINT OF VIEW

It is important to take time for and invest the necessary resources in comprehensive retrofits that holistically address specific deficiencies of buildings. One activity (such as energy renovation) should not be allowed to prevent other activities (such as seismic upgrading) from taking place; instead, the possibility should be left open for other renovations in the future (such as fireproofing). Experience shows that improving only the energy efficiency of buildings with significant seismic deficiencies does not make sense; the entire investment may be lost because of a single event, as demonstrated by the 2020 earthquakes. Other upgrading needs, such as fire safety, sanitation, and so on, should be addressed during seismic and energy efficiency strengthening to ensure a comprehensive solution and save funds for additional retrofits later. Also important is to document the implemented interventions (that is, their real, constructed, or derived state, which often does not correspond to the project documentation) because each new process consumes resources for the identification of the building's current state. At the very least, it is essential to document the “history of intervention” of each building and create a foundation for future activities.

Comprehensive and multifaceted DRM regulations must be developed to enhance preparedness and response to disasters. To be effective, seismic regulation must be wide reaching and include considerations for awareness raising; compliance with technical regulations and capacity building to implement technical regulations; and financial frameworks. Ideally, such regulations will also consider all other relevant hazards and urgent priorities—that is, they will integrate and/or link to regulations on energy efficiency, universal access, fire safety, flood management, and other relevant hazard preparedness measures, according to the National Risk Assessment.

Ways should be found to adapt modern energy efficiency standards, so they harmonize with traditional homes and buildings. Directly applied to traditional buildings, the energy efficiency standards designed for modern buildings present challenges. They could also hinder efforts to renovate older housing or build new housing based on principles of traditional architecture and, in turn, hinder efforts to preserve cultural heritage. In **Japan**, the modern energy efficiency standard for building envelope performance (or heat transfer coefficient) was found particularly difficult to meet in traditional buildings. The climate-adaptive housing category established there addresses this difficulty and offers an alternative pathway to meet energy efficiency standards in traditional homes.

PROMOTING A SMARTER APPROACH TO DISASTER AND CLIMATE RESILIENCE

Data to enhance local and regional climate risk models should be continually augmented. A lack of relevant information currently hinders more detailed assessment for integration into building design and urban planning.

Comprehensive measures to address multiple risks, including disasters and climate change, need to be adopted to ensure the resilience and energy efficiency of the built environment. Integrating renewable energy standards with seismic—among other hazard-related—standards can maximize resilience benefits from a single retrofitting opportunity.

Comprehensive programs should be developed that provide financial incentives for seismic and energy efficiency upgrades, new construction, and post-disaster reconstruction as part of the effort to achieve EU and global standards for renewable energy.

¹⁶⁹ The 2023 Country Report found that private investments are needed in addition to grants and subsidies improve energy efficiency in the building sector and achieve the 2030 energy efficiency targets. See EC. 2023a, [Link](#).

¹⁷⁰ See WB. 2023, [Link](#).

Investments should be made in the retrofitting and strengthening of CI and housing to improve performance against seismic and other hazards. This step involves developing national planning documents and empowering local governments responsible for implementation, while also requiring national governments to coordinate. **Japan**, for example, recognizes the importance of retrofitting critical buildings such as housing, schools, hospitals, and public facilities to improve their seismic performance and couples these structural investments with regular drills and education campaigns.

Annex 1. Further Information on Laws and Regulations

Table 5. Levels of Renovation of Earthquake-Damaged Building Structures in Relation to Mechanical Resistance and Stability – The area of the City of Zagreb, Krapina-Zagorje County, Zagreb County, Sisak-Moslavina County and Karlovac County

Renovation levels	Level 1: Repair of nonstructural elements
Claim	Bringing the nonstructural elements to the level of local load-bearing capacity and stability, by repairing or replacing the damaged nonstructural elements. Reconstructed damaged nonstructural elements should have local bearing capacity and stability in relation to earthquakes. The seismic resistance of the building as a whole is not considered.
Documentation	The works are carried out without a construction project. In order to carry out the repair of nonstructural elements of the building, it is necessary to prepare a report on the repair of nonstructural elements. The report contains graphic attachments, necessary calculations, detailed sketches of technical solutions, photographs, and technical and other descriptions.
Occupations and works	Repair of nonstructural elements includes the execution of construction and construction-craft works (if applicable): - Repair or removal and reconstruction of damaged chimneys, roof cornices and parapets, balcony fence walls - Repair or removal and reconstruction of parts of gable walls in the attic - Partial or complete rebuilding of nonbearing (partition) walls with material of the same or smaller mass - Roof repair (local replacement of rafters, laths, purlins) - Replacement of covering parts (tiles, gables) - Repair of cracks in nonstructural elements - Repair or replacement of parts of roof sheet metal, roof penetrations; repair of roof insulation, etc. - Other similar measures
Categories of buildings	- All buildings

Renovation levels	Level 2: Structural repair
Claim	Repair of the building structure in order to achieve the calculated earthquake resistance that the structure had before the earthquake, or higher, with local reinforcements of critical load-bearing elements and exceptional addition of new load-bearing vertical elements when it is a construction with significantly different earthquake resistance in one direction compared to the other.
Documentation	A construction project is being created—a construction repair project. To carry out the repair of the building, it is necessary to create: - An evaluation report on the existing state of the building structure, which, among other things, contains an assessment of the damage to the building according to EMS-98 from Table III.2. of this regulation - Construction project - Construction repair project - Project control in accordance with a special regulation prescribing project control - Projects of other professions (if necessary)
Occupations and works	The repair of the building structure includes the implementation of the following construction procedures: - Repair of cracks in load-bearing walls - More comprehensive roof repair - Repair of the staircase - Repair and connection of walls - Repair of mezzanine structures (beams, bearings, joints, etc.) and anchoring in walls - Stabilization measures for unsupported walls The implementation of the mentioned procedures includes the following construction works: - Local connection of load-bearing walls - Execution of reinforced plaster on individual walls - Installation of anchors for local connection of mezzanine structures and load-bearing walls and partitions with load-bearing walls - Reinforcement of mezzanine beams and board formwork with the aim of achieving a partially rigid diaphragm and accepting it for the perimeter walls - Local introduction of preload - Local strengthening of walls with fiber-reinforced polymer (FRP), glass fiber nets, etc. - Local rebuilding of load-bearing walls, partial or complete rebuilding of non-load-bearing (partition) walls with material of the same or lower specific weight - Execution of horizontal AB cerclages on roof parapets, cantilever walls, and gable walls - Local addition of new load-bearing elements if a significant lack of walls in one direction is determined - For buildings for which an exception is allowed, other works that contribute to increasing the seismic resistance of the building structure, but do not significantly increase the stiffness and mass of the original structure - Other measures of a similar scope as recommended by the designer - Level 2 structural repair work, if acceptable, includes Level 1 work The repair work of the Level 2 building structure should be carried out in such a way as to enable simple reinforcement of the Level 3 building structure.
Categories of buildings	Ordinary buildings that do not belong to other categories Importance class II according to HRN EN 1998-1 except for family houses and commercial buildings of importance class II according to HRN EN 1998-1. Multi-apartment, residential-business and commercial buildings, production buildings (importance class II according to HRN EN 1998-1) that are moderately damaged and considerably to severely damaged (degree of damage 2 and 3 according to EMS-98 from Table III.2. of this regulation) Agricultural and farm buildings (importance class I according to HRN EN 1998-1)

Renovation levels	Level 3: Construction reinforcement
Claim	Improvement with the aim of bringing the building structure to a state of improved calculated seismic resistance.
Documentation	A building project is being created—a project to strengthen the building structure. To carry out the repair of the building, it is necessary to create - An evaluation report on the existing state of the building structure, which, among other things, contains an assessment of the damage to the building according to EMS-98 from Table III.2. of this Regulation - A construction project—a project to strengthen the building structure - Project control in accordance with a special regulation prescribing project control - Projects of other professions (if necessary).
Occupations and works	Strengthening of the building structure damaged by the earthquake includes the implementation of the following construction procedures: - Reinforcement of load-bearing walls (injection, grouting, rebuilding, FRP, glass fiber nets anchored with glass fiber-reinforced polymer [GFRP] anchors, shotcrete) - Reinforcement or construction of new mezzanine structures and roofs with prescribed anchoring in the walls - Repair and/or construction of new staircases and landings - Construction of new (additional) rigid load-bearing walls (in place of partitions or in new positions) - Foundation reinforcement - Execution of new vertical and horizontal cerclages (complete cutting into the load-bearing structure of the wall should be avoided) - Other operations that strengthen the building structure damaged by the earthquake The implementation of the mentioned procedures includes the execution of construction works (if applicable): - From Level 1 and/or 2, to the extent and scope of appropriate strengthening of the earthquake-damaged building structure - Other works necessary for the implementation of construction interventions provided for in Level 3. Level 3 works assume that they can be continued to miscellaneous 2 works, although the building structure can be immediately strengthened to Level 3 with the interventions mentioned.
Categories of buildings	Buildings whose seismic resistance is important considering the consequences related to demolition (building importance class III according to HRN EN 1998-1) For example: - Sports buildings, cinemas, theaters, museums, churches, public administration buildings that are not vitally important for functioning after an earthquake, health institutions of lesser importance (polyclinics, health centers, etc.), pharmacies, schools, kindergartens, faculties and buildings, plants and equipment for supply and telecommunications, if they are not classified in importance class IV Family houses (building importance class II according to HRN EN 1998-1) regardless of the degree of damage Commercial buildings (importance class II according to HRN EN 1998-1) Multi-apartment, residential-business and commercial buildings, and public buildings that are significantly to severely damaged and very severely damaged (damage level 3 and 4 according to EMS-98 from Table III.2. of this regulation).

Renovation levels	Level 4: Complete reconstruction of the structure
Claim	Improvement with the aim of bringing the building structure to a state of full calculated seismic resistance in relation to the regulations.
Documentation	A construction project is being prepared—a project for the complete renovation of the building structure. To carry out the repair of the building, it is necessary to create: - An evaluation report on the existing state of the building structure, which, among other things, contains an assessment of the damage to the building according to EMS-98 from Table III.2. of this regulation - A construction project—a project for the complete renovation of the building structure - Project control in accordance with a special regulation prescribing project control - Projects of other professions (if necessary)
Occupations and works	The complete renovation of the building structure includes the implementation of construction interventions that completely restore the building structure, and are necessary to achieve the mechanical resistance and stability of the building according to the valid norms for designing the seismic resistance of the structure of the HRN EN 1998 series. The implementation of the mentioned procedures includes the execution of construction works (if applicable): - From Levels 1, 2 and 3, to the extent and coverage appropriate for the complete reconstruction of a building structure damaged by an earthquake - Other works required for the complete renovation of the building structure.
Categories of buildings	Buildings whose integrity during an earthquake is important for the wider community (buildings of importance class IV according to HRN EN 1998-1), regardless of the degree of damage. For example: – Health institutions of greater importance (clinical hospital centers, etc.), buildings of emergency services (fire brigade, ambulance, public and national security, etc.), public administration buildings of vital importance for functioning after an earthquake, buildings of vital importance for supply, telecommunications, energy buildings, buildings for storage of flammable liquids, gases and toxic materials All buildings of importance class II and III that are very badly damaged or partially collapsed (damage level 4 and 5 according to EMS-98 from Table III.2. of this regulation)

Reconstruction of earthquake-damaged building structures carried out according to the levels prescribed by this regulation increases their seismic resistance.

The expert decision on the need to repair or strengthen the building structure damaged by an earthquake, depending on the building's importance class, and the expert decision on the removal of the damaged building and the construction of a replacement, is made by the designer of the building structure.

All necessary construction operations for repair, reinforcement, or complete renovation of the building's construction are determined by the designer of the construction.

Level 2: The level of renovation should achieve a significant SDI of at least 0.5.

Level 3: The level of renovation should achieve a significant SDI of at least 0.75. At this level of renovation, in addition to checking the limit state of significant damage, it is mandatory to check the limit state of limited damage according to HRN EN 1998-3 for seismic action determined for an earthquake with a comparative probability of exceeding 10 percent in 10 years (comparative return period 95 years) and an importance factor for buildings according to HRN EN 1998-1.

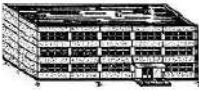
Level 4: The level of renovation should achieve a significant SDI of at least 1.0. At this level of renovation, in addition to checking the limit state of significant damage, it is mandatory to check the limit state of limited damage according to HRN EN 1998-3 for seismic action determined for an earthquake with a comparative probability of exceeding 10 percent in 10 years (comparative return period 95 years) and an importance factor for buildings according to HRN EN 1998-1.

Application of Article 16 of the Construction Act: A deviation from the basic requirement for the building prescribed by the renovation levels in this regulation is possible in case of meeting the conditions for the application of Article 16, Paragraph 1 of the Construction Act (Official Gazette, No. 153/13, 20/17, 39/19 and 125 /19), only for individually protected cultural assets of national importance and if the intended method of building construction reconstruction was previously unanimously approved by the expert committee consisting of two auditors for mechanical resistance and stability, two representatives of the academic community from the field of earthquake engineering, the branch of civil engineering, and the main state the conservator, who is appointed by the minister of spatial planning, construction and state property, in accordance with the rules of procedure adopted by the minister.

Source: GoC 2021c, [Link](#).

Table 6. Classification of Building Damage According to EMS-98

Classification of damage for masonry buildings	
	Stage 1: Negligible to small damage (no structural damage, minor nonstructural damage). Hairline cracks in a small number of walls. Falling off of only small pieces of plaster. Falling of loose wall elements from the upper parts of buildings in a small number of cases.
	Stage 2: Moderate damage (slight structural damage, moderate nonstructural damage). Cracks in many walls. Falling off of fairly large pieces of plaster. Partial demolition of the chimney.
	Level 3: Substantial to severe damage (moderate structural damage, severe nonstructural damage) Wide and numerous cracks in most walls. Tile falling off; chimney breaks in the plane of the roof; failure of certain nonstructural elements (partition walls, gables).
	Stage 4: Very heavy damage (severe structural damage, very severe nonstructural damage). Serious wall breaks; partial structural collapse of roofs and ceilings.
	Level 5: Destruction (very severe structural damage). Complete or almost complete demolition.

Classification of damage for RC buildings	
	Stage 1: Negligible to small damage (no structural damage, minor nonstructural damage). Narrow cracks in the plaster on the frame elements or at the base of the walls. Narrow cracks in partition and infill walls.
	Stage 2: Moderate damage (slight structural damage, moderate nonstructural damage). Cracks in the columns and beams of the frame and load-bearing walls. Cracks in partitions and infill walls; falling off of brittle coverings and plaster. Falling of mortar from wall panel joints.
	Level 3: Substantial to severe damage (moderate structural damage, severe nonstructural damage). Cracks in columns and beam joints; frame column at the base and in the joints of connected walls. Falling off of the concrete protective layer, buckling of reinforcing bars. Wide cracks in partition and infill walls, failure of individual infill panels.
	Stage 4: Very heavy damage (severe structural damage, very severe nonstructural damage). Wide cracks in structural elements with compressive failure of concrete and failure of reinforcement; breakdown of adhesion of bars for reinforcing beams; tilting of columns. Demolition of several columns or an individual upper floor.
	Level 5: Destruction (very severe structural damage). Demolition of the ground floor or parts of buildings (e.g., wings).

Source: Copernicus, “Damage Assessment,” [Link](#).

Table 7. Relevant Croatian National Jurisprudence: Construction/Building

Type of law	Law (in English)
Act	Building Code (Official Gazette 153/13 - Provisional Translation, 20/17, 39/19, 125/19)
	Construction Products Act (Official Gazette 76/13, 30/14, 130/17, 39/19, 118/20)
	Act on the Chamber of Architects and Chambers of Engineers in Construction and Physical Planning (Official Gazette 78/15 - Provisional Translation, 114/18, 110/19)
	Act on Physical Planning and Building Tasks and Activities (Official Gazette 78/15 - Provisional Translation, 118/18, 110/19)
	Act on Proceeding with Illegally Built Buildings (Official Gazette 86/12, 143/13, 65/17, 14/19)
	Administrative Fees Act (Official Gazette 115/16)
	Energy Efficiency Act 40/25
	Act on Reconstruction of Earthquake-damaged Buildings in the City of Zagreb, Krapina-Zagorje County, Zagreb County, Sisak-Moslavina County and Karlovac County (Official Gazette 102/20, 10/21, 117/21)
	Program of Measures for the Reconstruction of Earthquake-Damaged Buildings in the City of Zagreb, Krapina-Zagorje County, Zagreb County, Sisak-Moslavina County and Karlovac County (Official Gazette 137/21)

Act	Decision on rent financing to provide housing to persons whose property was damaged by the earthquakes in the territory of the City of Zagreb, Krapina-Zagorje County, Zagreb County, Sisak-Moslavina County and Karlovac County (Official Gazette 17/21, 65/21, 51/22)
	Decision on the provision of financial aid for the temporary and necessary protection and repair of earthquake-damaged buildings in the territory of the City of Zagreb, Krapina-Zagorje County, Zagreb County, Sisak-Moslavina County and Karlovac County (Official Gazette 34/21)
	Decision on the provision of financial aid for the procurement of condensing boilers in earthquake-damaged buildings (Official Gazette 49/21)
	Ordinance on the content and technical elements of design documents for the reconstruction, building removal design and design for the construction of replacement family houses that were earthquake damaged in the territory of the City of Zagreb, Krapina-Zagorje County, Zagreb County, Sisak-Moslavina County and Karlovac County (Official Gazette 127/20)
	Ordinance on implementation of procurement procedures of goods, services and works for reconstruction procedures (Official Gazette 126/21)
	Decision on granting an interest-free loan to local and regional self-government units affected by devastating earthquake consequences on the territory of the City of Zagreb, Zagreb County, Krapina-Zagorje County, Sisak-Moslavina County and Karlovac County for the restoration of earthquake damages (Official Gazette 12/22, 46/22, 55/22)
	Decision on the implementation of activities related to operations financed by the European Union Solidarity Fund within the scope of bodies responsible for financial contribution implementation (Official Gazette 51/22)
Regulations	Conclusion on the mitigation of consequences of global disruption in construction materials and products markets - Methodology for establishing the difference in the cost of works (Official Gazette 71/22)
	Regulation on administrative fee tariffs (Official Gazette 92/21, 93/21, 95/21) - entered into force on 1 September 2021
	Regulation on harmonization of the area of construction products with Regulation (EU) No 305/2011 in a transitional period (Official Gazette 46/13)
	Regulation on fee for retaining illegally built buildings in space (Official Gazette 98/12)
	Regulation on the definition of construction works, other projects and surfaces of state and regional significance (Official Gazette 37/14, 154/14, 30/21)
Decisions	Rulebook on building energy inspection and energy certification (40/25)
	Decision on criteria and methods for housing provision to inhabitants of destroyed buildings and for removal of remains of family houses and other residential buildings destroyed or damaged by landslides in the territory of Hrvatska Kostajnica and other areas in the Republic of Croatia (Official Gazette 60/18)
	Decision on adoption of the program for housing provision to inhabitants of destroyed buildings and for removal of remains of family houses and other residential buildings destroyed or damaged by landslides in the territory of Hrvatska Kostajnica (Official Gazette 27/19)
	Decision on the definition of relative weights for architectural and engineering and related advisory services in construction and physical planning (Official Gazette 119/18, 5/19)
	Decision on providing financial aid for the temporary and necessary protection and repair of earthquake-damaged buildings in the City of Zagreb and its surroundings (Official Gazette 55/20)
	Decision on the allocation of grant funds from the European Union Solidarity Fund approved for financing remediation of earthquake-caused damage in the City of Zagreb, Krapina-Zagorje County and Zagreb County, on the appointment and designation of responsibilities of the national coordinating body, of bodies responsible for the implementation of the financial contribution and of the independent audit body (Official Gazette 125/20)

Decisions	Decision on the adoption of the Long-term Strategy for the Reconstruction of the National Building Stock by 2050 (Official Gazette 140/20)
	Decision on the method of grant allocation from the EU Solidarity Fund to finance rehabilitation of earthquake damages in the territory of the City of Zagreb, Krapina-Zagorje County, Zagreb County, Sisak-Moslavina County, Karlovac County, Varaždin County, Međimurje County, Brod-Posavina County and Bjelovar-Bilogora County, on the appointment and on determination of responsibilities of a national coordination body, bodies responsible for the implementation of the financial contribution and an independent audit body (Official Gazette 127/21, 143/21)
	Decision on the adoption of the Program of Measures for the Reconstruction of Earthquake-damaged Buildings in the territory of the City of Zagreb, Krapina-Zagorje County, Zagreb County, Sisak-Moslavina County and Karlovac County (Official Gazette 137/21)
	Decision on the adoption of the circular management of space and buildings development program for the period 2021–2030 (Official Gazette 143/21)
	Decision on the adoption of the program of energy renovation of multi-apartment buildings for the period by 2030 (Official Gazette 143/21)
	Decision on the adoption of the program of energy renovation of buildings with the status of cultural property for the period by 2030 (Official Gazette 143/21)
	Decision on the adoption of the program to combat energy poverty, including the use of renewable energy sources in residential buildings in assisted areas and in areas of special state concern for the period by 2025 (Official Gazette 143/21)
	Decision on the adoption of the Urban Green Infrastructure Development Program for the period 2021–2030 (Official Gazette 147/21)
Ordinances	Ordinance on entry in the class of design auditors (Official Gazette 50/20)
	Ordinance on less complex works (Official Gazette 14/20)
	Ordinance on the mandatory contents and format of construction work designs (Official Gazette 118/19, 65/20)a
	Ordinance on the bodies, documentation and procedures on the construction products market (Official Gazette 118/19)b
	Ordinance on simple and other construction works and works (Official Gazette 112/17, 34/18, 36/19, 98/19, 31/20, 74/22)
	Ordinance on design validation (Official Gazette 98/99, 29/03, 20/17)
	Ordinance on the final inspection of construction works (Official Gazette 46/18, 98/19)
	Ordinance on ensuring access to construction works for disabled persons and to persons with reduced mobility (Official Gazette 78/13)
	Ordinance on supervision of construction products (Official Gazette 113/08) - Provisional Translation
	Ordinance on required expertise in the field of project management (Official Gazette 85/15)
	Ordinance on the method of establishing the construction work volume for purposes of public utility charge calculation (Official Gazette 15/19)
	Ordinance on design audit (Official Gazette 32/14, 72/20)
	Ordinance on the contents and layout of the board marking the construction site (Official Gazette 42/14)
	Ordinance on the contents of the written statement on the works completed and the requirements for the maintenance of a construction work (Official Gazette 43/14)
	Ordinance on the requirements and manner of issuing certificates to Croatian citizens and legal persons for realizing the right to provide services of the regulated profession of energy certification and energy audits of buildings in the countries that are Parties to the Agreement on the European Economic Area (Official Gazette 47/14)
	Ordinance on energy audits of buildings and energy certification (Official Gazette 88/17, 90/20, 1/21)c

Ordinances	Ordinance on the manner of performing building surveillance, the form, the requirements and manner of keeping the site diary and the contents of the supervising engineer's final report (Official Gazette 131/21, 68/22)
	Ordinance on maintenance of construction works (Official Gazette 122/14, 98/19)
	Ordinance on the control of energy certificates and reports on regular inspections of heating systems and cooling or air-conditioning systems in buildings (Official Gazette 50/25)
	Ordinance on persons authorized for energy certification, energy audits of buildings and regular inspections of heating systems and cooling or air-conditioning systems in buildings (Official Gazette 73/15, 133/15, 60/20, 78/21, 58/25)
	Ordinance on requirements and manner of issuing certificates to persons from countries that are Parties to the Agreement on the European Economic Area for providing services of energy certification and energy audits of buildings in the Republic of Croatia and on the recognition of foreign professional qualifications for providing services of energy certification and energy audits of buildings (Official Gazette 56/25)
	Ordinance on professional examination of persons performing construction and physical planning tasks (Official Gazette 129/15)
	Ordinance on professional training of persons performing physical planning and construction activities (Official Gazette 55/20)
Technical regulations	Technical regulation for windows and doors (Official Gazette 69/06)
	Technical regulation on ventilation systems, partial air conditioning and air conditioning of buildings (Official Gazette 03/07)
	Technical regulation for chimneys in construction works (Official Gazette 03/07)
	Technical regulation for protection systems against effects of lightning on construction works (Official Gazette 87/08, 33/10)
	Technical regulation on heating and cooling systems in buildings (Official Gazette 110/08) - Provisional Translation
	Technical regulation on low-voltage electrical installations (Official Gazette 05/10)
	Technical regulation on construction products (Official Gazette 35/18, 104/19)
	Technical regulation on energy economy and heat retention in buildings (Official Gazette 128/15, 70/18, 73/18, 86/18, 102/20)
	Technical regulation on technical specifications for construction products in a harmonised area (Official Gazette 4/15, 24/15, 93/15, 133/15, 36/16, 58/16, 104/16, 28/17, 88/17, 29/18, 43/19)
	Technical regulation for building structures (Official Gazette 17/17, 75/20)
	Technical regulation for masonry structures (Official Gazette 01/07)
	Technical regulation for wooden structures (Official Gazette 121/07, 58/09, 125/10, 136/12)
	Technical regulation for steel structures (Official Gazette 112/08 - Provisional Translation, 125/10, 73/12, 136/12)
	Technical regulation on composite steel and concrete structures (Official Gazette 119/09, 125/10, 136/12)
	Technical regulation for concrete structures (Official Gazette 139/09, 14/10, 125/10, 136/12)
	Technical regulation on aluminum structures (Official Gazette 80/13)d
	Technical regulation for glass constructions (Official Gazette 53/17)
	Technical regulation on asphalt structures (Official Gazette 48/21)
	Technical regulation on acoustics in buildings (71/25)

Source: Government of Croatia, “Regulations in the Field of Building,” [Link](#).

a. On the date of entry into force of this Ordinance (12 December 2019), the Ordinance on the mandatory contents and format of construction work designs (Official Gazette 64/14, 41/15, 105/15, 61/16, 20/17) cease to be valid, except Articles 27 to 29 of this Ordinance.

b. On the date of entry into force of this Ordinance (12 December 2019), the Ordinance on conformity assessment, documents of conformity and the marking of construction products (Official Gazette 103/08, 147/09, 87/10 and 129/11) cease to be valid, except for the provision of Article 4, paragraphs 4 and 5, Article 16 and Table 1 of this Ordinance and the Ordinance on technical approval for construction products (Official Gazette 103/08).

c. On the day of entry into force of this Ordinance, the Ordinance on energy audits of buildings and energy certification (Official Gazette 48/14, 150/14, 133/15, 22/16, 49/16, 87/16, 17/17 and 77/17) ceases to be valid. The provisions of the Ordinance on energy audits of construction works and energy certification of buildings (Official Gazette 81/12, 29/13 and 78/13) in the part related to the performance of energy audits of public lighting shall apply until the adoption of a special regulation that shall govern this field.

d. On the day of entry into force of the new Technical regulation for building structures (4 March 2017) these Technical regulations cease to have effect, with the exception that the standards from the lists of standards contained in these Technical regulations and relating to the non-harmonised area of construction products shall apply until the adoption of a special regulation governing construction products, provided that they are not contrary to the Technical regulation on construction products (Official Gazette 33/10, 87/10, 146/10, 81/11, 100/11 and 130/12, 81/13, 136/14 and 119/15).

Furthermore, the main design of a construction work in which the technical solution of the building structure is given in accordance with these Technical regulations shall be deemed a valid document for the issuance of acts on the basis of which building is permitted, provided that the application for the issuance of this act together with the main design is submitted within six months from the day of entry into force of the new Technical regulation for building structures.

Table 8. Relevant European Union Jurisprudence: Construction/Building

Regulation (EU) No 305/2011 of the European Parliament and of the Council of 9 March 2011 laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC (Official Journal of the European Union L 88, 4.4.2011, p. 5); full implementation of Regulation (EU) No 305/2011 came into effect on 01 July 2013
Commission Delegated Regulation (EU) No 568/2014 of 18 February 2014 amending Annex V to Regulation (EU) No 305/2011 of the European Parliament and of the Council as regards the assessment and verification of constancy of performance of construction products (Official Journal of the European Union L 157, 27.5.2014, p. 76) (shall enter into force on 16 June 2014)
Commission Delegated Regulation (EU) No 574/2014 of 21 February 2014 amending Annex III to Regulation (EU) No 305/2011 of the European Parliament and of the Council on the model to be used for drawing up a declaration of performance on construction products (Official Journal of the European Union L 159, 28.5.2014, p. 41)
Commission Implementing Regulation (EU) No 1062/2013 of 30 October 2013 on the format of the European Technical Assessment for construction products (Official Journal of the European Union L 289, 31.10.2013, p. 42)
Commission Delegated Regulation (EU) No 157/2014 of 30 October 2013 on the conditions for making a declaration of performance on construction products available on a website (Official Journal of the European Union L 52, 21.2.2014, p. 1)
Commission Delegated Regulation (EU) No 1291/2014 of 16 July 2014 on the conditions for classification, without testing, of wood-based panels under EN 13986 and solid wood paneling and cladding under EN 14915 with regard to their fire protection ability, when used for wall and ceiling covering (Official Journal of the European Union L 349, 5.12.2014, p. 25)
Commission Delegated Regulation (EU) No 1292/2014 of 17 July 2014 on the conditions for classification, without testing, of certain uncoated wood floorings under EN 14342 with regard to their reaction to fire (Official Journal of the European Union L 349, 5.12.2014, p. 27)
Commission Delegated Regulation (EU) No 1293/2014 of 17 July 2014 on the conditions for classification, without testing, of metal lath and beads for internal plastering covered by the harmonised standard EN 13658-1, metal lath and beads for external rendering covered by the harmonised standard EN 13658-2 and metal beads and feature profiles covered by the harmonised standard EN 14353, with regard to their reaction to fire (Official Journal of the European Union L 349, 5.12.2014, p. 29)
Commission Delegated Regulation (EU) 2016/364 of 1 July 2015 on the classification of the reaction to fire performance of construction products pursuant to Regulation (EU) No 305/2011 of the European Parliament and of the Council (Official Journal of the European Union L 68, 15.3.2016, p. 4–11)
Commission Delegated Decision (EU) No 1936/2015 of 8 July 2015 on the applicable systems to assess and verify constancy of performance of ventilation ducts and pipes for air ventilation (Official Journal of the European Union L 282, 28.10.2015, p. 34)
Commission Delegated Decision (EU) No 1958 /2015 of 1 July 2015 on the applicable systems to assess and verify constancy of performance of geosynthetics and related products (Official Journal of the European Union L 284, 30.10.2015, p. 181)
Commission Delegated Decision (EU) No 1959/2015 of 1 July 2015 on the applicable systems to assess and verify constancy of performance of wastewater engineering products (Official Journal of the European Union L 284, 30.10.2015, p. 184)
Commission Decision (EU) 2017/133 of 25 January 2017 on the maintenance with a restriction in the Official Journal of the European Union of the reference of harmonised standard EN 14342:2013 ‘Wood flooring and parquet: Characteristics, evaluation of conformity and marking’ in accordance with Regulation (EU) No 305/2011 of the European Parliament and of the Council (Official Journal L 21, 26.1.2017, p. 113–115)
Commission Decision (EU) 2017/145 of 25 January 2017 on the maintenance with a restriction in the Official Journal of the European Union of the reference of harmonised standard EN 14904:2006 ‘Surfaces for sport areas — Indoor surfaces for multi-sports use: Specification’ in accordance with Regulation (EU) No 305/2011 of the European Parliament and of the Council (Official Journal L 22, 27.1.2017, p. 62–64)

Commission Delegated Regulation (EU) 2017/959 of 24 February 2017 on the classification of horizontal settlement and short-term water absorption performance for in situ formed loose fill cellulose (LFCI) thermal insulation products under EN 15101-1 pursuant to Regulation (EU) No 305/2011 of the European Parliament and of the Council (Official Journal of the European Union L 145, 8.6.2017, p. 1–3)
Commission Delegated Regulation (EU) 2017/1227 of 20 March 2017 on the conditions for classification, without testing, of glued laminated timber products covered by the harmonised standard EN 14080 and structural finger jointed solid timber products covered by the harmonised standard EN 15497 with regard to their reaction to fire and amending Decision 2005/610/EC (Official Journal of the European Union L 177, 8.7.2017, p. 1–3)
Commission Delegated Regulation (EU) 2017/1228 of 20 March 2017 on the conditions for classification, without testing, of external renders and internal plasters based on organic binders covered by the harmonised standard EN 15824 and rendering and plastering mortars covered by the harmonised standard EN 998-1 with regard to their reaction to fire (Official Journal of the European Union L 177, 8.7.2017, p. 4–5)
Commission Delegated Regulation (EU) 2017/1475 of 26 January 2017 on the classification of frost resistance performance for clay tiles under EN 1304 pursuant to Regulation (EU) No 305/2011 of the European Parliament and of the Council (Official Journal of the European Union L 211, 17.8.2017, p. 1–2)
Commission Delegated Regulation (EU) 2017/2293 of 3 August 2017 on the conditions for classification, without testing, of cross laminated timber products covered by the harmonised standard EN 16351 and laminated veneer lumber products covered by the harmonised standard EN 14374 with regard to their reaction to fire (Official Journal of the European Union L 329, 13.12.2017, p. 1–3)
Commission Delegated Regulation (EU) 2018/771 of 25 January 2018 on the applicable system to assess and verify constancy of performance of anchor devices used for construction works and intended to prevent persons from falling from a height or to arrest falls from a height pursuant to Regulation (EU) No 305/2011 of the European Parliament and of the Council (Official Journal of the European Union L 129, 25.5.2018, p. 8–83)
Commission Delegated Regulation (EU) 2018/779 of 19 February 2018 on the applicable systems to assess and verify constancy of performance of metal-faced sandwich panels for structural use pursuant to Regulation (EU) No 305/2011 of the European Parliament and of the Council (Official Journal of the European Union L 131, 29.5.2018, p. 23–24)
Commission Implementing Decision (EU) 2019/450 of 19 March 2019 on publication of the European Assessment Documents (EADs) for construction products drafted in support of Regulation (EU) No 305/2011 of the European Parliament and of the Council (Official Journal of the European Union L 77, 20.3.2019, p. 78–9)
Commission Implementing Decision (EU) 2019/451 of 19 March 2019 on the harmonised standards for construction products drafted in support of Regulation (EU) No 305/2011 of the European Parliament and of the Council (Official Journal of the European Union L 77, 20.3.2019, p. 80–2)
Commission Delegated Regulation (EU) 2019/1188 of 14 March 2019 supplementing Regulation (EU) No 305/2011 of the European Parliament and of the Council by establishing classes of performance in relation to resistance to wind load for external blinds and awnings (Official Journal of the European Union L 187, 12.7.2018, p. 11–3)
Commission Delegated Regulation (EU) 2019/1342 of 14 March 2019 supplementing Regulation (EU) No 305/2011 of the European Parliament and of the Council by establishing classes of performance in relation to air permeability for roof lights of plastics and glass and roof hatches (Official Journal of the European Union L 211, 12.8.2018, p. 1–3)
Commission Delegated Decision (EU) 2019/1764 of 14 March 2019 supplementing Regulation (EU) No 305/2011 of the European Parliament and of the Council with regard to the applicable systems to assess and verify constancy of performance of balustrade kits and railing kits intended to be used in construction works solely to prevent falls and not submitted to vertical loads from the structure (Official Journal of the European Union L 270, 24.10.2019, p. 81–83)
Commission Delegated Regulation (EU) 2024/1399 of 10 November 2023 on the conditions for classification, without testing, of solid wood panelling and cladding with regard to their reaction to fire and amending Decision 2006/213/EC (Official Journal of the European Union L 2024/1399, 22.5.2024.)
Commission Delegated Regulation (EU) 2024/1681 of 6 March 2024 supplementing Regulation (EU) No 305/2011 of the European Parliament and of the Council by establishing classes of performance in relation to the resistance to fire of construction products. (Official Journal of the European Union L 2024/1681, 13.6.2024.)

Source: Government of Croatia, “Regulations in the Field of Building,” [Link](#).

Table 9. Relevant Croatian National Jurisprudence: Energy Efficiency

Type of law	Law (in English)
Law	Law on Energy Efficiency (Official Gazette 127/14 , 116/18 , 25/20 , 41/21)
	Law on Construction (Official Gazette 153/13 , 20/17 , 39/19 , 125/19)
	RegulationsRegulation on contracting and implementation of energy services in the public sector (Official Gazette 11/15)
	DecisionsDecision on adoption of the long-term strategy for the renewal of the national building fund until 2050 (Official Gazette 140/20) Long-term strategy for the renewal of the national building fund until 2050
	Decision on the Adoption of the Program for the Development of Circular Management of Space and Buildings for the Period from 2021 to 2030 (Official Gazette 143/21) Program for the Development of Circular Management of Space and Buildings for the Period from 2021 to 2030
	Decision on adoption of the program for energy renovation of multi-apartment buildings for the period up to 2030 (Official Gazette 143/21) Program for energy renovation of multi-apartment buildings for the period up to 2030
	Decision on adoption of the Energy Renovation Program for buildings that have the status of cultural property for the period until 2030 (Official Gazette 143/21) Program for the energy renovation of buildings that have the status of cultural property for the period until 2030
	Decision on the adoption of the Energy Poverty Suppression Program, which includes the use of renewable energy sources in residential buildings in subsidized areas and areas of special state care for the period until 2025 (Official Gazette 143/21) Energy Poverty Suppression Program, which includes the use of renewable energy sources in residential buildings in subsidized areas and areas of special state care for the period up to 2025
	Decision on adopting the Program for the Development of Green Infrastructure in Urban Areas for the Period from 2021 to 2030 (Official Gazette 147/21) Program for the Development of Green Infrastructure in Urban Areas for the Period from 2021 to 2030
	Decision on Adoption of the Program for Energy Renovation of Public Sector Buildings for the Period Until 2030 (Official Gazette 41/22) Program for Energy Renovation of Public Sector Buildings for the Period Until 2030
Ordinances	Ordinance on building energy inspection and energy certification (Official Gazette 88/17 , 90/20 , 1/21 , 45/21)
	Rulebook on conditions and standards for determining the quality system of services and works for the certification of installers of renewable energy sources - photovoltaic systems (Official Gazette 56/15)
	Rulebook on conditions and standards for determining the quality system of services and works for the certification of installers of renewable energy sources - solar thermal systems (Official Gazette 33/15 , 56/15 , 12/17)
	Rulebook on conditions and standards for determining the quality system of services and works for the certification of installers of renewable energy sources - small biomass boilers and stoves (Official Gazette 39/15 , 56/15 12/17)
	Rulebook on conditions and criteria for determining the quality system of services and works for the certification of installers of renewable energy sources - shallow geothermal systems and heat pumps (Official Gazette 56/15 , 12/17)
	Rulebook on systematic energy management in the public sector (Official Gazette 18/15 , 06/16)

Ordinances	Rulebook on control of the building's energy certificate and reports on the regular inspection of the heating system and the cooling or air conditioning system in the building (Official Gazette 73/15, 54/20)
	Rulebook on persons authorized for energy certification, energy audit of the building and regular inspection of the heating system and the cooling or air conditioning system in the building (Official Gazette 73/15, 133/15, 60/20, 78/21)
	Rulebook on the conditions and manner of issuing a certificate to Croatian citizens and legal entities for the exercise of the right to provide services of the regulated profession of energy certification and energy inspection of buildings in the contracting states of the Agreement on the European Economic Area (Official Gazette 47/14)
	Rulebook on the conditions and manner of issuing certificates to persons from contracting states of the Agreement on the European Economic Area for the provision of energy certification and energy inspection of buildings in the Republic of Croatia and the recognition of foreign professional qualifications for the provision of energy certification and energy inspection of buildings (Official Gazette 77/15)
	Rulebook on the system of training and certification of construction workers who install parts of the building that affect energy efficiency in building construction (Official Gazette 67/17)
Technical regulations	Technical regulation on rational use of energy and thermal protection in buildings (Official Gazette 128/15, 70/18, 73/18, 86/18, 102/20)
	Note of the Ministry on the application of provisions for the design of almost zero energy buildings
Other	Guidelines for creating an analysis of the existing state of the building with proposed measures and investment assessment in the section - healthy indoor climate conditions, mechanical resistance and stability, safety in case of fire
	Meteorological data - applicable from 01.01.2016.
	<u>Catalog of standard solutions for the application of alternative systems for buildings with an area of 50 to 1000 m²</u>
	<u>Applicability study of alternative systems</u>
	<u>Decision on the Methodology of Energy Inspection of Buildings (2021)</u>
	Methodology for conducting energy audits of buildings - applies from July 1, 2021
	<u>The new primary energy and CO₂ factors published on April 1, 2022 are not in mandatory application until further notice</u>
	Algorithm for calculating the energy properties of buildings - published on 15.05.2017, in mandatory application from 30.09.2017)
	Algorithms and calculation procedures necessary for updating and upgrading the computer program for calculating the energy performance of the building - published on October 5, 2021, not in mandatory application until further notice
	The algorithm for the preparation of meteorological data when calculating the energy performance of buildings, published on 08.12.2020, is not in mandatory application until further notice
	<u>Plan to increase the number of almost zero energy buildings by 2020</u>
	<u>Decision on repealing Decisions on the highest cost prices for the control of issued building energy certificates and reports on the regular inspection of the heating system and the cooling and air conditioning system in the building</u>
	Energy development strategy

Source: Government of Croatia, "The Field of Energy Efficiency" [Područje energetske učinkovitosti], Link.

Table 10. Relevant European Union Jurisprudence: Energy Efficiency

Directive (EU) 2018/844 of the European Parliament and of 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 (Official Journal of the European Union L 156, 19.6.2018 , p. 75)
Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy efficiency of buildings (amendment) (Official Journal of the European Union L 153 , 19.5.2010 , p. 13)
Special edition in Croatian: Chapter 12, Volume 003, p. 124
Amendment of Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy efficiency of buildings (Official Journal of the European Union L 5 , 9 January 2015 , p. 22)
Delegated Regulation Of The Commission (EU) No. 244/2012 of January 16, 2012 amending Directive 2010/31/EU of the European Parliament and of the Council on the energy performance of buildings by establishing a comparative methodological framework for calculating cost-optimal levels for the minimum requirements for the energy performance of buildings and parts of buildings (Text relevant to the EEA) (Official Journal of the European Union L 81 , 21/03/2012 , p. 18)
Special edition in Croatian: Chapter 12, Volume 005, p. 129
Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC (Text relevant to the EEA) (Official Journal of the European Union L 315 , 14.11.2012 , p. 1)
Special edition in Croatian: Chapter 12, Volume 004, p. 202
Special edition of the Official Journal of the European Union in the Croatian language, which contains the texts of binding general acts adopted in the period from 1952 to the date of accession - Chapter 12 Energy (Special edition of the Official Journal in the Croatian language: Chapter 12 - Energy , 2013)
Guidelines accompanying Commission Delegated Regulation (EU) No 244/2012 (Official Journal of the European Union C 115 , 19.4.2012 , p. 1)
Reports according to Article 5(2) of Directive 2010/31/EU and Article 6 of Regulation (EU) 244/2012 of 16.1.2012
Commission Recommendation (EU) 2016/1318 of 29 July 2016 on guidelines for the promotion of nearly zero-energy buildings and best practice to ensure that by 2020 all new buildings are nearly zero-energy buildings (Official Journal of the European Union L 208 , 2.8.2016 p. 46)
Eurostat guidance note: The recording of Energy Performance Contracts in government accounts

Source: Government of Croatia, "Regulations in the Field of Building," [Link](#).

Table 11. Relevant European Union Jurisprudence: Disaster Risk Management

Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks
Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 on establishing an infrastructure for spatial information in the European Community (INSPIRE)
Council Directive 2008/114/EC of 8 December 2008 on the identification and designation of European critical infrastructures and the assessment of the need to improve their protection
Directive (EU) 2022/2557 of the European Parliament and of the Council of 14 December 2022 on the resilience of critical entities and repealing Council Directive 2008/114/EC
Directive (EU) 2022/2555 of the European Parliament and of the Council of 14 December 2022 on measures for a high common level of cybersecurity across the Union, amending Regulation (EU) No 910/2014 and Directive (EU) 2018/1972, and repealing Directive (EU) 2016/1148 (NIS 2 Directive)
Council Regulation (EU) 2016/369 on the provision of emergency support within the Union
Decision No. 1313/2013/EU of the European Parliament and of the Council on a Union Civil Protection Mechanism (updated 2019)
Regulation (EC) No. 1257/96 concerning humanitarian aid
Directive 2001/42/EC on the assessment of the effects of certain plans and programs on the environment (SEA Directive)
Directive 2012/18/EU of the European Parliament and of the Council of 4 July 2012 on the control of major accident hazards involving dangerous substances, amending and subsequently repealing Council Directive 96/82/EC text with European Economic Area (EEA) Relevance (Seveso III Directive)
Regulation (EU) No 375/2014 of the European Parliament and of the Council of 3 April 2014 establishing the European Voluntary Humanitarian Aid Corps ('EU Aid Volunteers initiative')
Council Regulation (EU) 2016/369 of 15 March 2016 on the provision of emergency support within the Union
Commission Implementing Decision (EU) 2019/1310 of 31 July 2019 laying down rules on the operation of the European Civil Protection Pool and rescEU (notified under document C(2019) 5614)
Decision (EU) 2019/420 of the European Parliament and of the Council of 13 March 2019 amending Decision No. 1313/2013/EU on a Union Civil Protection Mechanism PE/90/2018/REV/1
Commission Implementing Decision (EU) 2020/452 of 26 March 2020 amending Implementing Decision (EU) 2019/570 as regards capacities established to respond to low probability risks with a high impact (notified under document C(2020) 2011)
Commission Implementing Decision (EU) 2020/414 of 19 March 2020 amending Implementing Decision (EU) 2019/570 as regards medical stockpiling rescEU capacities
Commission Implementing Decision (EU) 2021/88 of 26 January 2021 amending Implementing Decision (EU) 2019/570 as regards rescue capacities in the area of chemical, biological, radiological and nuclear incidents (notified under document C(2021) 313)
Agreement concerning the International Carriage of Dangerous Goods by Road (ADR 2021)
European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways (ADN)
Council Directive 96/49/EC of 23 July 1996 on the approximation of the laws of the Member States with regard to the transport of dangerous goods by rail
Nuclear Safety Directive (2014/87/Euratom)

Source: Authors.

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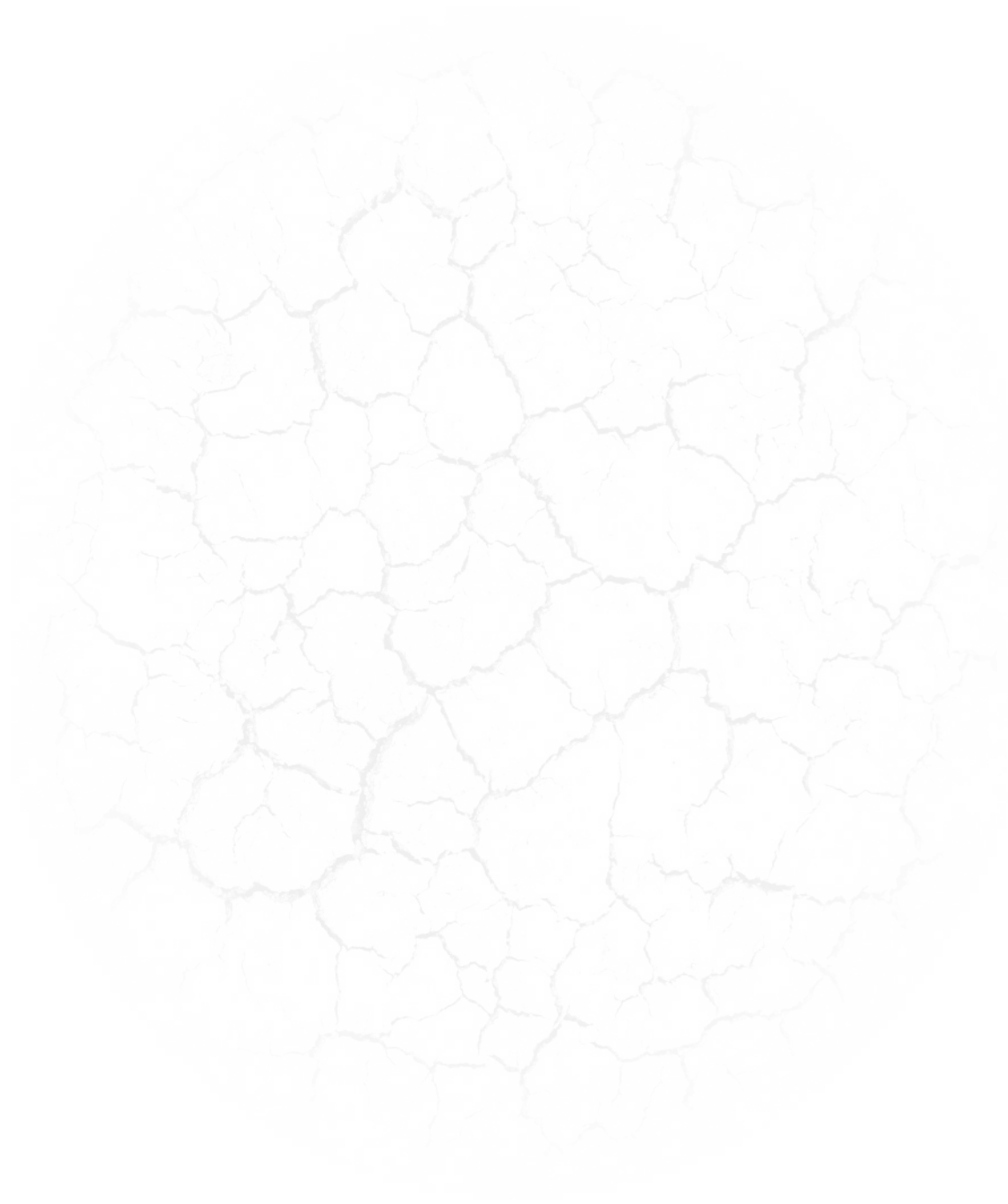
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