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REEBUILD Integrated Techniques for the Seismic Strengthening and Energy Efficiency of Existing Buildings

Policy measures for seismic and energy upgrading of buildings in EU Member States

Pohoryles, DA • Gkatzogias, K • Tsionis, G (editors)

Butenweg, C • Gervasio, H • Gkatzogias, K • Manfredi, V • Masi, A • Pohoryles, DA • Tsionis, G • Zaharieva, R

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Joint Research Centre

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Contact information
JRC-REEBUILD@ec.europa.eu

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Policy measures for seismic and energy upgrading of buildings in EU Member States

Editors:

Daniel A Pohoryles, Joint Research Centre, European Commission
Konstantinos Gkatzogias, Joint Research Centre, European Commission
Georgios Tsionis, Joint Research Centre, European Commission

Authors:

Christoph Butenweg, SDA Engineering
Helena Gervasio, University of Coimbra
Konstantinos Gkatzogias, Joint Research Centre, European Commission
Vincenzo Manfredi, University of Basilicata
Angelo Masi, University of Basilicata
Daniel A Pohoryles, Joint Research Centre, European Commission
Georgios Tsionis, Joint Research Centre, European Commission
Roumiana Zaharieva, University of Architecture, Civil Engineering and Geodesy

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Foreword

Our buildings are ageing, posing an urgent need for renovation to align with the goals of multidimensional European and international policies. The built-up area in Europe covers 25 billion square meters, 10 billion of which were constructed before 1960 and 20 billion before 1990. 40% of the European Union (EU) buildings are located in seismic prone regions and were built without modern seismic design considerations. Apart from Member States with moderate and high seismic risk, such as Greece, Italy and Croatia, with a severe impact from earthquakes during the last decades (fatalities, injuries and economic losses), attention should be drawn to regions with lower risk, e.g. in France and Spain. At the same time, buildings stand out as one of the most energy consuming sectors, therefore having a negative environmental impact. In fact, buildings are responsible for 40% of the EU energy consumption and 36% of the EU total CO_2 emissions, whereas 75% of the EU existing building stock is considered energy inefficient. The highest amount of energy use in old buildings derives by far from the operational stage of their life (e.g. heating, cooling), resulting in a significant source of carbon emissions with detrimental effects on climate change.

Notwithstanding this negative impact, the building sector provides a unique opportunity to create, through risk-proofed renovation, a safe, sustainable, and resilient built environment which promotes wellbeing and economic growth, and ensures that EU energy and climate targets are met. In this context, the European Parliament entrusted the European Commission's Joint Research Centre with the two-year pilot project "Integrated techniques for the seismic strengthening and energy efficiency of existing buildings" or REEBUILD.

REEBUILD 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. Thereby, increased earthquake resilience and limited environmental impact of buildings is sought by protecting life, economy and the environment. The project has the following key-objectives:

- Define the tools and guidelines to reduce, all at once, vulnerability and energy inefficiency of buildings
- Stimulate the use of integrated solutions
- Create awareness about the topic in the aim of prevention
- Increase resilience of the built environment to seismic hazard and climate change.

The geographical scope of the project covers EU seismic prone regions. However, all EU citizens are potential beneficiaries of the project since it can easily be extended to all EU regions considering the ageing of existing buildings and other hazards, including extreme climatic events.

In a policy context, REEBUILD provides scientific advice to support the development of an action plan, which shall supplement existing European Union policies and initiatives in the field of buildings' renovation. Crucially, the European Green Deal (COM (2019)640) emphasises the need for a Renovation Wave (COM (2020)662), supported by the New European Bauhaus ([1]) (COM (2021)573) to create sustainable, inclusive and beautiful living spaces. The plans to put the European Green Deal into effect further contribute to the economic recovery following the COVID-19 pandemic. In the Energy Performance of Buildings Directive (Directive 2018/844), and the recent proposal for its revision (COM 2021/802), besides reducing greenhouse gas and carbon emissions, measures related to seismic risk and fire safety are encouraged for planning deep renovations. The implementation of clean and circular economy principles for the construction sector to achieve a climate-neutral society by 2050 are stressed in the new Circular Economy Action Plan (COM (2020)98) which also addresses the revision of the Construction Products Regulation (Regulation (EU) 305/2011). The new idea for a holistic approach to the renovation of buildings is in line with the Union Civil Protection Mechanism (Decision (EU) 2019/420), with respect to disaster prevention measures and the integration of risk reduction and cohesion policies. Likewise, the Action Plan on the Sendai Framework (SWD 2016/205) encourages investment in disaster risk reduction, integrating "Build Back Better" principles for a more resilient built environment. The European Framework for Action on Cultural Heritage (European Commission, 2019) emphasises the need to safeguard cultural heritage against natural disasters and climate change, and relevant measures are encouraged when planning long-term renovation strategies and national disaster risk reduction strategies. The above policies and initiatives contribute to the 2030 Agenda for Sustainable Development ([2]) (Resolution 2015/A/Res/70/1) and the Sustainable Development Goal 11 "Make cities and human settlements inclusive, safe, resilient and sustainable".

([1]) https://europa.eu/new-european-bauhaus/index_en
([2]) https://knowsdgs.jrc.ec.europa.eu/intro-policy-mapping

Integrated retrofitting of existing buildings can be seen as a nexus between policies improving the disaster resilience of the EU, encouraging the energy renovation of buildings, promoting circularity within the building sector, and protecting cultural heritage.

Several activities were foreseen to achieve the REEBUILD objectives. EU buildings requiring upgrading were identified, and existing seismic and energy retrofit technologies were assessed in a life-cycle perspective. Combined retrofit solutions were explored based on available technologies and recent scientific developments in the field. A simplified method for the assessment of the combined upgrading was proposed and applied to case studies of representative building typologies retrofitted with the identified solutions. Seismic risk and energy performance of buildings along with socioeconomic aspects were assessed at regional level throughout Europe. Such regional assessments were used to identify appropriate intervention scenarios based on their regional impact and highlight the regions where interventions are of higher priority. National, regional and local authorities, industrial associations and expert communities were involved in enquiries and discussions of relevant implementing measures (legislation, incentives, guidance and standards), technologies and methodologies for the combined upgrading of existing buildings. Dissemination and outreach is further supported by reports, a web platform and public communication material. REEBUILD activities were organised in five main actions:

1. Overview and classification of technologies for seismic strengthening and energy upgrading of existing buildings
2. Analysis of technologies for combined upgrading of existing buildings
3. Methodologies for assessing the combined effect of upgrading
4. Regional impact assessment and contributions to an action plan
5. Stakeholders' engagement.

This report provides a summary of existing seismic and energy-efficient implementing measures such as legislation, incentives, guidance and standards for 16 EU MS.

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The pilot project 'Integrated techniques for the seismic strengthening and energy efficiency of existing buildings' or REEBUILD was financed by the European Union under the Commission Decision C(2019) 3874 final of 28 May 2019.

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Editors

Daniel A. Pohoryles, Konstantinos Gkatzogias, Georgios Tsionis

Authors

Chapters 1, 2, 3:	Daniel A. Pohoryles, Konstantinos Gkatzogias, Georgios Tsionis
Chapters 4, 9, 11, 16, 19:	Christoph Butenweg
Chapters 5, 6, 7, 10, 15, 17:	Roumiana Zaharieva
Chapters 8, 13, 14, 18:	Helena Gervasio
Chapter 12:	Angelo Masi, Vincenzo Manfredi
Chapter 20:	Christoph Butenweg, Helena Gervasio, Konstantinos Gkatzogias, Vincenzo Manfredi, Angelo Masi, Daniel A. Pohoryles, Georgios Tsionis, Roumiana Zaharieva

Abstract

With the aim of promoting an integrated renovation approach according to the scope of this Pilot Project, this report provides an overview of collected implementing measures for the upgrading of existing buildings across 16 EU Member States. The review includes measures such as legislation, incentives and guidance for improving the seismic and energy performance of buildings in EU Member States that included seismic risk in their national risk assessment in 2015: Austria, Bulgaria, Croatia, Cyprus, France, Germany, Greece, Hungary, Italy, Malta, Portugal, Romania, Slovakia, Slovenia, Spain and Sweden. Specific measures are presented and divided according to the objectives of "Seismic Strengthening", "Energy Upgrading", and, where available, "Seismic Strengthening & Energy Upgrading" within the built environment. Most identified measures regarding energy upgrading are implementations of National Energy Efficiency Action Plans and Long Term Renovation Strategies in line with the Energy Efficiency Directive and the Energy Performance of Buildings Directive. Instead, information regarding legislation, norms and standards for the seismic upgrading of buildings are more scarcely available and highly dependent of the perceived seismic risk in the respective Member State. Examples of measures for combined seismic and energy upgrading are few, including the Ecosisma bonus tax-break schemes in Italy, the recently published legislation for the rehabilitation of existing buildings in Portugal, energy upgrading funding linked to verifying structural performance requirements in Bulgaria and Romania or the “building cards” instrument in Slovenia. Finally, general recommendations for implementing measures are provided, based on the best practices identified in the studied Member States.

1 Introduction

Given that 80% of buildings in the EU were built before 1990 and can be considered energy-inefficient, the modernisation of the European building stock is central to key priorities of the European Commission. Crucially, the European Green Deal (COM (2019)640) emphasises the need for a buildings' Renovation Wave (COM (2020)662), supported by the establishment of a New European Bauhaus (COM (2021)573), in order to achieve ambitious energy and greenhouse gas reduction targets by 2030 and a climate-neutral society by 2050. This will be combined with the implementation of clean and circular economy principles, e.g. as set out in the context of the New Circular Economy Action Plan (Communication 2020/98).

With a large proportion of buildings in Europe having inadequacies in terms of structural and thermal performance, the scale of refurbishment works needed is significant. This comes with a significant financial burden in terms of the required investments into building renovation. To ensure cost-effectiveness and longevity of energy upgrading investments, a holistic approach to renovation is instrumental, as currently explored by the Pilot Project (PP) "Integrated Techniques for the Seismic Strengthening and Energy Efficiency of Existing Buildings", financed by the European Union (EU) under decision C/2019/3874-final of 28 May 2019. The PP 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. Thereby, increased earthquake resilience and limited environmental impact of buildings is sought by reducing CO_2 emissions and the waste generated through building replacement actions or future earthquake disasters.

The integrated retrofitting of buildings can be seen as the nexus between policies encouraging the energy renovation of buildings, as in the Energy Performance of Buildings Directive (Directive (EU) 2018/844), promoting circularity within the building sector, improving the disaster resilience of the EU, as well as protecting cultural heritage. The new idea for a holistic approach to the renovation of buildings is in line with the Union Civil Protection Mechanism (Decision (EU) 2019/420), with respect to the importance of disaster prevention measures and integration of risk reduction and cohesion policies.

As a consequence of the legal requirements to transpose EU directives into national legislation and to encourage renovation of their building stock, EU Member States (MS) have adopted different implementing measures including legislation, incentives, guidance and standards. With the aim of promoting an integrated renovation approach as proposed in this Pilot Project, this report provides an overview and assessment of current implementing measures for the upgrading of existing buildings across 16 EU MS. Specific measures are presented and divided according to the objectives of "Seismic Strengthening", "Energy Upgrading", and, where available, "Seismic Strengthening & Energy Upgrading" within the built environment. Best practices from the 16 MS are highlighted, aiming to learn from the current state-of-practice for future implementing measures at EU and national level. By providing an overview of measures implemented in the 16 MS, this report intends to give to policy makers examples of policy measures and good practice.

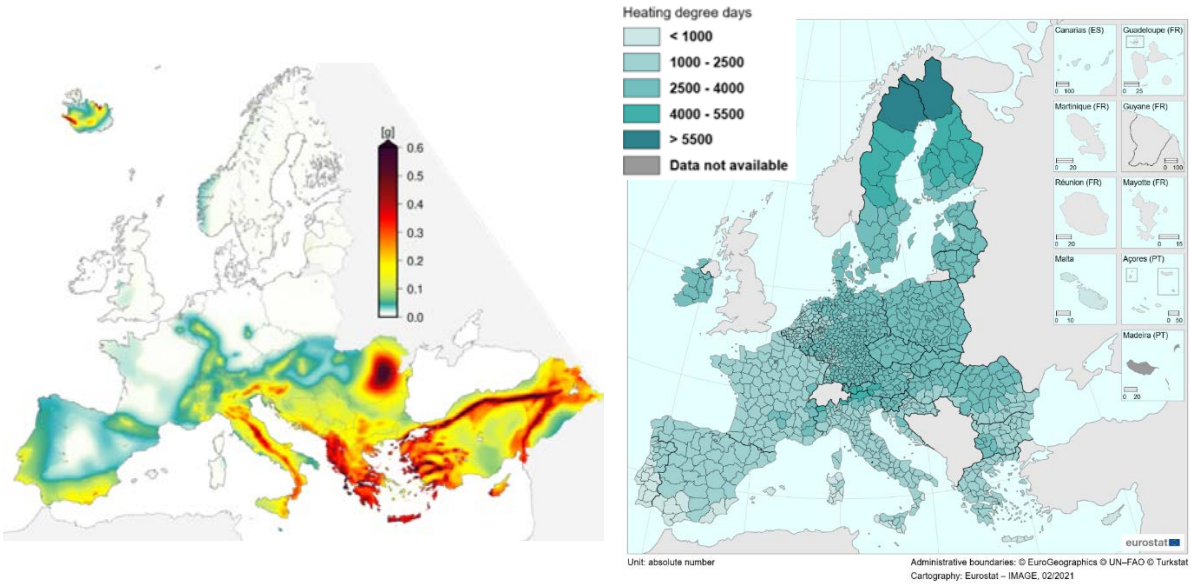
To provide the context for the implementing measures presented in this report, the seismicity and climatic conditions across the EU are first presented in Chapter 2. This is followed by an overview of measures for seismic strengthening and energy upgrading at EU level in Chapter 3. Then, an overview of implementing measures and best practices is given for the EU Member States that included earthquakes in their national risk assessment in 2015 (European Commission, 2017), namely Austria (Chapter 4), Bulgaria (Chapter 5), Croatia (Chapter 6), Cyprus (Chapter 7), France (Chapter 8), Germany (Chapter 9), Greece (Chapter 10), Hungary (Chapter 11), Italy (Chapter 12), Malta (Chapter 13), Portugal (Chapter 14), Romania (Chapter 15), Slovakia (Chapter 16), Slovenia (Chapter 17), Spain (Chapter 18), and Sweden (Chapter 19). In each chapter measures were classified by sector, i.e. measures related to seismic strengthening, energy efficiency upgrading, combined renovation.

2 Seismic and climatic characterisation

The adoption of measures by each country is driven by the respective vulnerability to seismic events and climatic conditions. Therefore, a brief overview of the climate and seismic hazard of Europe is provided here, to give an adequate context for the measures implemented in each country presented in this report. In each country-specific chapter, further information on local seismicity and climate conditions is provided.

Figure 1a displays the seismicity of European countries based on the 2021 European Seismic Hazard Model (Danciu et al., 2021). Specifically, it shows the mean peak ground acceleration (PGA) in units of gravity (g) with a 10% exceedance probability in 50 years. White indicates regions with no seismic hazard, while cold-blue colours indicate comparatively low hazard areas (PGA ≤ 0.1g), yellow and orange indicate moderate-hazard values (0.1g < PGA ≤ 0.25g), and red colours indicate high-hazard areas (PGA ≥ 0.25g). It can be generally observed that the seismicity is higher in the Mediterranean, Balkan and central European countries.

Figure 1. (a) European seismic hazard map - mean PGA [g] for a return period of 475 years; (b) Heating Degree Days in the EU-27 at NUTS3 level, 2020 data.



(a) (b)

Source: (a) ESHM20 - Danciu et al. (2021), (b) Eurostat (2021), Cooling and Heating degree days by NUTS3 regions (nrg_chddr2_a)

Instead, to understand building energy requirements, Heating Degree Days (HDD) and Cooling Degree Days (CDD) are a useful proxy for representing climatic conditions. Degree Days are quantitative indices with a direct correlation to the energy demand for heating or cooling buildings. Both variables are derived from measurements of outside temperature according to the Eurostat baseline temperatures for HDDs and CDDs (15 °C and 24 °C, respectively). The sum of difference of the outside temperature with the base line temperature gives the annual HDD and CDD. Indicatively for the intensity of heating requirements in different EU MS, **Figure 1b** presents the HDD values at NUTS3 level across the EU for 2020 (Eurostat, 2021). Conversely to the distribution of seismic hazard, Northern European countries and alpine regions present more demanding climates with respect to heating needs, as indicated by darker shades of blue in **Figure 1b**.

3 Measures at the EU level

While the objective of this report is to discuss country-specific implementation measures for seismic strengthening and energy upgrading, it is important to summarise main measures introduced at EU-level, which have relevance for all MS. These are presented in the following section.

3.1 Seismic strengthening

First issued in 2005, Part 3 of the European standard EN 1998 (Eurocode 1998-3, 2005) was developed for the seismic retrofitting of the existing buildings in seismic regions. The scope of EN 1998-3 is to provide criteria for the evaluation of the seismic performance of existing individual building structures and to describe the approach to select necessary strengthening measures. Furthermore, Part 3 of Eurocode 8 provides criteria for the design of retrofitting measures regarding the conception, the structural analysis with intervention measures, the dimensioning of structural members and their connections to existing structural elements.

The publication of National Annexes (NA) for EN 1998 is often linked to the necessity of seismic design in each country, as it is evident that the publication rate is significantly lower in the northern countries where seismicity is low. EN 1998-3 is obligatory for use in Bulgaria, Cyprus, France, Portugal Slovenia, while Malta and Sweden have not published any NA for the EN 1998 Parts. Germany had published NAs for EN 1998 Parts 1, 2 and 5 by 2015 and Hungary for EN Parts 1, 3 and 5. In Slovakia the NA for EN 1998-3 was also published. Croatia has published NAs for all EN 1998 Parts, but the use of the Eurocodes is not obligatory. In Greece, the NA has also been published, but the Greek Code for Assessment and Retrofitting (KAN.EPE, 2012) is applied in parallel with EN 1998-3 as noncontradictory complementary information (Athanasopoulou et al., 2019). For more detailed information about the state of implementation of EN 1998-3 and the Eurocodes in general, the reader is referred to recent works by Athanasopoulou et al. (2018, 2019) and Dimova et al. (2015).

The Union Civil Protection Mechanism, UCPM, (Decisions 2013/1313/EU, 2019/420) promotes resilience from man-made and natural hazards and facilitates cooperation and sharing of knowledge and best practices between participating states in the field of risk mitigation, management and preparedness. Further important objectives are to achieve a high level of protection against disasters by reducing their potential effects, by fostering a culture of prevention and to increase the public awareness and preparedness for disasters. The objectives are generally described for all natural and man-made disasters and they are not directly addressing the seismic strengthening of buildings.

In the framework of the UCPM, the Commission recently provided an overview of natural and man-made disaster risks the European Union may face (European Commission, 2021). Seismic risk is included within the twelve selected disaster risks and an assessment of the implications for risk management is provided. National risk assessments evaluated in the report indicate seismic risk is considered in 22 of the countries that are participating in the UCPM[3]. Crucially, it was noted that the exposure to earthquakes has been increasing over recent decades and, in particular, exposed built-up environment increased by 142% between 1975 and 2015. Given that it is not possible to avoid the occurrence of earthquakes, risk mitigation policies focussing on increasing resilience, reducing vulnerabilities and minimising exposure of elements at risk are suggested. To prevent loss of life and damage to infrastructure, economy, environment and cultural heritage, ensuring structural safety through the implementation of Eurocode 8[4] for new construction and retrofitting of existing ones is supported by the report Additionally, investment in risk mitigation, as well as cross-border and transnational cooperation in this area is recommended.

The purpose of the Action Plan on the Sendai Framework for Disaster Risk Reduction 2015-2030 (SWD 2016/205) is to enhance the reduction and prevention of disaster risk around the world. The Action Plan encourages investment in disaster risk reduction and integrating "Build Back Better" principles for a more resilient built environment. It aims to achieve the substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries.

3.2 Energy upgrading measures

With respect to enhancing energy upgrading, a crucial initiative of the European Green Deal within the building sector is the Renovation Wave (COM (2020)662), emphasising the need to at least double current renovation

[3] In the 2018 reporting cycle, 26 EU Member States and 4 participating states to the Union Civil Protection Mechanism submitted summaries or full national risk assessments.

[4] https://eurocodes.jrc.ec.europa.eu/showpage.php?id=138

rates of public and private buildings. The Renovation Wave initiative builds on the implementation of the Energy Performance of Buildings Directive (EPBD) and the national long-term building renovation strategies. The EPBD (Directive 2010/31/EU) forms the framework for building energy performance strategies to be implemented by the MS. In its 2018 amendment (Directive 2018/844), and the recent proposal for its revision (COM 2021/802), besides reducing greenhouse gas emissions, measures related to fire safety and seismic risks, which affect the lifetime of buildings, are specifically encouraged for planning long-term renovation strategies (LTRS) by the MS.

The requirement for EU MS to adopt a LTRS was initially set out in the Energy Performance of Buildings Directive (2010/31/EU). The amended EPBD introduced a number of key changes with the view of enhancing the role of LTRS as 'roadmaps' with an action plan aiming to create the necessary conditions to scale up renovations and achieve decarbonisation of the national building stocks by 2050, including specific milestones for the years 2030 and 2040. These strategies form part of the integrated national energy and climate plans (NECPs) ([5]) for each MS.

As such, the LTRS shall be supported by measurable progress indicators and explain how these indicators contribute to the overall 32.5% energy efficiency target for 2030 (as part of the implementation of the Energy Efficiency Directive). Additionally, the strategies shall facilitate the cost-effective transformation of existing buildings into nearly zero-energy buildings (NZEBs). The LTRS also contain information on the progress of Energy Performance Certification (EPC), set up by Member States in compliance with the EPBD. The primary scope of EPCs is to guide prospective buyers or renters in their decision making process, increase demand in buildings of high energy efficiency, and act as a driver for more energy renovations (de Ayala et al., 2016, Zangheri et al., 2021).

A preliminary analysis of the LTRS published by 2020 from 14 MS showed, however, that the ambition level, scope and depth of analysis varied significantly from country to country (Zangheri et al., 2021). More recently, an updated analysis of all long-term renovation strategies by all MS (SWD(2021) 365 final/2) listed the planned measures and highlighted best practices. Further information on the LTRS are given in the following country-specific chapters.

Energy efficient retrofitting interventions are addressed by a wide range of measures, with their implementation depending on factors such as building type, age, occupancy, and the financial and business case per se. An extensive review of conventional and new financial mechanisms supporting energy renovations of residential, commercial and public buildings across the EU was undertaken by Economidou, Todeschi and Bertoldi (2019). The review provided a country-by-country overview of financial and fiscal instruments in support of energy renovations by type of public policy and building, as shown in **Table 1** (adapted from Zangheri et al., 2021).

With reference to the countries of relevance to this report, **Table 1** highlights that Croatia, Cyprus, Malta and Greece relied particularly on grants and subsidies for upgrading energy efficiency in the building sector. In just over half of the considered MS, soft loans were available, sometimes supported by state guarantees such as in Bulgaria, France, Italy and Romania. Tax incentives (e.g. income tax or VAT reduction schemes) were active in France, Italy and Sweden, among others. In Bulgaria, additional tax exemption schemes for energy upgrades have also been identified (see section 5.2.2). For most countries, the main focus was the residential sector, with some instruments also targeting commercial buildings and/or public buildings. France, Italy and Portugal enacted all types of instruments for all types of buildings.

([5]) All the strategies are available in national language and English at: https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficient-buildings/long-term-renovation-strategies_en

Table 1. Financial and fiscal instruments in support of energy renovation by type of public policy and building (residential, commercial, public) identified across the EU.

	Grants/Subsidies			Loans/Soft Loans			Tax Exemption/Reduction			Mixed schemes		
	RES	COM	PUB	RES	COM	PUB	RES	COM	PUB	RES	COM	PUB
AT	✔	✔	✔							✔		
BE	✔	✔	✔	✔	✔	✔	✔	✔	✔			
BG	✔	✔		✔	✔	✔						
CY	✔	✔										
CZ	✔	✔	✔	✔	✔							
DE	✔	✔	✔	✔	✔	✔						
DK	✔						✔	✔	✔			
EE				✔								
EL	✔		✔									
ES	✔	✔	✔	✔						✔		✔
FI	✔						✔					
FR				✔	✔	✔	✔	✔	✔	✔	✔	✔
HR	✔	✔	✔									
HU	✔	✔	✔	✔								
IE	✔											
IT	✔	✔	✔	✔	✔	✔	✔	✔	✔			
LT	✔	✔	✔							✔		
LU	✔			✔	✔	✔						
LV	✔	✔	✔							✔		
MT	✔											
NL	✔	✔		✔			✔	✔				
PL	✔		✔							✔		
PT	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔		
RO	✔			✔								
SE	✔						✔	✔	✔			
SI	✔		✔							✔	✔	
SK	✔	✔	✔	✔								

Source: Zangheri et al., (2021)

4 Implementing measures in Austria

4.1 Overview

Austria is partially located in a moderate seismic zone. The most active seismic regions are the Vienna Basin, the Mürz Valley, and the Inn Valley in Tyrol. The seismic map of Austria in ÖNORM EN 1998-1 differentiates five seismic zones (maximum reference PGA> 1.0 m/s^2) (ÖNORM B 1998-1:2017-07-01).

In terms of climate, in Austria the heating season is more demanding than the cooling season with 3323 HDD and 10 CDD (Eurostat, 2021).

4.1.1 Seismic strengthening measures

Austria is covered under the Union Civil Protection Mechanism (Decisions 2013/1313/EU, 2019/420, 2019) of the European Union. In Austria, special earthquake insurances are offered by insurance companies for building owners. However, these insurances are not directly related to seismic strengthening measures, because the insurance premium has not been connected so far with strengthening or renovation of buildings. Low-level seismic design codes were introduced in 1955 and 1979 and high-level seismic design codes were implemented in 1997, 1999 and 2009. The National Annex ÖNORM B 1998-1 (2017) to Eurocode 8 (2004) was firstly introduced in 2009.

There is a lack of information regarding existing guidelines, codes, legislations and incentives for seismic retrofitting in Austria. A 'grandfather clause' or 'Bestandschutz im Baurecht' exists, which guarantees building owners that the state cannot make any demands on the existing structure as long as no substantial modifications of the load-bearing system are carried out. Restrictions for the use of EN 1998 exist in Austria (Athanasopoulou et al., 2018), however the National Annex to Eurocode 1998-3 was recently published as ÖNORM B 1998-3 (2018).

Austria has also recognised the need to verify the safety of existing buildings according to Eurocode 8 (Mikulits, 2015) in the case of building modifications or extensions. As an example, the required increase of the living space in the centre of Vienna by the expansion of attic storeys in historical buildings causes major difficulties. For this reason, the OIB Guideline 1 (2015) regulates the assessment of structural modifications to existing structures with an impact on the load-bearing system. The guideline aims to preserve the building stock and generate new living spaces with additional stories on top of existing structures. Therefore, the guideline accepts deviations from the current state-of-the-art for existing structural elements, provided that the legally required level of safety of existing structures at the time of the construction does not decrease. To make the applicability of this provision more understandable, a separate guideline has been published for the application of the OIB guideline (2015). The introduction of additional guidelines and the intensive discussions show clearly that seismic strengthening is an important topic for Austria.

4.1.2 Energy upgrading measures

Austria introduced important measures for energy upgrading within the National Energy Efficiency Action Plans (NEEAP).

The Energy Performance Certificate Submission Act (Energieausweis-Vorlage-Gesetz 2012 - EAVG) is a federal act that came into force on 1st December 2012. The law regulates the obligation of the seller or building owner to present an energy performance certificate to the buyer within 14 days in the case of buying or renting a building (with some exceptions). The energy performance certificate should not be older than 10 years. The Act also stipulates the obligation to provide certain indicators regarding the energy quality of the building or property in advertisement to prepare for such legal transactions. This regulation ensures the energy performance of the building in the case of sale and purchase, however, this regulation does not cover the conditions when the owner of the building resides in the building. The EAVG is developed to implement the Energy Performance of Buildings Directive 2010/31/EU (2012). Since 2012, it is also mandatory to provide the space heating energy demand and a factor of total energy efficiency if a building is advertised. Public buildings need to display the front page of the certificate.

In Austria, the thermal quality of buildings is determined according to the federal building law and/or the building regulations of the federal states (Nieboer et al., 2012). The Austrian Institute for Construction Engineering (OIB) is the platform of the Austrian provinces to harmonise legislation which is the competence of the provinces. The OIB-Guideline 6 on energy saving and thermal insulation was introduced in 2007 and implemented in the federal states. The latest revision of the OIB-Guideline 6 was published in March 2019. This guideline contains

requirements concerning the maximum heating consumption of residential and non-residential buildings - both with respect to newly constructed and renovated buildings (UNECE, 2018). Furthermore, the guideline includes energy benchmarks and calculation guidelines, the definition of the Energy Performance Certificate and detailed requirements regarding the inspections and the energy demand of buildings. Finally, the OIB-Guideline 6 (2019) serves as the implementation of the Directive 2002/91/EG (2002) for the energy performance of buildings and the updated Directive 2010/31/EU into national law.

In the recent LTRS for Austria, plans foresee to achieve an 80% decarbonisation of the building stock by 2050. This shall be achieved in part through increases in renovation rates (across all building types) to 3% from the current 1.5% p.a. (for the 2020-2050 period). It is estimated that approximately EUR 5.3 billion are needed per year in order to maintain the current level of renovation. This figure would increase to over EUR 10 billion with increased renovation rates (SWD(2021) 365 final/2).

4.2 Best practices

4.2.1 Seismic protection and seismic risk assessment

As a part of the seismic risk reduction, the Austrian Ministry of Internal affairs (BMI) has published a guideline for earthquake protection “Erdbebenschutz Ratgeber” (2011) which deals with the earthquake situation in Austria and provides guidance for preventive measures. Published in 2011, the document advises on earthquake protection in general, by adhering to construction standards of Eurocode 8 (2004). Furthermore, the Central Institute for Meteorology and Geodynamics (Zentralanstalt für Meteorologie und Geodynamik, 2022) provides brochures, teaching material relevant to preventive measures.

Adam (2012) presents an overview of activities in Austria with respect to earthquake resistant design of buildings, the seismic hazard in Austria and projects undertaken to reduce the seismic risk of masonry buildings. The main activities and projects include the project “Seismic System Identification for the Vienna Basin based on Measurements” (2012), SEISMID, which was an Austrian national research project aiming to assess the seismic resistance of Viennese brick-masonry buildings more realistically. The research for SEISMID was carried out between 2007 and 2010. The involved partners were: VCE Holding GmbH, Aplica Advanced Solutions GmbH, Brusatti GmbH, University of Natural Resources and Life Sciences, University of Innsbruck, AIT Mobility and BAGF Birkenweg. The funding agency was the ZIT-Center for Innovation and Technology. The main results and findings of this project represent a decisive contribution to the discussion on earthquake hazards and earthquake safety in the Vienna area and have been published in the form of the book "Erdbeben im Wiener Becken" by Achs et al., (2011).

Adam (2012) reported also on the development of damper systems such as tuned liquid column dampers that can be installed in buildings to reduce the seismic impact as an advanced seismic strengthening measure. The overview of activities in the publication shows that seismic design and seismic strengthening of existing buildings is a topic of interest in Austria, therefore research activities are expected to increasingly reflect on the Austrian industry.

A new seismic hazard map for Austria was developed recently (Weginger, 2020). The new hazard map employed probabilistic seismic hazard assessment based on an expanded and updated earthquake catalogue with more detailed information about depth, source mechanism and moment magnitudes. It can be expected that the new hazard maps will be incorporated in the next version of the National Annex for the new generation of Eurocode 8 that is already under development.

4.2.1 Energy upgrading programmes

The improvement of heat generation systems and thermal quality in residential and commercial buildings, older than 20 years, is supported by subsidies. The renovation campaign “Sanierungscheck” introduced in 2016 grants to financially support the renovation of existing buildings. The financial support was provided for thermal insulation of roofs, external walls, floors, replacement of windows and exterior doors and for replacing the existing heating system with a renewable one. As per the household action 2016, a maximum of 30% of the renovation cost can be subsidised. These subsidies have been provided to households since 2009, starting with 20% of the renovation cost or a maximum amount of EUR 5000 per household with a limit of EUR 50 million in total. A renovation voucher has continued to provide financial subsidies for building renovation and efficient heating technologies. The programme is long term and is therefore part of the National Energy and Climate Plan (NECP). An update of this support programme was launched in 2021 (information is provided by the Federal

Ministry for Climate Protection, Environment, Energy, Mobility, Innovation and Technology, BMK), allowing electronic applications through an Online-Portal.

Best practices from submitted long-term renovation strategies highlighted in the recent assessment by the Commission (SWD(2021) 365 final/2) include quality reviews of EPCs organised through independent control systems, in parallel with continuous improvement of EPC databases. Support for renovation and other incentives are usually linked with the submission of an EPC, which ensures that cost-optimal remediation steps can be taken.

4.2.2 New standards for efficient buildings

The “klimaaktiv building standard” (2022) is an initiative within the Austrian government’s climate strategy linked to the 2030 Agenda. “klimaaktiv building standard” was launched in 2004. The programme has been growing into a platform for successful dialogue between research, industry, federal and state governments and the communities contributing to sustainable development in Austria. Online tools are available to calculate the primary energy value and CO_2 emissions from residential buildings. The results of these calculations are used to check the economic efficiency for individual efficiency measures and to estimate and optimise the quality of planned measures for the renovation in minimum time. The platform contains several other information in the areas of construction and renovation, energy saving, the use of renewable energies or mobility and gives support to which measures can be implemented sensibly and with high quality. It is not only energy efficiency that is assessed and evaluated in “klimaaktiv” buildings, but also quality assurance and location, the quality of construction materials and design as well as core aspects of comfort and indoor air quality. “klimaaktiv” building standards for residential and non-residential buildings have been introduced, addressing both new buildings and renovation of existing ones. Moreover, three categories of building awards, bronze, silver and gold, are given for complying with the scoring system which is used to assess the buildings and certify their compliance. Since September 2020, there is a new edition of the “klimaaktiv” criteria catalogues for all building categories, new construction and refurbishment. The new criteria catalogue is now fundamentally excluding the use of fossil fuels in “klimaaktiv” buildings and tightens the quality requirements in the area of energy efficiency.

5 Implementing measures in Bulgaria

5.1 Overview

The seismic map of Bulgaria is composed of four seismic zones, with a maximum reference PGA of 0.32g (BDS EN 1998-1:2005).

In terms of climate, Bulgaria has in general a temperate climate, with 2247 HDD and 166 CDD (Eurostat, 2021). Hence, the heating season is more demanding than the cooling season.

5.1.1 Seismic strengthening measures

5.1.1.1 Legislation & Standards

The seismic conditions in Bulgaria have been taken into account from the very beginning of the construction regulations. For example, in 1927 the Italian "Technical and sanitary norms for earthquake areas" were adopted. In the period 1944 to 1989, the Soviet Union's structural design codes have been adopted and adapted and the Bulgarian seismic zoning map has been applied (Ignatiev and Sotirov, 2012). The Eurocodes has been introduced in Bulgaria in the period 2005-2011, but became mandatory only in 2012. The BDS EN 1998, Parts 1, 3 and 5 have been translated to Bulgarian and the national annexes have been prepared and published. Still, there is an option to use national technical legislation, applicable to the design of new buildings and the design, related to reconstruction, major repair, substantial renewal, substructure, extension and changes in the functional purpose of existing buildings (Athanasopoulou et al., 2018). Ordinance No. RD-02-20-2 of 2012 defines the requirements for the design of buildings in earthquake areas. Among others, this Ordinance considers "Unsecured" against seismic impacts those existing buildings that were built before 1987. The Ordinance sets the conditions to perform construction and installation works in existing buildings, involving changes in their structures. For the buildings that are objects of immovable cultural heritage, some deviations from the requirements can be allowed (RD-02-20-2-BG, 2012).

5.1.2 Energy upgrading measures

5.1.2.1 Legislation & Standards

The Energy Efficiency Act (EEA-BG, 2015) transposes the provisions of EED and general provisions of EPBD into the legal system of the Republic of Bulgaria. The main features of EBPD are reflected in Ordinance no 7 on the energy efficiency (EE) of buildings. The part "EE" is a compulsory part of building design. All new buildings after 2020 shall be NZEB, being of class "A" of energy consumption and using at least 55% of the annual primary energy for heating, cooling, ventilation, lighting and hot water from renewable energy sources (RES), situated nearby the building (Ordinance 7-BG, 2015). A set of other relevant secondary legislation exists to cover other aspects related to the EE of buildings, such as EE audit and EPC, indicators for energy consumption and energy performance of buildings, energy savings, Energy Service Company (ESCO), etc.

5.1.2.2 Strategies

Bulgaria duly developed and submitted the main strategic documents as requested by the European legislation, namely the National Energy Efficiency Action Plans, the last one issued in 2017 (NEEAP-BG, 2017), the national long-term programme for the promotion of investments in measures aimed to improve the energy performance of the national stock of public and private residential and commercial buildings, 2016-2020 (LTRS-BG, 2017), the National NZEB Plan 2015–2020 (NZEB-BG, 2015), the National Plan for the improvement of the energy performance of buildings used by the state administration 2016-2020 (NPStAdm-BG, 2017) and the Integrated National Energy and Climate Plan for the Republic of Bulgaria, 2021-2030 (NECP-BG, 2020).

In the LTRS submitted by Bulgaria to the Commission (SWD(2021) 365 final/2), plans are set out to renovate 8% by 2030 and 46% of the total floor area of the existing building stock by 2050 in order to achieve 7329 GWh in energy savings. Investment needs of EUR 5.96 billion are estimated.

5.1.2.3 Programmes & Funding

Several programmes for energy upgrading of existing buildings have been funded since 2005.

Many public buildings (51 from the healthcare, 598 from the educational, 72 from the cultural and 138 from the social services infrastructures), have been energy renovated within the Operational Programme “Regional Development” 2007–2013 (OPRD), Priority Axis 1, with a budget of EUR 901 million. Reduction of greenhouse gas emissions by 55.19 tons CO_{2eq} and energy savings of 169.9 MWh/y were reported. By 2018, the OPRD 2014-2020 has funded 119 projects with a total value of EUR 318.5 million for the rehabilitation (including energy upgrade) of a total of 442 kindergartens, primary and secondary schools and universities.

In 2018, the European Commission (EC) has approved another EUR 107 million for the repair of the educational infrastructure in the country under the Operational Program "Regions in Growth" (OPRG) 2014-2020.

Among the high priority projects, financed by the Kozloduy International Decommissioning Support Fund (KIDSF) was the energy upgrade of buildings with 100% public ownership with a grant budget of EUR 35 million. The amount of grant funding was 50% for municipal ownership buildings in Sofia-city and six other big towns and 100% for municipal ownership buildings in other municipalities and the buildings with 100 % state ownership. The priority order was as follows: health facilities and educational infrastructure buildings; administrative buildings for which there are no opportunities to apply for other EU programmes; administrative buildings; sports facilities and cultural and historical buildings.

The National Programme for Renovation of Residential Buildings (started in 2005) aimed at updating multi-family residential buildings of three or more floors. During the first stage (2005 - 2015) the eligible buildings were from 4 towns situated in 4 different climatic zones. During the second stage (2008-2019), buildings in 36 towns from all 9 climatic zones in Bulgaria were eligible. The total budget for the two first stages amounted to EUR 2,122 million. Initially, it was planned to apply state subsidies amounting to 20% of the total value of the substantial renewal, covering technical inspection, issuance of building passports, design and consulting services. Later on, the share of the grant attained 100%. The Programme has been modified and upgraded within the following Operational programmes projects:

— Project “Energy renovation of Bulgarian homes” (2012-2015) was launched in 2012 with the financial support of OPRD 2007–2013. The scope of the project were multi-family residential buildings in 36 towns in the territory of Bulgaria, designed before 1999, having 6 or more separate independent dwellings on 3 or more storeys. Financial support, via the municipal administration, was provided to owners associations, as follows: 1) up to 100% of the eligible expenditure on technical audit, technical passport, the EE audit and the fees of the project manager; 2) up to 50% of the eligible expenditures on technical design, compliance assessment of the design project, construction and installation works, design and construction supervision, commissioning of the project and obtaining of permission documents. The owners of residential properties had to provide the remaining funds necessary for the energy renovation of the building. For a budget of EUR 25.6 million, 299 buildings were contracted and 158 buildings were renovated and commissioned, 137 buildings have been transferred to another programme for EE in buildings.

— An “Energy Efficiency of Multi-Family Residential Buildings National Programme” was run between 2015 and 2020. At least class “C” of energy consumption was to be achieved. Multi-family residential buildings on the territory of all 265 municipalities, built in an industrial way (large-panel buildings, package-lifted slabs, large-area formwork, climbing formwork and their varieties) and multi-family residential buildings, designed before April 26, 1999, with three or more storeys, were eligible. Exceptionally and at the discretion of the municipality, buildings with a minimum of 32 separate residential units, which were built before 1975 and where some structural problems have been established were also included in the renovation programme. The most economically effective package of EE measures was to be financed for each building. As of January 2020, 5037 contracts have been signed, 1820 energy upgraded buildings have been in use; the number of contracts with ongoing activities (design, public procurements procedures, audits, construction works) was 2161. Registered owners’ associations of buildings were entitled to a grant amount of up to 100 % of the eligible costs.

— The EE programmes for public infrastructure (administrative buildings of the state and municipal administration and municipal buildings of educational, cultural and social infrastructure) and the housing sector of municipalities in the peripheral areas have been launched since 2015 within Priority axis 2 of the OP "Regions in Growth" 2014-2020. The national co-financing is 15%. Eligible candidates are the 28 municipalities of small 4th level cities of the national polycentric system. Multi-family and single-family massive residential buildings designed before April 26, 1999 and buildings with no more than 35 separate residential units (households) built in an industrial way are eligible. Single-family residential buildings are eligible upon the following conditions: a) the owners are socially disadvantaged and have received social help for the current/last heating period and b) the buildings are used only for residential purposes and there is no economic activity in them. EE measures shall be implemented based on an EE audit and a valid EPC

of the building. The most cost-effective package of energy-saving measures is to be funded ensuring the energy consumption class "C" is achieved. By 2021, 230 contracts were signed for about EUR 137 million.

5.1.3 Seismic strengthening & energy upgrading measures

5.1.3.1 Legislation & Standards

The Bulgarian Spatial Development Act (SDA-BG, 2001), which regulates the design, construction, use and maintenance of all buildings in the territory of the Republic of Bulgaria, prescribes legislative measures for both structural safety and energy efficiency of buildings. However, there is no concept of integrated or combined seismic strengthening and energy upgrade.

5.1.3.2 Programmes

The majority of programmes on the energy upgrading of buildings consider the issue of the structural (incl. seismic) resistance of buildings, but in different ways: 1) In EE programmes for public and residential buildings, funded through OPRD (2007-2013), the necessary measures to ensure structural safety, such as technical audit, elaboration of a technical passport and structural rehabilitation and retrofitting were considered eligible expenditure; 2) The implementation of structural rehabilitation/strengthening activities was eligible within the Energy Efficiency of Multi-Family Residential Buildings National Programme (2015-2020) only if the technical audit report has assessed these activities as mandatory and if the economic analyses have confirmed they would be justified; 3) In the projects for increasing EE in public infrastructure and the housing sector in the peripheral municipalities (funded through OPRG 2014-2020), the structural rehabilitation measures are also eligible if prescribed as “mandatory”. However, the upper limit of the amount of the requested grant for each individual project (e.g. EUR 613,550 in 2018 and EUR 766,938 in 2020) does not allow significant strengthening works to be funded; 4) Within the Project “Energy renovation of Bulgarian homes” (2012-2015), no technical measures related to the structural safety were funded. Only if a positive technical assessment for seismic resistance of the buildings was issued, the building was accepted to be funded for energy upgrading. In conclusion, because of restrictions on funding and/or lack of available resources, only a few public and residential buildings found to be structurally deficient are actually being funded under the programmes for energy upgrading. In addition, the structural design and approval processes for such projects entail additional time and complexities.

5.2 Best practices

5.2.1 Seismic Strengthening

The Chamber of the engineers in the investment design (which is the competent body to issue certificates for the designer’s professional capability) has organized training courses and has delivered several guidelines to help structural designers in studying and applying Eurocode 8 (BDS EN 1998) (KIIP-BG, 2020).

Specialised research centres - Department of Earthquake Engineering at the National Institute in Geophysics, Geodesy and Geography within the Bulgarian Academy of Sciences, and the National centre of Seismic Engineering at the University of Architecture, Civil Engineering and Geodesy (NCSE – UACEG), have been established.

5.2.2 Energy upgrading

It is possible to include buildings with historical and cultural heritage significance within the scope of some programmes for energy upgrading. In these cases, the approval of projects shall be done according to the Bulgarian Cultural Heritage Act (CHA-BG, 2009). According to the Law on local taxes and fees in Bulgaria, the energy upgraded buildings might be exempted from tax for a certain period of time, according to the achieved class of energy consumption (LLTF-BG, 1998). The Bulgarian Sustainable Energy Development Agency took part in ENERFUND project (2016-2019), as described in item 7.1.2.5.

5.2.3 Seismic strengthening & energy upgrading measures

5.2.3.1 Legislation

Technical passports of a building (TPB) have been introduced in Bulgaria by Ordinance No 5 in 2006 (Ordinance 5-BG, 2006). TPB is a set of documents, which contain all relevant technical information about the building, e.g. the year of construction, type of construction, Energy Performance Certificate (EPC), information about the seismic stability of the building, measures undertaken to maintain its safety and security, information about all completed construction and repair work after the commissioning of the building, as well as prescriptions for necessary repairs/rehabilitation/strengthening. For an existing building, the TPB is issued after performing a technical inspection/audit. The deadlines for certification of all existing buildings were extended several times mainly because of technical audit affordability. Finally, although there is common recognition of the necessity of TPBs, in 2021 the obligations for the owners of the existing buildings were withdrawn, except for the buildings undergoing major repair, substantial renewal (such as energy upgrade), reconstruction or changes in the functional purpose.

5.2.3.2 Other

A study on Earthquake Risk Reduction for Large Panel Multi-Family Residential Buildings (LPBs) in Bulgaria was realized by the IBRD with the financial support provided by the Global Facility for Disaster Reduction and Recovery. The study was supported by the Bulgarian Ministry of Regional Development and Public Works and the Ministry of Interior - Directorate for Fire and Civil Protection (World Bank, 2019). LPBs were constructed across Bulgaria between 1960 and the 1990s and were designed for a 50-years lifespan. Detailed 3-D nonlinear models were developed for the various types of LPBs to determine thresholds for different levels of damage (slight, light, moderate, extensive, and collapse). Based on this analysis, estimates of repair cost and time were made, and building vulnerability functions were developed.

Among the potential risk reduction measures related to LPBs, the strengthening of facade panel connections from outside, alongside energy efficiency retrofits, partial or full replacement of the facade panels with new lightweight and energy-efficient panels and balcony enclosures were discussed, considering the EE issues.

6 Implementing measures in Croatia

6.1 Overview

The Republic of Croatia is one of the most vulnerable countries in Europe in terms of earthquake risk because it geographically belongs to the Mediterranean-Trans-Asian belt, which has a high level of seismic activity. The seismic map of Croatia includes a maximum reference PGA of 0.38g (HRN EN 1998-1:2011/NA).

In Croatia, the heating season is more demanding than the cooling season, with 2138 HDD and 130 CDD (Eurostat, 2021).

6.1.1 Seismic strengthening measures

6.1.1.1 Legislation & Standards

Despite its seismicity, until 1948, the design and construction of buildings in Croatia did not apply the regulations related to earthquake resistance of buildings. The development of the application of building regulations related to earthquake design and construction of buildings is shown in **Table 2**. (Pavic et al, 2020a). The Eurocodes are enforced by the Technical regulation for building structures, published in March 2017. National Annexes on Eurocode 8 – parts 1 and 3 were published in 2011. A technical regulation for structures of buildings prescribes the technical performances for structural elements in buildings, requirements for design, construction, maintenance, removal and other requirements for building structures (TRStrBuild, 2018).

Table 2. The application of design codes, characteristics of performance, and earthquake design

Period	Until 1948	1948-1964	1964-1981	1981-2005	2005-2012	2010-present
Applicable standards	Without set of rules	Temporary technical standards for allowed loads for buildings	Temporary technical standards for construction in earthquake areas	Set of rules on technical standards for construction of high-rise buildings in earthquakes areas	Pre-standards HRN ENV 1998-1	Standards HRN EN 1998-1:2011
Characteristic construction	-URM with wooden floors; -from 1920 RC structures	- URM without ties, rigid floors; - RC floors prevail	-confined masonry; -RC structures	-confined masonry; -RC structures: frames, RC walls, dual structures	- confined masonry; -RC structures; - steel structures; -laminated wood structures	
Seismic design	- earthquake not taken into design	- earthquake taken into the design like a force at the top of the building	-first earthquake resistance design codes; -Seismic map, 1950	- simple design	-complex design; -increase of design load	-more complex design; -further increase of design load -seismic map from 2012

Source: Pavic et al., 2020a

6.1.2 Energy upgrading measures

6.1.2.1 Legislation & standards

The requirements of EED and EPBD are transposed into the legislation of the Republic of Croatia by the Energy Efficiency Act (EEA-CR, 2014) and Building Act (BA-CR, 2013). The most relevant among the secondary legislation is the technical regulation on rational use of energy and thermal protection in buildings (TREnUse, 2018). It provides on the energy performance of buildings, taking into consideration the climate zone and functions of buildings, both for new and existing buildings. The NZEB definition for residential and non-residential buildings includes requirements on the annual required thermal energy, annual primary energy and the use of RES (at least 30% of the annual primary energy supply). Other aspects of the EE of buildings such as energy services, methodology for energy savings, products in public procurement procedures, energy management in the public sector, energy audit and energy certification are also covered by secondary legislation.

6.1.2.2 Strategies

The Republic of Croatia duly developed and submitted the main strategic documents as requested by the European legislation, namely the National Energy Efficiency Action Plans, the last one being for the period 2014-

2020 (NEEAP-CR, 2017) containing a Strategy for mobilising investment in the field of building renovation (LTRS-CR, 2014 and LTRS-CR, 2017), National Plan for increasing the number of NZEB till 2020 (NZEB-CR, 2014) and Integrated National Energy and Climate Plan for the Republic of Croatia, 2021-2030 (NECP-CR, 2020).

Several measurable targets are set out for the period by 2050. For instance, the share of NZEBs and high-level EE buildings shall be 30% in 2030 and 100% in 2050. The percentage of buildings renovated annually shall raise from 1% in 2020 to 4% in 2040. By 2040, the percentage of historical buildings renovated annually is specified as 4%. The users' awareness of the positive effects of deep renovation shall attain 95% in 2040. The percentage of qualified contractors (having a certificate for energy renovation of NZEBs and trained workers for performing such works) shall be 50% already in 2025. As a whole, the reduction of GHG emissions in the building sector is to reach 80% in 2050 (LTRS-CR, 2017).

Among the non-measurable targets, which have also been defined for the period 2017-2030, the following can be listed: a) Prepared regulations for requirements that all building properties be at a high EE level as a condition for sale or lease; b) Construction companies with a certificate for renovation and with workers educated for carrying out works in the energy renovation of buildings; c) Developed techniques for the renovation of historic and buildings of cultural significance; d) Governmental support to banks in lending the full renovation for socially vulnerable groups; e) Ensured budget for the renovation of public buildings and incentives for the renovation of buildings of social character; f) Prepared educational materials for the implementation of training in schools and faculties (LTRS-CR, 2017).

6.1.2.3 Programmes

The programme of energy renovation of public sector buildings, implemented during the period 2014-2018, was the first programme that encourages a complete cost-effective renovation of buildings, including measures on the building envelope, thermo-technical, electrical and water supply systems. The following measurable results should have been achieved: completely renovated 200 public sector buildings with ca. 420 000 m^2 of heated floor area, energy savings of 30-60%, 3% renovation rate of the central government, initiation of investments of about EUR 52 million. Among the non-measurable results, the development of the energy services market, applicable model for promoting EE in the market principles, and market strengthening of new companies specialized in providing energy services (ESCO) shall be mentioned. The implementation of the programme for the next period (2016-2020) continues the main features but aims for a complete energy renovation especially of buildings where social activities are carried out. It is co-financed by the ERDF. The basic eligibility criterion is an annual reduction in heating/cooling energy consumption of at least 50%. By the end of 2020, 9.46% of the total fund of public sector buildings in the Republic of Croatia should have been renovated, i.e. 1 305 169 m^2 of buildings.

The programme of energy renovation of family houses (2014-2020) aimed for the energy upgrading of 2000 houses/year, with a budget of about EUR 87 million. It applies to existing single-family houses, regardless of the year of construction. Family houses in protected cultural and historical sites are also eligible. Energy class is a condition to apply: Family houses are required to be at least "D" in continental areas and "C" - in coastal areas. The eligible EE measures include: 1. Renovation of the building envelope; 2. Replacement of heating system; 3. Installation of systems for the use of RES. Citizens at risk of energy poverty are eligible for 100% of funds for energy efficiency measures. Co-financing was provided entirely from national funds through the Environmental Protection and Energy Efficiency Fund (EPEEF). It is envisaged to continue the implementation of the Programme in the next ten-year period (NECP-CR, 2020).

In the programme of energy renovation of multi-apartment buildings, the priority buildings are those built between 1945 and 1987. The Programme aims at reducing energy consumption for heating/cooling and DHW preparation, to achieve energy class B, A or A+. The target of the energy renovation was 1% per year of the total surface area of existing multi-apartment buildings (500 000 m^2/year). The amount of total investment is about EUR 130 million, and more than EUR 72.8 million constitute a grant from the ERDF, within the Operational Program Competitiveness and Cohesion. The other financing sources for the implementation of this programme include EPEEF funds, sources of financing on the part of citizens (savings) and building loans. As of September 2018, 584 contracts have been concluded.

The programme of energy renovation of commercial buildings (2014-2020) is focused primarily on pre-1987 buildings and aims at EE measures to achieve energy class B, A or A+. The main measure is related to the renovation of the building envelope to achieve the standards of low-energy buildings as per (TREnUse, 2018). For the implementation of the programme after 2020, no individual measures, but packages of measures are to be implemented to reach the NZEBs.

6.1.2.4 Other measures

Targeted promotional campaigns on the programmes for co-financing energy renovation of buildings and energy services through the national EE portal are regularly implemented.

Research centres and public bodies take part in several European projects such as HAPPEN, PrioritEE, Build Up initiative, to further develop national competencies and tools in the field of EE of buildings.

6.1.3 Seismic strengthening & energy upgrading measures

The Building Act (BA-CR, 2013), which regulates the design, construction, use and maintenance of all buildings in the territory of the Republic of Croatia, prescribes legislative measures for both structural safety and energy efficiency of buildings. However, there is no concept of integrated or combined seismic strengthening and energy upgrade.

An article on the barriers and incentives for extensive implementation of combined seismic and energy efficiency retrofits in Croatia identified and reviewed the barriers limiting the possibility of extensive implementation of seismic and energy efficiency retrofits in buildings in Croatia (Sigmund, 2018).

6.2 Best practices

6.2.1 Seismic strengthening measures

The technical regulation for structures of buildings provides for regular maintenance as a part of preventive measures (TRSrBuild, 2017), applicable to both structural and non-structural elements and to both new and reconstructed structures. Regular inspections are prescribed: 1) the general state of the structure is determined by the basic inspection, by checking the available documentation and by visual inspection of the main structural elements. 2) Main inspections determine the state of the structure and materials. 3) Additional inspections are prescribed by special rules for specific types of structures. 4) Extraordinary maintenance of a building structure shall be carried out after extraordinary events.

Seismic vulnerability and exposure models were developed within the research work of a team from the University of Osijek (Pavic et al, 2020b). A methodology for the selection of seismic reinforcement technology for masonry buildings was developed, corresponding to an innovative approach to strengthening technique selection for existing buildings (Sigmund, 2016). A study on the strengthening techniques for masonry structures of cultural heritage buildings analyses the applicability of traditional and modern techniques for seismic strengthening of masonry buildings (Hadzima-Nyarko et al, 2018).

6.2.2 Energy upgrading measures

Assistance to public bodies is organised through the Agency for legal transactions and real estate brokerage (APN) conducting the public procurement procedure for energy service in buildings on behalf and for the account of budgetary and extra-budgetary users of the state budget of the Republic of Croatia. Other public sector entities may authorise the APN to conduct a public procurement procedure for energy service in buildings, too.

The Programme of energy renovation of public sector buildings (2014-2018) is the first programme that uses private capital investments in public buildings at no additional cost to the state with co-financing from the EPEEF. The Croatian Bank for Reconstruction and Development (HBOR) offers favourable lending conditions: ca. 50% of the needed amount with a grace period of 1 year and a maximum repayment period of up to 14 years. A Certificate of the technical and financial feasibility of the project is issued by APN with the prior opinion of the Croatian Agency for Small Business and Investments Invest guarantee programme (HAMAG). Guarantees for the obligation to pay under the loan agreement are provided through the HAMAG.

The Programme for energy upgrade of family houses includes a second part, dedicated to the vulnerable groups of citizens. The social welfare centres make a recommendation according to established social criteria, for those beneficiaries who meet the conditions. This second part, in addition to equipment and works, co-finances the implementation of energy audits and energy certificates before and after renovation, as well as providing technical assistance to applicants. The financing rate is up to 100%.

An Energy Renovation Programme for Heritage Buildings for the implementation period 2021–2030 is developed. An integral approach, but also individual energy renovation measures will be applied. The total needs amount to about EUR 2.4 billion (NECP-CR, 2020).

To mobilise all stakeholders in the process of building and renovating buildings to achieve the long-term target of reducing CO_2 emissions, the Ministry of Construction and Spatial Planning has initiated a Charter of Cooperation for the Decarbonisation of Buildings by 2050 (NECP-CR, 2020).

National guidelines for the continuous education of construction workers within EE activities have been prepared within the project BUILD UP SKILLS HR. A certification system for workers has been established. The implementation of green buildings as an essential segment of sustainable development and the circular economy is promoted.

In Croatia, targeted promotional campaigns related mainly to Programmes for co-financing energy renovation of buildings and promotion of energy services through the national energy efficiency portal are regularly implemented.

Among the non-measurable targets, which have been defined for the period 2017-2030, the following can be listed: a) All buildings to be at a high EE level as a condition for sale or lease; b) Construction companies shall be certified for energy renovation of buildings; c) Techniques for the renovation of cultural heritage buildings are to be developed; d) Governmental support to banks in lending the full renovation for socially vulnerable groups shall be established; e) The budget for the renovation of public buildings and incentives for the renovation of buildings of social character shall be ensured; f) Educational materials for the implementation of training in schools and faculties are to be prepared (LTRS-CR, 2017).

6.2.3 Seismic strengthening & energy upgrading measures

There are analyses on the opportunities to apply seismic and energy efficiency retrofits and studies on the cost of joint measures. It has been found that there is an opportunity to link the seismic retrofit programmes to renovation for EE. Moreover, when the energy renovation is applied individually, the seismic retrofit potential might be significantly postponed since it would require further construction interventions on the façades. A cost-benefit analysis demonstrates that when energy and seismic retrofitting incentives are combined, the total cost is considerably lower than the costs when both retrofitting measures are applied independently (Savor Novak et al, 2019). It was established that retrofitting expenditures depend strongly on many variables. The studies on the costs for the combined energy and seismic retrofit of blocks of flats show the cost currently ranges from 100 to 230 EUR/m^3. The main part of these renovation costs is attributed to the seismic strengthening component, which ranges from about 50 to 150 EUR/m^3. Additional rental costs for an alternate accommodation may increase the involved costs (Sigmund, 2018).

7 Implementing measures in Cyprus

7.1 Overview

Cyprus, being located on the boundary of two tectonic plates, the Eurasian and the African ones, has high seismicity. The seismic map of Cyprus consists of three seismic zones and has a maximum reference PGA of 0.25g (CYS EN 1998-1:2004).

Cyprus has in general a warm Mediterranean climate, with 630 HDD and 803 CDD (Eurostat, 2021), where the cooling season is more demanding than the heating season.

7.1.1 Seismic strengthening measures

7.1.1.1 Legislation & Standards

Despite the recorded history of destructive earthquakes, the first seismic design measures in Cyprus were imposed after 1986 and the first seismic design code was introduced on a voluntary basis in 1992 and was made compulsory through a law in 1994. In 2012, all previous standards were withdrawn and were replaced by the Eurocodes, including CYS EN1998 for the design of seismic resistant structures. Therefore, the majority of structures have been designed without any seismic provisions, which increases their vulnerability to seismic loads (Chrysostomou, 2013). The National Annex to CYS EN 1998-1:2004 was elaborated in 2010. In 2019, the National Annex to CYS EN 1998-3:2005 (Including AC:2013) was published. It is noted that all EN 1998 Parts are obligatory for use in Cyprus. A regulatory framework enforcing the use of Eurocode Parts in Public Procurement also exists (Athanasopoulou A., 2018).

7.1.1.2 Guidance

To meet challenges related to the static and anti-seismic inadequacy of many existing buildings, as well as the lack of their systematic maintenance, the regulatory framework is supplemented by a Methodology of Constructive Inspection of Buildings Concerning Their Structure, issued in 2019 (ETEK, 2019). The inspection and subsequent control are considered a necessary precautionary measure for the safety of public buildings and should be a priority in important buildings and buildings of particular cultural significance.

7.1.1.3 Other measures

Among the other measures two educational programmes are to be mentioned: a) the Postgraduate programme “Specialisation in Earthquake Engineering” at the University of Cyprus, Department of Civil and Environmental Engineering and b) the short educational programme "Evaluation of Existing Buildings", organised by the Educational and Research Centre of Cyprus Association of Civil Engineers in October 2019, to train professionals in the correct application of CYS EN1998 and to guide them in the proper application of the regulations. Additionally, research and educational centres took part in many research projects and European programmes.

7.1.2 Energy upgrading measures

7.1.2.1 Legislation and standards

For transposing the provisions of EED into the national legislation of Cyprus, several laws have been amended and secondary legislation has been adopted. The Regulation of Energy Efficiency of Buildings and its Amendments (EEESL-CY, 2015) transposes the requirements of EPBDs. The Regulation specifies the minimum energy performance requirements for buildings, including for existing buildings. Those requirements have gradually increased during the years: U-values were reduced, the total floor area (TFA) of buildings for the mandatory energy upgrading decreased, EPCs with a minimum class B of renovated buildings to be issued, etc. From 2013 onwards any revision of the requirements is based on the results of calculating the cost-optimal levels of minimum energy performance requirements as it is foreseen by the EPBD (2010). The amendments made in March 2020 specify the requirements to low energy buildings - Table 3. Considering existing buildings that are renovated, higher energy performance than category B should be required, but lower than the NZEB level. It has to be noted that the definition of NZEB is the same for new and for existing buildings (NECP-CY, 2020).

Table 3. Minimum energy performance requirements for existing buildings in Cyprus since March 2020

Major renovation	Minimum energy class on the Energy Performance Certificate (EPC)	A for residential buildings B+ for non-residential buildings
Building elements that are replaced or retrofitted	Walls maximum U - value	0.4 $W/m^2 K$
	Roof and floor in contact with the external environment maximum U - value	0.4 $W/m^2 K$
	Window maximum U - value	2.25 $W/m^2 K$

Source: NECP-CY, 2020.

Cyprus' secondary legislation in the field of EE of buildings includes also energy audits and EPCs of buildings, an EE calculation methodology, a methodology for calculating the cost optimal levels of EE requirements, and requirements and technical characteristics to be met by NZEBs.

7.1.2.2 Strategies

Cyprus has duly developed and submitted National Energy Efficiency Action Plans, the last one being for the period 2014-2020 (NEEAP-CY, 2017). It includes, as required, a strategy for mobilising investment in the field of building renovation (LTRS). The implementation of the EED is under the responsibility of the Energy Service of the Ministry of Energy, Commerce, Industry and Tourism (MECIT). The implementation of both measures in regard to the building renovation strategy for EE and the energy upgrade of public buildings has been assessed with an average score bigger than 75 % (Economidou M. et al, 2018).

The second LTRS provides a good overview of the existing building stock and identifies energy-saving opportunities, considering their cost-effectiveness. A scenario analysis of the energy performance evolution of the building stock up to 2030 is presented, including an analysis of the renovation investment prospect. According to that scenario, until 2030, a little more than 20 % of homes and 35 % of non-residential buildings will have a good energy efficiency rating, and a very small ratio of buildings will have a high energy efficiency rating (LTRS-CY, 2017). The second LTRS includes also a comprehensive set of measures, broken down into legislative, financial, information and training initiatives. To achieve the energy upgrading of buildings, investments need to be made by the public, and primarily the private, sector: to attain the renovation of an annual 3 % of the total floor area of buildings owned and operated by the central government, an estimated EUR 18 million will be required in the period 2014-2020, while larger investments will be required for the energy upgrading of private buildings (LTRS-CY, 2017).

The first definition of NZEB in Cyprus was adopted in 2014. This definition includes all buildings (single-family houses, apartment blocks, offices, educational buildings, hospitals, hotels/ restaurants, sports facilities and wholesale/retail) and it differs only between residential and non-residential buildings. It specifies the maximum permissible primary energy consumption and the minimum share of RES in energy consumption, but the provided values for primary energy appear higher compared to many other Member States (D'Agostino et al., 2017). The 2nd National Plan for the increase of NZEBs provides data on the cost-optimal levels of minimum energy performance requirements and NZEBs, although NZEBs do not need to achieve cost-optimal levels. The results have shown that the NZEBs deviate from cost-optimal levels, but they still have a significant economic value over the life cycle of the building as compared to applying no requirements at all. It was assessed that investing in lower U-values primarily for the roof and secondarily for the walls was the optimal way to reduce energy consumption (NZEB-CY, 2017).

Cyprus' NECP for the period 2021-2030 sets the national objective and targets, analyses the current situation and projections with existing policies and measures and makes an impact assessment of planned policies and measures. The EE of buildings is outlined as a particular dimension, especially energy upgrade of existing buildings in both household and service sectors. An overview of investment needs is also presented.

7.1.2.3 Programmes

A Special Fund for renewable energy sources (RES) and energy-saving was established in 2003. The aid schemes of this Special Fund were put in place from February 2004 to the end of 2013 and a total of EUR100 million was granted for investments implemented by natural and legal persons and public sector bodies engaging in economic activity, for both new and existing buildings. For the period 2004-2013, a total of 26982 investments were implemented as follows: 81% of requests were for windows changes, 8% for wall thermal insulation and 11% for roof thermal insulation (NECP-CY, 2020).

EUR 53 million has been secured from the European and Structural Funds 2014-2020 for grant schemes and projects for EE investments in private and public buildings. EUR 33 million were allocated for improving the EE for buildings used by SMEs and households while the remaining amount was allocated for improving the energy efficiency in central government public buildings. The projects in the public sector have started in 2018.

The 'Save & Upgrade' support scheme was enacted in 2015. This programme finances major renovation of homes and buildings owned or used by SMEs, which had requested a building permit before 21 December 2007. It is the follow-up of the completed pilot scheme that ran from 2004 to 2013 and is based on the same financial model: provision of grants for direct investments partly covering the purchase and installation costs of various technologies. Among the technical measures subject to verification are the issuance of EPCs and recommendations, thermal insulation of building envelop and replacement of window and door frames. Implementation of individual energy savings measures in buildings or building units used as permanent dwellings by vulnerable consumers is still allowed. In 2017 it was estimated that 1 138 homes and 164 SME buildings would undergo energy upgrading as of the 1st call issued in the context of the 'Save & Upgrade' programme. The second phase of the scheme was announced in 2018.

In the framework of two Interregional European programmes between Cyprus and Greece (SYNERGEIN and STRATENERGY), 11 buildings in municipalities and the wider public will be energy upgraded in the period 2018-2020 (Piripitsi, 2019).

The PEDIA project (Promoting Energy Efficiency and Development of Innovative Approaches in Schools, Sept 2020 – Aug 2025) is the first project that considers in a holistic way the needs of school buildings in Cyprus to be converted to NZEB. The PEDIA project will undertake a wide range of actions aimed at improving energy efficiency and comfort conditions of at least 25 public school buildings in Cyprus. The PEDIA project will activate EUR 7.5 million of public and private investment and develop a long-term energy renovation strategy for all public school buildings, introducing a process framework for energy upgrades based on environmental, energy and socio-economic criteria. The project is partially funded (EUR 500,000) under H2020-EU.3.3.7 and H2020-EU.3.3.1.

7.1.2.4 Guidance

A "Technical Guide for Nearly Zero Energy Buildings" was issued in 2015 by MECIT to assist buildings professionals in designing new buildings and renovating existing buildings to NZEBs (MECIT, 2015)

7.1.2.5 Other measures

According to the roadmap developed in the context of the 'Build up skills – Pillar I' initiative, there was a need to provide 'green' training to at least 4 500 workers for 13 different skills until 2020, to achieve the national targets for the energy performance of buildings (LTRS-CY, 2017). Some training events on NZEB were organised by the Cyprus Association of Civil Engineers.

The responsible body for the EE measures in Cyprus is the Ministry of Energy, Commerce, Industry and Tourism (MECIT). It organises information campaigns (leaflets and advertising flyers) to the general public, but also seminars and presentations directed at professionals in the building industry. In the last years, such events have been targeting also the professionals in the financial sector. Since 2004, the "SAVENERGY" exhibition gathers all companies and organisations who are actively involved in the EE buildings sector.

The ENERFUND tool rates and scores deep renovation opportunities and was developed within a H2020-EU.3.3.7 funded project. The Cyprus University of Technology is a leading partner of a consortium of members from 12 EU countries. Thus, funding institutions can provide targeted loans, retrofit companies can identify sound opportunities, municipalities can promote targeted incentives and the public's trust in retrofitting will be enhanced. Currently, there are approximately eight million buildings mapped across thirteen EU MS and more than seventy million unique data entries (such as wall energy efficiency, construction year, etc.) are available within the context of this tool.

7.1.3 Seismic strengthening & energy upgrading measures

No specific legislation, standards, programmes or guidance have been identified on combined/integrated seismic strengthening & energy upgrading measures with regard to the existing buildings in Cyprus.

A topic on "The Need for Seismic Upgrading of Existing Buildings Along with their Energy Upgrading" was included in the programme of a workshop entitled "Thermal Protection and Building Upgrade in Optimal Energy

and Environmental Behaviour", which took place on 7 December 2019 in Nicosia. The event was under the auspices of the Cyprus Scientific and Technical Chamber.

7.2 Best practices

7.2.1 Seismic strengthening

In 2000, the Cyprus has decided on the seismic retrofitting of all school buildings, taking into account that any loss of life due to their seismic vulnerability would have unbearable consequences. As of 2013, 90% of the school buildings of Cyprus were assessed as seismically resistant: 26 buildings were demolished and replaced by new ones at a cost of about 31 million Euros and 280 were retrofitted for 140 million Euros. The rest were designed after the enforcement of the seismic codes and thus did not require any intervention. For the RC structures, the applied methodologies were the use of reinforced concrete jackets, R/C walls or carbon fibres. In masonry structures, the use of injections and/or pre-stressing tendons, the construction of a ring beam, as well as the pointing of the joints, were the main methods used. In addition, special care was taken for the introduction of diaphragmatic action at the storey level, so the seismic forces are shared by all the load-bearing walls. The mean value of the strengthening cost was EUR 483,667. The contract value (total cost of construction) varied from EUR 75,992 Euros to EUR 2,120,711. In 50% of the buildings, upgrading, strengthening and maintenance operations were undertaken while in 8% it was additionally required to make expansions of the school and to upgrade the electrical and mechanical installations (Chrysostomou et al, 2013).

The procedures for inspection and control of building structures, introduced in 2019, are considered a necessary precautionary measure for public safety and a priority, especially for important buildings and buildings of particular cultural importance. The procedures apply to a large scope of buildings – those of central government, public buildings, private buildings and other buildings. The control includes also an assessment of the stability of non-load-bearing elements. An "Inspection Certificate" is published after the inspection to identify and record possible static or seismic deficiencies of the buildings. However, no energy efficiency issues are considered. The certificate should be renewed at regular intervals depending on the type and use of the building, at the responsibility of the owner.

7.2.2 Energy upgrade

In Cyprus, higher aid is granted for buildings that are renovated into NZEBs, than for other energy upgrades. Additionally, higher (75% instead of 50% public contribution) aid is granted to vulnerable consumers wishing to upgrade their buildings to energy efficiency class B or to achieve a 40% reduction in primary energy consumption. The vulnerable groups are also entitled to individual measures aid, such as thermal insulation on the roof and changing door and window frames.

A lower VAT rate of 5% (instead of 19%) was introduced in 2015 by the Cypriot Ministry of Finance for renovation and repair works carried out in existing private dwellings. The lower rate is used, *inter alia*, for works consisting in applying thermal insulation on the external building envelope and replacing external door and window frames.

In the case of new buildings and buildings undergoing renovation, it is allowed to increase the TFA by 5% of the buildings which achieve energy efficiency class A and where at least 25% of their total energy needs will be covered from RES, i.e. at least two of the criteria laid down for NZEBs must be met.

An In-Depth Assessment of the Energy Efficiency Potential in Cyprus has been conducted in the framework of a Technical Assistance project for the government of Cyprus and the aim was to assess the maximum theoretical and economically viable EE potential in Cyprus. A scenario that assumes the implementation of cost-optimal measures in all economic sectors under a modest deployment of financial resources has been evaluated as "realistic". It assumes the energy upgrade for around 1% of the existing number of buildings every year from 2018 to 2030 as a feasible objective. The average intervention cost of a deep renovation per average dwelling (i.e. weighted average after considering single-family, two-family and multi-family buildings) is estimated at ca. EUR 65 000. The proposed level and allocation of EE investments in buildings according to the 'realistic scenario' will require expenditures amounting to 870 million EUR until 2030, with a rather balanced budget distribution – 60% for residential buildings and 40% for service sector buildings. These annual expenditures represent 0.33% of the annual GDP of Cyprus over the 2018-2030 period (Zachariadis et al, 2017).

The Cypriot 'save & upgrade' programme finances renovations in homes and buildings owned or operated by SMEs. It has been highlighted as good practice in the recent analysis of the LTRS (SWD(2021) 365 final/2), as it helps to raise people's awareness of EPCs. Financial incentives are linked to the issuing of EPCs and a larger

subsidy is awarded to buildings that are being refurbished into NZEBs. In order to further improve the role of EPCs in selling and renting properties, there is a plan to increase inspections of commercial advertising, revise the existing legislative framework for the sale and rental of buildings, and make a further link with financial and fiscal incentives (SWD(2021) 365 final/2).

Participation of Cypriot research centres, public bodies, professional associations, etc. in several other research and training projects dedicated to the promotion of NZEBs, creates credible national know-how and competencies (NZEB-CY, 2017). For instance, the Cyprus Energy Agency takes part in the project HAPPEN (Holistic APproach and Platform for the deep renovation of the residential ENvironment) (2018-2021). This project aims to stimulate the market uptake of deep retrofitting of buildings to NZEBs, with special regard to the Mediterranean area and to the residential built stock. The project is funded under H2020-EU.3.3.7 and H2020-EU.3.3.1. Within the INTERREG Europe project entitled "Preserve Traditional Buildings Through Energy Reduction" (2017-2021, acronym VIOLET), a National Action Plan was prepared and approved and a significant amendment to the legislation is made: buildings that have been declared as listed buildings or as ancient monuments cease to be exempted from the obligation to have an EPC when sold or rented. Those buildings can be exempted from the minimum energy efficiency requirements only if their owners present to the competent authorities the proposed energy upgrade interventions and supply adequate documentation for exemption.

8 Implementing measures in France

8.1 Overview

The seismicity in France varies from low (PGA < 1.1 m/s^2) in most of mainland France, moderate in the Pyrenees and the Alps (1.6 m/s^2 < PGA < 3.0 m/s^2), to strong in the Caribbean islands (PGA > 3.0 m/s^2). In terms of climate, France has in general a temperate climate, with 2038 HDD and 76 CDD (Eurostat, 2021). Hence, the heating season is much more demanding than the cooling season.

8.1.1 Seismic strengthening measures

Given the limited number of regions with moderate to high seismicity, there is not a global national strategy for the seismic strengthening of buildings. However, plans describing the French policy of earthquake risk prevention are available, in particular, for the most vulnerable regions, e.g. the Antilles seismic plan (MTES, 2016) and the plan for the prevention of seismic risk of the Pyrenees (Occitanie, 2020). Such plans are mainly applicable to the construction of new buildings but provisions are made also for existing buildings and other construction works. With regard to the Eurocodes, in France EN 1998-3 is obligatory for use (Athanasopoulou et al., 2018).

8.1.2 Energy upgrading measures

On the other hand, to comply with EU obligations, namely Directive 2012/27/EU (2012) and Regulation (EU) 2018/1999, different action plans have been implemented in France to promote energy upgrading of buildings:

- **National Action Plan for Energy Efficiency** [*Plan national d'action en matière d'efficacité énergétique* (PNAEE)] (MEDDE, 2014; MEEM, 2017)

  France aimed for an ambitious goal of reducing final energy consumption to 131.4 Mtoe and primary energy consumption to 219.9 Mtoe, by 2020, excluding international aviation and non-energy uses. In the second version of this plan (MEEM, 2017), the estimated consumption of energy by 2020 was updated to 140.1 Mtoe (or 133.3 Mtoe, excluding international aviation and non-energy uses) and 226.9 Mtoe (or 220.1 Mtoe, excluding international aviation and non-energy uses), respectively. This enables concluding that the 2020 target values seem achievable. The estimated contribution from the residential sector, in terms of final energy, is about 36.68 Mtoe.

- **Long-term strategy for mobilising investment in the renovation of the national stock of residential and commercial buildings, both public and private** (*Stratégie à long terme pour mobiliser les investissements dans la rénovation du parc national de bâtiments à usage résidentiel et commercial, public et privé*) (MEEM-MLHD, 2017)

  The long-term and priority-based objectives set in this strategy aim for the ambitious targets of reducing greenhouse gas emissions by 40% in 2030, compared to 1990 levels, and by 75% in 2050, compared to 1990 levels. This target in 2050 represents a reduction by a factor of 4.

- **Integrated National Energy and Climate Plan for France, NECP** [*Plan National Intégré Énergie-Climat de la France* (PNIEC)] (MTE, 2020)

  The targets set for France to 2030, taking into account the implementation of the energy and climate strategy, in terms of both primary and final energy consumption, are 202.2 Mtoe (reduction of 24.2%) and 120.9 Mtoe (reduction of 32.6%), respectively, in relation to the reference value (PRIME 2007).

- **Label "High performance energy renovation**" (*Label HPE renovation*) (Law 2009/1154/FR, 2009)

  In 2020, the number of buildings committed to low-level renovation consumption showed an increase of 10% compared to 2019. In total, about 235,000 housing units are committed to a low-consumption renovation in the residential sector, generating on average a reduction of 75% of GHG emissions (effinergie, 2020).

- **National Plan for Housing Thermal Renovation** (PREH - *Le Plan de rénovation énergétique de l'habitat*) (ADEME, 2019)

Since its implementation in 2013, this plan contributed to the general renovation of about 3.5 million homes in the private housing sector in 2014. Of these, around 2 million homes have undergone energy renovations, including 288,000 renovations with high performance or very high performance.

Within the latest LTRS of France, more ambitious targets of achieving carbon neutrality by 2050 for the residential sector were set out (SWD(2021) 365 final/2). To achieve this, French strategy includes a gradual set of measures, starting with a ban on rent increase in the case of poorly performing buildings ('passoire énergétique', no performance specified) as from 2021, a ban on renting these as from 2023 and an obligation to renovate all worst performing buildings as from 2028. Through measures of improving energy efficiency, a 22% reduction in energy consumption in the building sector by 2030, 29% by 2040, and 41% by 2050, compared to base year 2015 shall be achieved. Combined with other measures, France aims to decrease building sector GHG emissions by 49% in 2030 compared to 2015 and 94% by 2050 (SWD(2021) 365 final/2).

In order to achieve the above targets, different measures were introduced in France, focussing on energy efficiency, reduction of greenhouse gases and production of energy from renewable sources in buildings. These measures support the implementation of the above plans by providing funding and financial benefits. The most relevant ones are summarized in **Table 4**.

Table 4. Summary of the different financing programmes in France

	Renovation approach			Technologies								
Programme	Low	Medium	High	Structural work	Walls insulation	Roof insulation	Improvement of glazed areas	Solar energy	Biomass	Geothermal	Ventilation	HVAC/heat pump/ other
CITE [a]					√			√		√		√
0% Eco-loan [a]					√	√	√	√				
Living better [a]				√	√	√					√	√
Reduced VAT [a]					√	√						√
ADESTIA [b]					√	√	√	√	√			
MaPrimeRénov [a]					√	√	√	√		√		

[a] ADEME (2020); [b] EIB (2020)

The timeframe of the above measures is shown in **Table 5**. Some of the listed programmes are foreseen to continue after 2020, and therefore, they are indicated in light grey.

Table 5. Timeframe of the different programmes in in France

Programme	2004	2006	2008	2010	2012	2014	2016	2018	2020	2022	2024	2026	2028	2030
CITE														
0% Eco-loan														
Living better														
Reduced VAT														
ADESTIA														
MaPrimeRénov														

8.2 Best practices

8.2.1 Programmes and other measures

8.2.1.1 Seismic strengthening

The Antilles seismic plan represents a successful measure implemented in support of seismic strengthening of existing buildings. The second phase of the plan (2016–2020) (MTES, 2016) was developed in consultation with the Antillean local authorities, as well as other local actors. Apart from reducing the seismic vulnerability of buildings, the plan aimed to support raising awareness of earthquake and tsunami risks and preparing for crisis management. Since its launch, the Antilles seismic plan resulted in the regional retrofit of approximately 30% of vulnerable educational establishments, 30% of vulnerable social housing, and 75% of Departmental Fire and Rescue Services.

8.2.1.2 Energy upgrading

Conversely, in terms of energy upgrading of buildings, the estimated results from the programmes listed in 8.1.2 are provided in the following paragraphs. It is noteworthy that specific performance indicators for the different programmes were not found. Hence, the values provided in the next paragraphs are the values considered or estimated in the most recent versions of the most relevant strategies.

Taking into account the regulatory measures described above, the implementation of such measures led to the following results (MEEM, 2017):

- **2012 Thermal regulation** [*Règlement Thermique* 2012] (Governmental Decision of 28th December 2012/FR, 2012) – This regulation introduced higher thermal performance requirements for new buildings. The final energy savings resulting from the new requirements of this regulation were 0.50 Mtoe in 2015, and the estimated values in 2020 and 2030 are 1.68 Mtoe and 4.22 Mtoe, respectively. However, it is noted that these values are referring to new buildings.
- **Energy transition in supporting Green Law** [*Loi de la Transition Énergétique pour la Croissance Verte* (LTECV)] (Law 2015/992/FR, 2015) – This law requires that when major work takes place, the energy performance of the building should be improved. The estimated savings due to this obligation, in terms of final energy, are 0.06 Mtoe in 2017, 0.26 Mtoe in 2020, and 0.91 Mtoe in 2030.

In relation to the different financial instruments referred above for the energy renovation of existing buildings, the available results are the following (MEEM, 2017; ADEME, 2020):

- **The energy transition credit tax** (CITE - *Le crédit d'impôt pour la transition énergétique*) - The implementation of this programme allowed a reduction in the annual final energy consumption of 0.78 Mtoe in 2013, 0.93 Mtoe in 2016, and 1.08 Mtoe in 2020.
- **Reduced VAT** (*La TVA à taux réduit*) – This programme together with CITE are some of the programmes most used by households. However, no indicators were found for this specific programme.
- **0% Eco-loans** (*L'éco-prêt à taux zéro*) – Since the beginning of this programme, about 800,000 to 1,000,000 houses, per year, have been involved. The implementation of this programme has enabled to reduce the annual final energy consumption in 0.18 Mtoe in 2013, and 0.19 Mtoe in 2016 and 2020.
- **The Programme "Living Better" of the National Agency for Housing Improvement** (*Le programme « Habiter Mieux » de l'Anah*) - The number of homes renovated under the "Living Better" programme is about 31,265 in 2013, 49,831 in 2014, 49,706 in 2015, and 40,726 in 2016. Until 2017, the programme expected to renovate about 300000 homes by improving their energy performance in at least 25% (with a target of 100,000 homes for the year 2017).
- **'MaPrimeRénov' –** This programme, replacing the previous programmes CITE and 'Living better', is recent and no indicators were found for this specific programme.

Additionally, the Commission's analysis of the latest submitted LTRS (SWD(2021) 365 final/2) highlights as best practice that from 1 January 2022, energy performance certificates and tenancy agreements will have to include information on the actual energy consumption of dwellings expressed in primary and final energy, and an estimate of the theoretical amount of energy expenditure.

8.2.2 General investments in renovation

According to the information from the EU Buildings Database (2019), the building stock in France, in 2016, was composed of a share of 73% of residential buildings and 27% of non-residential buildings.

Considering the time span 2012-2016, the average renovation rates related to non energy upgrading were 14.9% and 12% for residential and non-residential, respectively. For energy-related renovations, the renovation rates were 13.3% and 6%, for residential and non-residential, respectively.

In terms of investments in renovation, the total volume for residential and non-residential buildings is provided in **Figure 2** for the time span of 2012-2016; while, **Figure 3** represents the volume of energy-related investments, for the same time span.

Figure 2. Total volume of investments in renovation of residential and non-residential buildings in France (EU Buildings Database, 2019)

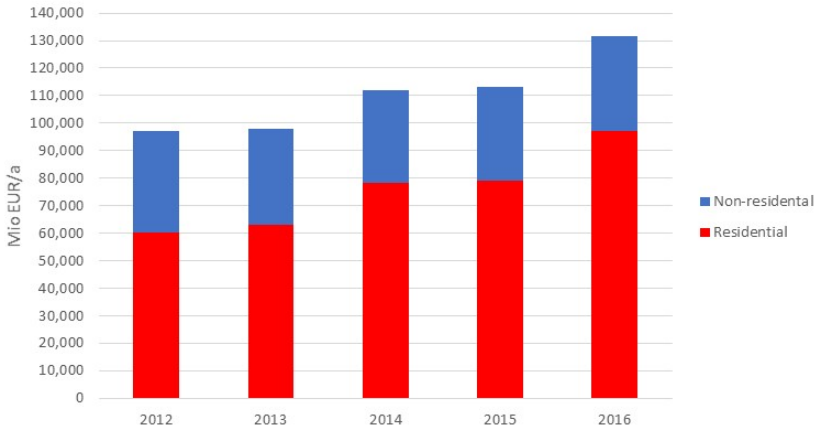
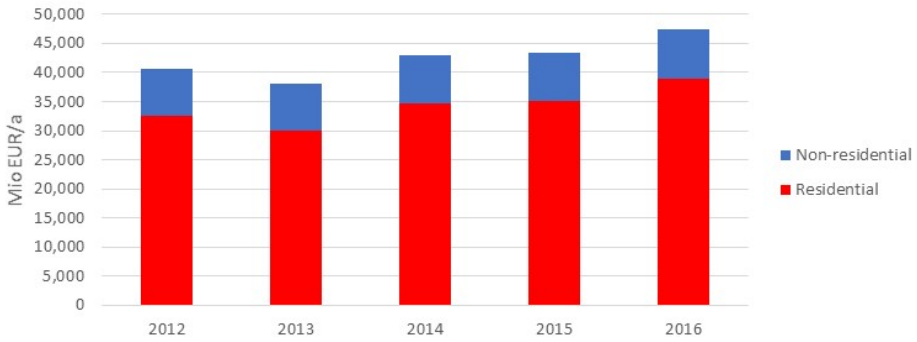


Figure 3. Total volume of energy-related investments in renovation of residential and non-residential buildings in France (EU Buildings Database, 2019)



The energy-related renovation led to a total primary energy savings (average), in the period of 2012-2016, of 447,412 toe for residential buildings and 269,758 toe, for non-residential buildings. This value represents the average reduction of the total annual primary energy use (from heating, cooling, ventilation, domestic hot water, lighting (only non-residential buildings) and auxiliary energy) that was achieved compared to the previous year, during the period 2012-2016, through energy-related renovation.

In terms of the type of work, **Table 6** indicates the proportion of energy renovation works carried out between 2006 and 2016, for buildings built in different periods of time. This table indicates that the replacement of windows is the most common renovation practice, independently of the construction period, both for multi-family buildings (apartments) and single-family buildings. In the case of single-family buildings, the insulation of the remaining building envelope is also a common practice, particularly in terms of the insulation of the roof. In any case, none of the renovation work indicated in **Table 6** leads to a deep renovation of the building.

Table 6. Energy renovation work in the period 2006-2016 [extracted from (MTE, 2020)]

ENERGY RENOVATION WORKS CARRIED OUT BETWEEN 2006 AND 2016	APARTMENTS			ONE-DWELLING HOUSES		
	Before 1948	1949-1974	After 1975	Before 1948	1949-1974	After 1975
Insulation of loft floor or roof rafters – attic	5.00%	1.70%	1.60%	18.60%	22.20%	14.30%
Insulation of roof slab or joists – flat roof	2.40%	3.70%	2.30%	13.40%	9.50%	5.30%
Internal wall insulation – External wall insulation	4.80%	5.80%	2.50%	12.00%	11.20%	4.40%
Windows – total replacement	15.90%	17.10%	10.20%	32.80%	31.40%	19.40%
Windows – partial replacement	9.80%	14.00%	5.40%	14.40%	14.80%	7.70%
Windows – shutters only	6.60%	13.10%	7.30%	18.20%	19.80%	14.40%
Replacement or installation of a central heating system – fluid network	18.40%	12.70%	10.90%	31.80%	30.80%	21.10%
Replacement or installation of domestic hot water system – fluid network	9.70%	7.90%	6.80%	17.10%	14.50%	10.90%
Upgrading of heating controls – fluid network	6.20%	5.00%	3.10%	8.20%	8.00%	4.20%
Lagging of all or part of an installation for producing or distributing heat or domestic hot water – fluid network	0.90%	0.60%	0.80%	1.10%	1,60%	0.30%
Replacement or installation of renewable energy sources for heating – fluid network	0.40%	1.10%	0.60%	6.80%	4.70%	5.80%
Replacement or installation of renewable energy sources for domestic hot water – fluid network	0.40%	0.60%	0.30%	3.30%	1.60%	2.90%
Replacement or installation of equipment for electricity production from a renewable energy source – Joule room and water heating	0.30%	0.40%	0.20%	2.40%	2.20%	3.80%
Installation or replacement of a controlled mechanical ventilation (CMV) system	7.10%	5.40%	4.00%	14.50%	14.10%	12.60%

For the latest LTRS, the estimated annual amount of (public/private and public) investment for the 2019-2032 period includes EUR 15-25 billion for buildings (from the NECP). Additionally, EUR 1.8 billion are allocated for government building thermal renovation for 2017-2022 (SWD(2021) 365 final/2).

9 Implementing measures in Germany

9.1 Overview

Germany is a country with low to moderate seismicity and the maximum PGA is about 1.6 m/s^2 in the south of Germany (DIN EN 1998/NA:2020-05).

In terms of climate, Germany has in general a temperate climate, with 2741 HDD and 25 CDD (Eurostat, 2021). Hence, the heating season is more demanding than the cooling season.

9.1.1 Seismic strengthening measures

There is a lack of information regarding existing guidelines, codes, legislations and incentives for seismic retrofitting in Germany. The so-called 'grandfather clause' or 'Bestandschutz im Baurecht' guarantees building owners that the state cannot later make any demands on the existing structure as long as no substantial modifications of the load-bearing system are carried out. Eurocode 8-3 (2005) is not introduced in Germany and the corresponding National Annex does not exist. The first low-level seismic code was introduced in 1981 and the high-level seismic hazard code DIN 4149 (2005), very similar to Eurocode 8 (2004), was implemented in 2005.

Germany is covered under the Union Civil Protection Mechanism (Decisions 2013/1313/EU, 2019/420) of the EU. Furthermore, earthquake insurance is offered by insurance companies for building owners. However, these insurances are not directly related to seismic strengthening measures, because the insurance premium doesn't depend on the strengthening or renovation of the building but the age of the building.

9.1.2 Energy upgrading measures

With the aim of upgrading the energy performance of buildings, Germany introduced and implemented laws and incentives over the years. The important measures for the energy retrofitting adopted by Germany are given below which also includes National Energy Efficiency Action Plans (NEEAP) and National Energy and Climate Plans (NECP). The German Energy Saving Ordinance (German: Energieeinsparverordnung - EnEV) provides minimum requirements for the energy standard of the building envelope and systems engineering for new buildings and major renovations of existing buildings. The EnEV was passed in October 2013 and is in effect from May 2014. The German EnEV is in accordance with the EU programme "Energy performance of buildings directive 2010/31/EU" (EPBD). The German EnEV is the central instrument within the energy and climate protection policies in Germany. Its purpose is to ensure the achievements of the targets of the Federal Government's energy policies. The ordinance provides structural and heating system standards for buildings and specifies the energy efficiency for new and existing buildings.

EnEV is based on the Energy Saving Act (EnEG) and complemented by further standards and laws such as the Renewable Energies Heat Act (EEWärmeG). EnEV sets increasingly higher standards for mainly new construction, but certain rules are also given for the existing building stock. The obligation to change the boilers installed prior to 1985, the application of the thermal insulation of the top floor ceilings, the introduction of an obligatory energy performance certificate are some examples of implemented standards within the framework of EnEV. Schettler-Köhler (2016) reported that from 2016, 60% of the top floor ceiling of a representative sample of the existing building stock were thermally insulated. These refurbishments, completed in 2015, led to a reduction of 7,008 MWh/year. The reduction of energy consumption leads to lower maintenance costs, which in turn results in attracting the public and increasing awareness among them. It is compulsory to show the energy performance certificates (EPCs) to the prospective buyer or tenant and leads to a penalty for non-compliance to the owner of the building by the building authorities. The German market instrument "cease and desist letter" ("Abmahnung") supports to achieve a high level of compliance in practise. These letters are issued by the private stake holder organizations or competitors.

The latest LTRS of Germany assessed by the Commission (SWD(2021) 365 final/2) include plans to reduce greenhouse gas emissions to 70 $MtCO_{2eq}$ by 2030, which represents a 67% reduction compared to 1990. From 2030 onwards, the renovation rate is expected to increase from around 1.3% to over 2% for single and two-family houses and from around 1.5% to over 2% for apartment blocks. Investments in renovation were reported for 2018, when EUR 182.2 million were given out as grants, triggering total investments of EUR 734 million.

9.2 Best practices

9.2.1 Disaster risk reduction (DRR)

Disaster risk reduction in Germany includes prevention, preparedness and part of recovery process, giving special emphasis on the vulnerability reduction. However, specific strategies are not implemented for seismic strengthening measures. However, the DRR identifies the risk including the seismic risk and suggest methodologies for risk reduction. The Federal Office of Civil Protection and Disaster Assistance (BBK), is involved in communicating and educating the public about the risk within the framework of civil protection. BBK provides a video series on civil protection against seismic actions and shows possibilities to protect buildings against earthquakes. The Sendai Framework for Disaster Risk Reduction 2015-2030 (SWD, 2016) and the European Civil Protection Mechanism (CPM) are followed by the DRR which is formed by several governing bodies (Marx et al., 2017): Federal Ministry of the Interior, Federal Office of Civil Protection and Disaster Assistance (BBK), Academy for Crisis Management, Emergency Planning and Civil Protection (AKNZ) and German Federal Agency for Technical Relief (THW).

9.2.2 Energy upgrading programmes

The programme “Upgrading the CO_2 Building Renovation Programme” includes financial subsidies for the renovation of buildings to improve the energy efficiency. The funds of this programme are used to finance the actions within the KfW support programme for energy-efficient building renovation. The German Ministry for Economic Affairs and Energy (BMWi) currently issues over EUR 2 billion a year for the programmes, which form part of the campaign "Efficiency first". Every second newly built home in Germany is currently supported by funds from the "Energy-efficient Construction" programme and close to 290,000 homes received an energy-efficient makeover with the support of KfW in 2016. This is the most significant provider of financial incentives for energy efficiency in German housing sector. The measures supported through this programme are those which exceeds the legal requirements according to EnEV, which points to a higher standard of the energy efficiency than minimum required legally. Energy efficient upgrading measures in buildings are also supported with low-interest loans, in part repayments and investment grants. The programme started in 2015. In 2019 the programme has contributed to yearly added savings of 7.7 PJ for the final savings measure (ODYSSEE-MURE, 2022). This shows the substantial impact in terms of energy savings. The debt relief of the incentive is starting at 12.5% up to 27.5% in the most ambitious level. Only in 2015, 237,000 housing units were refurbished to more energy efficient levels with the support of the programmes. This makes an essential contribution in achieving the objectives of the ‘energy concept’, the implementation of the EU directives (EPBD) for energy efficiency in the building sector to prepare the market for the introduction of zero-energy building standards. The energy concept started in 2010 for an environmentally sound, reliable and affordable energy supply with renewable energy sources, implementing a long-term overall strategy for the period up to the year 2050. With the coalition agreement, it is planned to reduce the greenhouse gas emissions of Germany by 40% in 2020 and 80% by 2050 (EESB, 2014).

The Climate Action Programme 2030 makes Germany’s climate policy more binding than before. The Climate Action Act (*Klimaschutzgesetz*) will, for the first time, give the national climate targets the status of law. The Climate Action Act will also introduce a continuous review of climate targets, with clear responsibilities for the individual sectors and obligatory adjustments if a particular sector is not on course to reach its targets. This will ensure to reach the goals of the programme on an annual basis. The Climate Action Programme 2030 provides tax incentives for the refurbishment of buildings to increase energy efficiency. This includes also smaller-scale modernisation measures such as installing new energy-efficient windows or insulating roofs and external walls. Furthermore, it will support the replacing of heating systems to switch to more climate-friendly heating from renewable sources. As an example, the programme tries to encourage people to replace oil central heating with new more environmentally friendly systems with high levels of subsidies (up to 40%).

9.2.3 Energy efficiency strategies

The energy efficiency strategy of the Federal Government is set out using the National Action Plan on Energy Efficiency (NAPE). NAPE aims to reduce the primary energy consumption to 20% by 2020 compared to that of 2008. The long-term aim is a reduction to 50% by 2050. The short-term measures of the NAPE include:

— Introducing new competitive tendering for energy efficiency

— Raising funding for building renovation (CO_2 Building Renovation Programme) and introducing tax incentives for efficiency measures in the building sector supported by the Federal Government and state governments.

— Setting up energy efficiency networks together with business and industry

It is commissioned under EU Energy Efficiency Directive 2012/27/EU, and was approved in December 2014. The NAPE measures will have impacts in the short, medium and long term, as the Action Plan comprises short-term measures that will already take effect as of 2015 as well as longer-term work processes for the remainder of the legislative term.

The energy efficiency strategy for buildings (ESG) sets out a comprehensive strategy for the building sector. It brings together the three aspects of power, heat, and energy efficiency to form a clear policy framework for the energy transition in the buildings sector. The principles set out in ESG are part of the National Action Plan on Energy Efficiency (NAPE)[6]. ESG outlines several steps that can be taken to achieve an almost climate-neutral building stock by 2050, based on a combination of energy-saving measures and the use of renewable energies.

The target by 2020 is to increase the share of renewable energy sources in overall energy consumption by 18% and to reduce the primary energy consumption through energy efficiency by 20%. Climate-neutral buildings are also part of long-term strategy of the national energy and climate plan (NECP). In addition to the NAPE methods, ESG proposes further options to increase energy efficiency and the share of renewable energy in the buildings:

— Establishing a building-specific renovation roadmap

— Further development and expansion of the energy consulting services

— Public funding for investment in ambitious building renovation and new building projects

— Public funding for energy-efficient urban and neighbourhood renovation

— The “renewable energies in low-temperature heat grids” showcase

— Further development of energy saving legislation for buildings

— Targeted support for research and innovation, faster transfer to practice

The following programmes are documented under ESG:

— Market incentives programme and Energy Efficiency Incentives Programme as a replacement for the tax incentives

— Since 2016, “Deutschland macht’s effizient (Germany Makes It Efficient)” campaign

— The “Heating Optimization Funding Programme” providing funding for low-investment measures to optimize existing heating systems

— The “ENff.Building.2050” initiative, providing funding for model projects

— The “Solar Construction/Energy- Efficient City” initiative providing funding for research and development.

The Energy Efficiency Strategy for Buildings is in effect from November 2015 and should be interpreted as a “learning” strategy that will be developed further according to the needs and on the basis of new results and considering the changing of overall conditions, to achieve the goals by 2050.

9.2.4 Guidance for energy efficiency checks, retrofitting and optimization

Germany introduced a new tool for the energy-efficient retrofitting of buildings, a renovation road map tailored to individual buildings. This software-based tool is used by energy advisors on efficiency in buildings (“Energieeffizienz-Experten für Förderprogramme des Bundes”) to give owners a clear and simple overview of the required modernisation measures. It points to untapped possibilities for energy conservation and the use of renewables, and also gives an estimate of the relevant investment costs and of the savings that could be achieved in terms of heating costs and carbon emissions.

The tool is also able to estimate the relevant investment costs and the savings that could be achieved in terms of heating costs and carbon emissions. Through this software the experts in the region sought are listed. The experts further give consultations and advises according to individual requirements. This action is running under the umbrella of the Federal Office for Economic Affairs and Export Control (BAFA).

The Caritas association offers free energy efficiency checks specifically for low-income households together with the Association of Energy and Climate Protection Agencies in Germany (Bundesverband der Energie- und

[6] https://www.bmwk.de/Redaktion/EN/Artikel/Energy/national-action-plan-on-energy-efficiency.html

Klimaschutzagenturen Deutschlands — eaD). This measure enables house owners to collect the information about the energy efficiency of their buildings as a basis for further measures co-financed by the state.

The basic idea of the action is the visit of "energy-saving assistants" to the affected household to analyse the individual household power consumption. Specific data are collected, such as the electricity consumption of the refrigerators and freezers, electric heating system and lighting equipment etc. The energy-saving assistants prepare specific savings proposals for the individual household. The personalized assistance in the cost saving emphasise the socio-economic aspect of the guidance. Moreover, the energy-saving assistants are long-term unemployed people, specially trained for the energy assistance. This will create more job opportunities at the same time. The measure was introduced in 2009 and evaluated in 2017.

Over time, various measures of information and energy consulting in Germany have been established. The Energy Consulting provides the investors and other related parties (such as tenants) an important contribution to stimulate the motivation to invest and to support refurbishment measures. The energy consulting is closely linked with the CO_2 Building Rehabilitation Programme (Nieboer et al., 2012). The quality assurance and optimization of existing energy consulting will support:

— Consultations to a comprehensive renovation of the building

— Advice for creating a recovery timetable with coordinated individual energy efficient measures leading towards progressive building renovation

— Energy consulting services at the home owner associations

The existing energy consulting programmes (including that of Consumer Centre and the on-site consultation by BAFA) in accordance with requirements will be further developed as goal-oriented. For example, it is planned to link better together the different measures, to increase the consistency, transparency and to avoid the overlapping of the different energy consulting programmes.

Additionally, the Commission's analysis of the latest submitted LTRS (SWD(2021) 365 final/2) highlights the individual renovation passport (iSFP) as best practice in Germany. It was initially developed and tested in Baden-Wuerttemberg and was officially adopted by the Federal Ministry for Economic Affairs and Energy (BMWi) in 2017 for application across Germany. At this stage it can already be used voluntarily by energy consultants and for documentation purposes within the Federal Office for Economic Affairs and Export Control (BAFA) 'Energieberatung vor Ort' support programme. iSFP is financially supported through the energy advice for residential buildings (on-site advice, building renovation passport) with up to 80% of the consultancy costs incurred through a grant.

10 Implementing measures in Greece

10.1 Overview

Greece belongs to the countries with high seismicity in the EU. Seismic zonation in Greece identifies three seismic zones with a reference PGA in the range of 0.16g–0.36g (EAK 2000/2003).

In terms of climate, Greece has 1489 HDD and 345 CDD (Eurostat, 2021), corresponding to a moderate heating season that is more demanding than the cooling season.

10.1.1 Seismic strengthening measures

10.1.1.1 Legislation & Standards

The first nation-wide seismic code was introduced in 1959 and it was revised in 1984. The latter edition was updated in 1992 into the New Seismic Code of Greece and implemented in parallel with the previous version until 1995. In 1999, the Greek Seismic Code 2000 (EPPO, 2001) was approved, adapting the earlier version to ensure consistency with the Eurocodes. The obligatory implementation of the Greek Seismic Code 2000 started in 2001, whereas the code was revised further with ministerial decisions in 2003 and 2010. . The amended Greek Seismic Code 2000 was set in parallel implementation with Eurocode 8 in 2014.

All Eurocodes Parts are published as National Standards and translated in Greek. National Annexes ELOT EN 1998-1:2005/NA: 2010 and ELOT EN 1998-3:2005/NA: 2010 are published in Greek. The Ministerial Decision" DIPAD/372/30-05-2014 implies that the Eurocodes in combination with the relevant National Annexes may be used as regulatory documents for the design of new structures and the assessment and redesign of existing ones, both for public and private (civil engineering) works. The pre-existing National Codes/Regulations are no longer mandatory, and the relevant actors may choose the framework of regulatory documents for structural design between the two following options: implement either the pre-existing regulatory documents or the Eurocodes together with their National Annexes (Athanasopoulou, 2019). A selective use of clauses from both regulatory frameworks is not allowed.

In 2012, the Code of Structural Interventions, (KAN.EPE, 2012) was approved in Greece. This high level code addresses the structural assessment and seismic redesign of existing reinforced concrete. It harmonised to the Eurocode framework, and therefore it is applied in parallel with EN 1998-3 as a noncontradictory and complementary national standard (Athanasopoulou, 2019). The code was amended in 2013 and 2017.

A draft of the Code for the Assessment and Structural Interventions of Masonry buildings (KADET, 2021) is currently at the stage of public consultation.

10.1.2 Energy upgrading measures

10.1.2.1 Legislation & Standards

Law 3661/2008 on the "Measures to reduce energy consumption in buildings and other provisions" was the main law for the transposition of the first EPBD. According to the law, construction of new buildings and major renovation of existing ones shall be based on the Greek Regulation for the Energy Efficiency of Buildings (KENAK). Law 4122/2013 on the Energy Performance of Buildings harmonizes Greek legislation with EPBD (recast). The Energy Efficiency Act (Law 4342/2015) transposed the EED.

The Building Energy Performance Regulation (KENAK, 2017) defines the relevant calculation methodology, minimum requirements for the energy performance of buildings, the Energy Performance Study of buildings, the procedure for energy inspections of buildings and heating and cooling systems, the EPC issuance, etc. New buildings and existing ones subject to major renovations are addressed. KENAK sets minimum requirements for the thermal resistance of building elements (i.e. maximum U-values), as well as for energy losses and gains for the whole building envelope, and minimum requirements for the efficiency of heating, cooling and hot water production systems. For existing buildings under major renovation, it is compulsory to upgrade the energy performance of the building up to class B at least.

By the Ministerial Decision YPEN/DEPEA/85251/242 (2018), a building is defined as NZEB when its primary energy consumption is in the range of 33–50% of the primary energy consumed in a reference building, and assigned with class A (Bololia, 2020).

10.1.2.2 Strategies

The Fourth National Energy Efficiency Action Plan (timeframe: 2011-2020), identified the measures needed to renovate residential buildings, public buildings and commercial buildings (NEEAP-GR, 2017). A long-term strategy for mobilising investment in the renovation of the national building stock (residential and commercial buildings, both public and private) (LTRS), was submitted in 2017 and updated in April 2018. The strategy provides a very good and detailed description of the building stock, a detailed analysis of the barriers to energy efficiency take, together with the description of a comprehensive package of measures supporting the renovation of buildings along with a section of cost-effective approaches. The strategy was prepared by considering two scenarios for residential buildings obtained by combining a constant renovation rate with various types of renovation (moderate and deep). Based on those scenarios, 40% renovation of residential buildings at a cost of EUR 1.7 billion would result in cumulative primary energy savings of 236 ktoe, while a 60% renovation at a cost of EUR 2.5 billion would result in 354 ktoe by 2030. For the period 2020-2030, special attention is drawn to measures aiming to improve the energy performance of buildings and KENAK implementation, use of RES in residential and tertiary-sector buildings, develop energy management systems in public- and tertiary-sector buildings, raise awareness, promote the provision of energy services (ESCOs), support research and technological development in RES-related, energy-saving and other technologies, develop environmentally-friendly energy production, and apply energy-saving interventions.

The National plan for increasing the number of nearly zero-energy buildings was submitted in December 2017 (NZEB-GR, 2017), but at that time no national definition on NZEB was available. The policies and measures related to the existing buildings to NZEB foresee pilot projects for improving the energy performance of public buildings (owned or rented for 20 years or more) through major renovations, implemented by ESCOs with co-financing from the public investment programme.

According to the National Energy and Climate Plan, 600 000 dwellings shall be renovated by 2030, which represents a share of 12-15% of the building stock. To achieve this, the renovation rate shall be increased to 1.6% (doubling the 2015 one). In particular, by 2050, 45-49% of building envelopes in residential and 19-20% in non-residential buildings shall be renovated according to the latest LTRS (SWD(2021) 365 final/2). The plan envisages setting up tailored funding schemes to improve the EE of 'vulnerable consumer' homes. After 31 December 2023, all buildings housing public authorities must be classified in energy category B or higher on the basis of the EPC (NECP-GR, 2019).

10.1.2.3 Programmes

The programmes 'Save' and 'Save II' provide grants aiming at the energy upgrading of energy-intensive public buildings, exploiting the potential for energy savings and improving energy efficiency in the public building sector, as an example to mobilise the entire economy. According to 'Save II' (Ministry of Environment and Energy, 2018a), the energy upgrade of public buildings shall exceed the minimum required energy efficiency levels or, if economically and technically feasible, be upgraded to energy classes B+, A, A+, or to NZEB. The energy upgrades include, *inter alia*, interventions, such as adding thermal insulation, replacing window frames and glazing, replacing heating systems/boilers/piping with a RES system, replacing old air conditioning systems, passive solar systems, etc. The programme is funded by the ERDF through operational programmes within the National Strategic Reference Framework (NSRF) 2014-2020. The total public expenditure of the operation amounts to EUR 244.93 million.

The 'Save energy at home' (2007-2013) programme was initiated to improve the energy performance of residential buildings. It succeeded to allocate 95% of its EUR 548 millions of available funding, supporting over 50,000 beneficiaries. Average energy savings of 43% surpassed the initial 30% target. The maximum eligible funding per applicant was EUR 15,000. The grant varied between 15 and 70%, depending on the family income. Most interventions have been in old, energy-intensive buildings. Nearly half of the programme's budget was allocated to the replacement of doors and windows, with the rest split between heat insulation and heating system projects. The scheme counts as one of the most advanced schemes available, providing direct benefits to citizens, but also, in terms of employment (over 3,000 new jobs a year) and turnover to companies (especially SMEs) and professionals in the Greek construction sector.

The 'Save energy at home II' (2014-2020) programme (Ministry of Environment and Energy, 2018b) involves implementation of interventions to improve the energy performance of residential buildings that are proven to have low energy performance and belong to owners who cannot fully fund the energy upgrade of their residence, or in buildings where interventions aim to achieve a higher level of energy performance than the minimum required. Aid is granted either directly to the beneficiary or in the form of a grant coupled with an interest-free or low-interest loan. Eligible interventions include replacement of window frames with new thermal

insulated/break frames with double glazing, installing thermal insulation in the building envelope, including the flat roof/roof and pilotis, upgrading of the heating system (with RES). The programme is funded by the ERDF trough operational programmes of NSRF 2014-2020. The total public expenditure of the programme amounts to EUR 292.18 million. The eligible budget of interventions per application may not exceed EUR 250 per square meter with a maximum cost of interventions per house / apartment of EUR 25,000 including VAT. Approximately, 45,000 applications have been submitted (50% of applications are for buildings built before 1980).

The programme 'Improving the energy efficiency of SMEs', starting in 2018, aims to support micro, small and medium-sized enterprises from manufacturing, handicraft, trade, services, tourism and shipping sectors to improve their EE (Ministry of Environment and Energy, 2018c). The action involves, inter alia, performing interventions in the building envelope such as adding thermal insulation, replacing window frames/glazing, adding shading systems, along with energy inspections and/or energy audits before and after assessing the energy outcome, certification of the energy management system according to ISO 50001 and project consultation. The action is funded by the ERDF through the Operational Programme 'Competitiveness, Entrepreneurship, Innovation' 2014-2020. The total budget of the action amounts to EUR 64.06 million and the total public expenditure amounts to EUR 32.3 million.

10.1.2.4 Guidance

All necessary technical specifications and information for the implementation of KENAK are included in four technical guidelines (TOTEE 20701/2010, updated in March 2012 and in November 2017), which include relevant assumptions, calculations, climatic data files and thermal characteristics of building materials. The guidelines are prepared by the Technical Chamber of Greece (TEE) and are also supported by a software (TEE-KENAK). *TEE KENAK* is used by energy inspectors to issue the EPCs. It is also used for building EE studies either for issuing a licence permit for new buildings or for major renovations work.

10.1.2.5 Other measures

Greek institutions and research centres took part in several projects under the European programmes: a) H2020 Programme, such as PRODESA, QualitEE, ENERFUND, PUBLEnEf, ODYSSEE-MURE, CAIV_EPBD, EPC+, STEAM-UP, EnPC-INTRANS, multEE; b) INTERREG MED Programme such as SHERPA, IMPULSE, PEGASUS and PrioritEE; c) INTELLIGENT ENERGY EUROPE (IEE), such as RePublic_ZEB, thus creating favourable conditions for the development of national know-how based on best practices and recent achievements in the field of EE of buildings in Europe.

10.2 Best practices

10.2.1 Seismic strengthening

KAN.EPE.2012 (2012, 2013, 2017) enacts criteria for the assessment of the structural capacity of existing structures, and rules of application for their redesign, replanning, as well as for potential interventions, repairs or strengthening. The code contains provisions with mandatory application, which define a) the criteria for the assessment of the structural capacity of an existing structure, b) the minimum mandatory requirements of the structural capacity of redesigned structures or their parts, c) the specification of the ways an intervention can be carried out, and d) the interrelation of this code with other Standards (i.e. regarding materials, loads etc.).

10.2.2 Energy upgrade

Tax incentives, introduced in 1994, allowed 20% of the cost of EE measures and RES installations in buildings, capped at EUR 700, to be deducted from the taxpayer's total income. From 2010, 10% of the relevant cost, capped at EUR 6,000 (i.e. EUR 600 maximum) could be deducted from income tax and, in 2011, that cap was reduced to EUR 3,000 (i.e. EUR 300 maximum). Although most tax breaks, including EE measures, were abolished in 2013, the Building Code of 2012 (Law 4067/2012) introduced further incentives towards buildings of minimum energy consumption. These included a 5% increase in the building-to-land ratio for A+ rated buildings, and a 10% increase in the building-to-land ratio for very high-efficiency buildings (with primary energy consumption of less than 10kWh/m^2/year) (LTRS-GR, 2018).

Offsetting fines for buildings without planning permission against energy improvement measures is applied as a particular measure according to Law 4178/2013 and Law 4495/2017. The measure allows to offset up to 50% of the special fine against the cost of fees for services, work and materials to improve the energy performance of the building. The fine is offset provided that the measures improve the building by at least one

energy category or generate annual primary energy savings of over 30% of the consumption of the reference building (LTRS-GR, 2018).

The Commission's analysis of the latest submitted LTRS (SWD(2021) 365 final/2) highlights the link between the issuing of EPCs and financial incentives as a best practice. The Greek "*Save energy at home II" Programme* is mentioned as an example of good practice. In the programme, there are seven categories of incentives in which beneficiaries are classified, depending on their income, the degree KENAK requirements that are achieved. For income categories 1 and 2, it is required to meet the minimum requirements of KENAK for each intervention and to achieve annual savings of primary energy (expressed in kWh/m^2) greater than 40% of the energy consumption of the reference building. For income categories 3 to 7, the required percentage of savings is 70%. If the implemented project concerns deep renovation of the building, all interventions should lead to energy class B, to the extent that this is technically and functionally feasible. In case this is not feasible, the renovated building should be classified in the energy category resulting from the Energy Performance Study. In the category 7 no grant is provided, but a loan up to 100% of eligible costs and interest subsidy. In general, grants vary from 25% to 70%. Interestingly, the grant may increase by 5% per dependent child up to 70%.

In Greece, the schemes providing financial support for heating and cooling RES systems have either been completed under the Partnership Agreement for the Development Framework (PADF) 2007-2013 Operational Programmes or implemented under the PADF 2014-2020. A special scheme to promote the installation of photovoltaic solar systems on buildings was introduced in 2009. The scheme applies to systems up to 10 kWp and to buildings used for residential or micro-business purposes. Additionally, mandatory installation of solar thermal systems in new buildings and buildings undergoing major renovation is highlighted in (SWD(2021) 365 final/2).

11 Implementing measures in Hungary

11.1 Overview

Hungary is generally a low to moderate seismic hazard country, divided into five regions with a maximum PGA up to 1.5 m/s^2 according to its National Annex to Eurocode 8 MSZ EN 1998-1 (2005).

In terms of climate, Hungary has in general a temperate climate, with 2547 HDD and 70 CDD (Eurostat, 2021). Hence, the heating season is more demanding than the cooling season.

11.1.1 Seismic strengthening measures

Eurocode 1998-3 (2006) is not compulsory in Hungary, but a National Annex to this document is available (Athanasopoulou et al., 2018). A low seismic design code was introduced in 1978 and in 2006 the Eurocode 8-1 (2004) was implemented based on the National Annex MSZ EN 1998-1 (2005). Hungary is a part of the Union Civil Protection Mechanism according to the Decisions 2013/1313/EU and 2019/420 of the European Parliament and of the Council.

11.1.2 Energy upgrading measures

The existing regulations for energy upgrading include requirements on technical building system elements such as control, pipes, ventilation ducts etc. The upper threshold of the total primary energy consumption is set; however, direct system performance requirement is not specified. From 2018, cost-optimal requirements are mandatory for renovations and extensions.

The national plan is the introduction of nearly zero-energy building (NZEB) requirements and to transpose them into a national rulebook on the energy efficiency of buildings. It was intended to apply the NZEB requirements to public buildings built after 31 December 2018, and all new buildings built by 31 December 2020. The initiatives for the improvement of energy efficiency of the existing building stock and to apply renewable energy systems to new buildings are included in the regulation. The regulation is set on elements of the buildings, building envelope, threshold for the primary energy consumption and renewable energy share (Csoknyai et al., 2018). The national plan on NZEB was adopted in 2015. As a part of this since 2017, a new support system "Renewable support system" (METAR) was installed in Hungary. The renewable share of the produced electricity should be 14.65% according to this system. A reliable statistic about the number of NZEB buildings is not available yet. However, according to the Hungarian Passive House Association, 100 to 300 existing buildings are NZEB.

The Directive 2002/91/EC (2002) was implemented in Hungary by the 7/2006 TNM Decree and the 176/2008 Governmental Decree and in 2008 a building certification scheme was implemented. This leads to about 30 % higher heat requirements than before. The Directive 2010/31/EU introduced even stricter requirements by means of amendments to the TNM decree. In 2014 an important amendment of the decree was introduced that regulates the cost-optimal energy efficient requirement as a basis for funding from either state budget or EU funds. The TNM decree was further developed in 2021 to prescribe that all new-constructed buildings must comply with the requirements of NZEB.

Furthermore, the sale and purchase of residential or non-residential buildings in Hungary requires an energy performance certificate (EPC). The owner has to present a valid EPC to the buyer or renter. EPC was introduced in 2012 and is valid for 10 years and has to be issued by independent experts. Since January 2013, EPCs are registered in a central database. Around 150,000 EPC are issued every year. The database is partly public and the energy performance of the building can be searched by using the address of the house. EPC assigns an energy performance label to building units and also lists the cost-effective measures for improving their energy performance.

The Hungarian National Energy and Climate Plan introduced in 2020 aims to reach a high energy saving target between 2020 and 2030 based on the large potential of existing buildings. Due to a low construction rate and demolition rate with an annual dwelling construction rate of about 0.2 - 0.4% of the total stock according to Hungarian Central Statistical Office (HSCO), extensive energy efficiency upgrading measures of existing buildings are required. There is a very large potential for energy saving for the existing building stock. It was foreseen to implement a competitive programme in 2021 with 50% grant, up to 3 million Hungarian forint (HUF) for any type of flat modernization for families with children.

The latest Hungarian LTRS estimates 90% CO_2 emission reduction by 2050 (compared to 2018-2020 levels), to be achieved through tripling the current 1% yearly renovation rate by 2030 and by having 90% of buildings at NZEB level in 2050. In terms of investment, the LTRS foresees by 2030 EUR 5.1 billion (HUF 1760 billion) for the renovation of residential and public buildings (HUF 80.2 billion annually) by 2050 estimated costs of achieving climate neutrality (all the economic sectors) are EUR 145 billion EURO (50 000 billion HUF), corresponding to 2.5% of GDP per year by 2050 (SWD(2021) 365 final/2).

11.2 Best practices

Different subsidy programmes exist in Hungary for supporting the energy efficient renovation and refurbishment of buildings. The programme KEHOP[7] (Environmental and energy efficiency operative programme, 2022) primarily directed to contribute to increasing energy and resource efficiency. The KEHOP programme focuses on public buildings with 100% subsidy cost. A residential retrofit programme is underway, providing loans with 0% interest rate for an approximate budget of EUR 400 million. The critical point is that the programmes often run out of funds very quickly.

As a part of the Agenda 2030 for sustainable development, the government has announced several proposals for the energy modernization of residential buildings. The "Warmth of Home" programme is financed from the Hungarian national budget of 102 million Euro. The programme aimed at providing households with non-refundable financial support to increase the energy efficiency of homes. Further sub-programmes are also available under the "Warmth of Home" programme.

The purpose of these subprograms is energy efficient modernization of family houses and apartment houses. Furthermore, the programmes intend the exchange of outdated household appliances for energy efficient models. The programme is in force since 2014. The programme has reached 5% of Hungarian households over the period of 3 years, and the grants have also a significant impact on the CO_2 emissions and energy savings per year. The government is keen to ensure the sustainable funding for the continuity of the programme.

Another sub-programme is the "Otthon melege" programme. This measure supports the energy efficient renovation of residential buildings and purchase of energy efficient household appliances. It is financed through the Green Investment System and the Green Economy Financing Scheme managed by Ministry of National Development.

Hungary has also adopted an alternative measure for inspection of heating systems and air conditioning systems. Action plans to improve awareness for energy efficiency and climate protection include campaigns to replace low-efficiency boilers, air conditioning and heating systems. However, the inspection and enforcement are not mandatory. As a part of the strategy, the government is planning programmes to subsidise the installation of new condensing boilers to replace the obsolete ones, which will attract more owners.

[7] http://www.palyazat.gov.hu/

12 Implementing measures in Italy

12.1 Overview

In Italy, after the OPCM3274/2003 Ordinance, all the Italian territory is classified as prone to seismic hazard, although different levels of seismic hazard are considered with four seismic zones and a maximum PGA >0.25g. Consequently, most of the residential buildings built prior to the ordinance are not protected against seismic events, as they were was designed by neglecting horizontal seismic forces and, more generally, without seismic considerations.

In terms of climate, Italy has 1750 HDD and 242 CDD (Eurostat, 2021), with large variations between the South and the Northern alpine regions. The Italian building stock is also characterized by a large deficit of thermal insulation due to the lack of regulation addressing thermal performance criteria up to 1991 (Law 10/1991), when about 88% of the present Italian building stock had already been realised (Manfredi and Masi, 2008).

In order to face the above-mentioned deficit, modern codes addressing both energy and seismic issues have been released for newly designed buildings as well as for assessing existing ones. Further, different financial measures able to support the economic efforts required for reducing both seismic vulnerability and increasing the energy performance of buildings have been implemented. These generally act in terms of tax deduction of the intervention expenses with different percentages over the years, mainly depending on the type of intervention (i.e. energy and seismic) and the type of building (i.e. single apartment or multifamily building).

12.1.1 Seismic upgrading measures

According to the Italian policy generally adopted in case of disasters from natural events, public contributions cover all the expenses for repairing and strengthening damaged buildings. As a consequence, a large number of the Italian existing buildings has been renovated during the reconstruction processes related to the main damaging earthquakes occurred in the past. For example, results from three of the most recent earthquakes, i.e. L'Aquila 2009, Emilia 2012 and Central Italy 2016, show that more than 200,000 private residential buildings were included in the reconstruction processes, with a total economic cost of about EUR 16 billion (excluding the 2016 Central Italy due to unavailability of relevant data).

The main seismic events that occurred in the past also boosted the most important changes in the framework of seismic design codes. Specifically, starting from the catastrophic earthquake of 1908 in the area of Messina-Reggio Calabria, the Italian territory was increasingly classified as seismic and new seismic rules were released. An important turning-point was the 2002 Molise earthquake. Following this event, a first attempt to implement a comprehensive strategy for seismic risk mitigation was promoted by means of a new approach in the seismic classification, a modern seismic code and an extensive programme for the seismic assessment of public buildings/infrastructures (i.e. hospitals, schools etc.). More specifically, the OPCM 3274/2003 classified as seismic all the Italian municipalities according to four seismic zones (ZS), from ZS1 to ZS4 (in decreasing order of seismic intensity). The OPCM 3274/2003 also introduced relevant developments in the field of the design of new buildings, and especially, the assessment of existing ones, in line with Eurocode 8 (CEN, 2004).

Further changes in the field of seismic design rules were introduced after the 2009 L'Aquila earthquake. Specifically, the Ministerial Decree of 14/01/2008 (and relevant commentaries) was mandatory for designing/assessing new/existing private buildings. The Ministerial Decree also introduced a more refined hazard map, which provides the seismic hazard values based on a grid with more than 16,000 points, thus permitting a more accurate definition of the seismic hazard for both design and assessment purposes.

At present, the code in force is the Ministerial Decree of 17/01/2018. Beyond an upgrading of the rules for designing new buildings, a detailed procedure for assessing existing building is also reported and three categories of strengthening interventions are considered, i.e.: i) local strengthening addressing only parts of buildings, ii) global strengthening, able to increase the capacity/demand ratio by at least 0.1 with respect to the as-built value, and iii) full upgrading intervention, which permits reaching the same safety level as in new buildings. In the framework of Sisma-bonus (described also later), the Ministerial Decree 65/2017 introduced "Guidelines for the seismic risk classification of constructions" which define eight seismic risk classes (from G to A+) on the basis of the building safety index assessed at the life-safety limit state (IS-V, capacity/demand ratio in terms of peak ground acceleration), and the expected annual loss (EAL).

Following the 2009 L'Aquila earthquake, the first seismic prevention financial programme was introduced. The Decree Law 39/2009 allocated almost one billion euro over seven years to reduce seismic vulnerability of private buildings. Three types of intervention were allowed, including local strengthening, global upgrading, and

demolition and reconstruction, each one having a different economic contribution values (i.e. EUR 100, 150 and 200 per square meter of the total surface area of the building in case of local strengthening, seismic upgrading and demolition and reconstruction, respectively). For global upgrading interventions, a minimum value of the capacity/demand ratio equal to 60% or, at least, an increase of 20%, had to be reached. Criteria to define the economic contribution were the age of building, the type of structure, the number of occupants, and the hazard on site. Updated data (October 2020) for private buildings show that about 4000 interventions were allowed, involving about EUR 48 millions of investments.

Starting from 1997 (Law 449/1997), several measures were issued in the field of maintenance/renovation/rehabilitation for the Italian existing building stock. In general, measures consisted of fiscal benefits such as tax deduction and/or reduced VAT rate. For example, the Decree law 201/2011 allowed a 36% tax deduction (max EUR 48,000 per dwelling) for different types of renovation/rehabilitation interventions, also involving seismic upgrading of structural components. For seismic interventions in high and moderate seismicity zones (i.e. ZS1 and ZS2 according to the OPCM 3274/2003 classification), the rate of tax deduction was increased to 65% (with a maximum value of expenses equal to EUR 96,000 per dwelling) by the Decree law 63/2013.

At present, the 2017 Budget Law (Law 232/2016, so-called "Sisma-bonus") provides significant benefits. First of all, the rate of tax deduction ranges from 70 to 85% as a function of the type of building (i.e. single apartment and multi-family buildings) and the intended upgrading of risk class. Further, the tax benefit is also extended to buildings in seismic zone ZS3 (according to the OPCM 3274/2003 classification). Finally, in order to increase the number of beneficiaries, Sisma-bonus allows transferring the tax deduction value to other recipients, including credit institutes and other financial intermediaries. Alternatively, the tax deduction may be introduced as a discount in the purchase of renovation materials and services, and subsequently recovered by the supplier.

Recently, in the framework of post Covid-19 recovery actions, additional benefits have been introduced by Law 77/2020. The rate of tax deduction has been increased to 110% for both local and global seismic interventions in ZS1, ZS2 and ZS3 (according to the OPCM 3274/2003 classification), irrespective of the risk class reached after strengthening. More details on both the Sisma-bonus and Super-bonus measures are reported in Section 12.2.

12.1.2 Energy upgrading measures

The first Italian code addressing the energy efficiency of buildings in a comprehensive way was issued in the early 90s (Law 10/1991), as a consequence of the first studies of the "greenhouse effect". It provides requirements on the energy performance of buildings along with thermal criteria for the design of the building envelope and the management of energy facilities. After this, the Presidential Decree 412/1993 identified six different climatic zones (from A to F) throughout the Italian territory as a function of the heating degree days (HDDs), using a baseline temperature of 20°C. The EU directive 2002/91/CE was adopted through the Legislative Decrees 192/2005 and 311/2006, which provided criteria to improve the energy performance of buildings as well as encourage the use of renewable energy sources. Furthermore, they provided threshold values in terms of thermal transmittance of the vertical building components (e.g. infill walls) for different climatic zones. Successively, in 2009, the Presidential Decree 59/2009 introduced guidelines for issuing "Energy Performance Certificates" and defined seven energy performance classes (from A to G) on the basis of energy demand required for heating and domestic hot water. Another important step in the framework of energy efficiency of buildings was made in line with the European Directive 2010/31/EU through the Legislative Decree 28/2011. The decree updated the provisions of the Energy Performance Certificate which was mandatory in case of buying and selling a house/building. Currently, the energy performance of buildings is evaluated in accordance with the Ministerial Decree of 26 June 2015, where an upgraded version of the Energy Performance Certificate is provided along with new threshold values of thermal transmittance. The energy performance is evaluated according to 10 different classes, defined as a function of the energy demand deriving from non-renewable sources, $EP_{gl,nr}$, computed with regard to a reference building (i.e. having a performance class of A1).

In order to support the energy efficiency of the existing building stock, starting from 1997, several financial measures have been promoted. The first one (Law 449/1997) promoted the reduction of energy demand (also including systems based on renewable energy sources) in existing buildings by a 36% tax deduction of the relevant renovation expenses. Subsequently, Law 296/2006 introduced a 55% tax deduction for energy requalification expenses on existing buildings able to reach a specific target in terms of energy savings and/or thermal transmittance values. The maximum threshold of the allowed expense was a function of the type of interventions (e.g. thermal insulation of the building envelope, windows and shutters replacement etc.). The tax deduction rate was further increased to 65% by the Decree law 63/2013. Currently, the so-called "Eco-bonus"

(Law 232/2016) represents the main measure in the field of energy efficiency upgrading, which includes most of the previous features and introduces new ones. Among them, for interventions on common parts of multifamily buildings, able to attain a given energy performance, the tax deduction may increase up to 75%. Further, similarly to Sisma-bonus, the Ecobonus measure permits transferring the tax deduction value to other financial entities or alternately introduce it as a discount for the purchase of materials and services.

Recently, the so-called "Super-bonus" (Law 77/2020) has increased the tax deduction percentage to 110% for different types of energy interventions targeting the common parts of multifamily buildings, e.g. through measures such as thermal insulation applied to at least 25% of the external shell, and measures for centralised heating systems. More details on both the Eco-bonus and Super-bonus measures are reported in Section 12.2.

In the LTRS for Italy, ambitious building renovation plans for decarbonisation of the building stock is foreseen (SWD(2021) 365 final/2). The strategy foresees 66% of the existing buildings and 80% of the current non-residential buildings to be renovated by 2050. This means that the current renovation rate needs to be doubled (from 0.85 to 1.9%) for the period 2020-2030 and to be tripled (2.7%) for the period 2030-2050. In terms of investments, EUR 5-8.8 billion (2020-2024) are made available for Municipalities to make buildings seismic safer and more energy efficient. By 2050 investment needs (2020-2050) for the residential sector are estimated at EUR 9-12 billion/year.

12.1.3 Seismic and energy integrated measures

Beyond specific measures devoted to separately increase the energy and seismic performance of buildings, the 2018 Budget Law (205/2017) has introduced the tax deduction of expenses for integrated interventions. In particular, for energy efficiency interventions, applied to at least 25% of the outer surface of building envelope, implemented together with structural ones, able to reduce the seismic risk by one class, a tax deduction rate equal to 80% is prescribed. The rate increases to 85% for a seismic risk reduction by two or more classes. The maximum eligible expenditure is equal to EUR 136,000 per dwelling over 10 years. This measure is allowed for multi-owner buildings in moderate and moderate-to-high seismic zones (i.e. ZS1, ZS2 and ZS3 according to the OPCM 3274/2003 classification).

12.2 Best practices

Currently in Italy, modern technical codes are available in the field of both energy and seismic design/assessment. Specifically, the Ministerial Decree of 26 June 2015 permits assessing energy performance of buildings according to 10 different classes, defined as a function of the energy demand deriving from non-renewable sources. Regarding the seismic performance, the DM 17/01/2018 considers a hazard map permitting an accurate definition of the seismic hazard for both design and assessment purposes. Apart from seismic design criteria consistent with the Eurocodes, a methodology (further detailed in the commentary of the code released on 21 January 2019) for existing building assessment is provided, along with the classification and design rules for strengthening interventions. Furthermore, the Ministerial Decree 65/2017 permits classifying buildings through eight seismic risk classes (from G to A+), defined in terms of ta safety index considering the life-safety limit state (IS-V), and the expected annual loss (EAL).

Regarding financial measures in support of the building renovation, three measures should be highlighted, i.e. the Eco- and Sisma-bonus, along with the Ecosisma-bonus targeting combined interventions.

Eco-bonus (Decree Law 63/2013 and subsequent amendments) is a tax deduction measure which supports energy efficiency interventions such as insulation of vertical and horizontal building components, windows replacement, installing solar panels to produce domestic hot water etc. For each type of intervention, different rates of tax deduction (in the range of 50–75%) along with maximum eligible expense are considered. Higher tax deductions (i.e. 70–75%) are provided for interventions on common parts of multi-owner buildings extended to more than 25% of the building envelope or able to reach a given energy performance (according to the Ministerial Decree 26/6/2015). For these types of intervention, the maximum eligible expense is equal to EUR 40,000 per dwelling. The fiscal advantage acts over 10 years and can be also transferred to suppliers of materials and services who implemented works (invoiced discount) or to financial entities.

Sisma-bonus (Law 232/2016 and subsequent amendments) offers a tax deduction equal to 50% (over 5 years) of the incurred strengthening intervention expenses (max EUR 96,000 per dwelling) on buildings in seismic zones ZS1, ZS2 and ZS3 (according to the OPCM 3274/2003 classification). The incentive increases in the case of upgrading interventions (also considering the option for demolition and reconstruction) which improve the seismic risk classification (Ministerial Decree 65/2017) by one (70%) or two classes (80%). In the case of interventions on common parts of multi-owner buildings, the deduction raises up to 75 or 85%, respectively for

one or two seismic class upgrades. For some building types, one risk class improvement can be implicitly reached by means of local strengthening interventions (i.e. beam-to-column joint confinement in RC structures with resisting frames along the two orthogonal in-plane direction). Similarly to Eco-bonus, in order to increase the number of beneficiaries, Sisma-bonus also allows credit transfer options.

Special attention is paid to integrated interventions able to simultaneously reduce seismic vulnerability and energy efficiency. Specifically, the 2018 Budget Law (205/2017) promotes the tax deduction of the expenses for seismic interventions implemented together with energy efficiency ones.

Beyond the above-mentioned measures, in the framework of the recovery actions due to Covid-19 pandemic, the Law 77/2020 introduced the "Super-bonus" measure to further promote seismic/energy upgrading interventions on private residential buildings, both single apartments and multi-owner buildings. Two main types of interventions are considered, i.e. "leading" and "pulled" interventions. The first one refers to insulation interventions (extended to at least 25% of the building envelope), replacement of heating facility and seismic interventions. The second one, which can be implemented only together with at least one leading intervention, comprises energy efficiency interventions in general (e.g. windows replacement), the installation of photovoltaic solar power systems, electric charging stations etc. In the case of energy efficiency interventions, buildings have to be upgraded by at least two energy classes (according to the DM 26/6/2015). For each type of intervention, a 110% tax deduction (over 5 years) of the expenses is offered, along with the aforementioned credit transfer options.

As noted in the report by the Chamber of Deputies issued in 2020, from 1998 (i.e. when the first financial measure was released) to 2020, the total amount of public investments for building renovation in general (i.e. including energy/seismic/maintenance interventions) has been approximately EUR 346 billion, involving about 21 million interventions. In the 2018-2019 period (when both Eco and Sisma-bonus were in force), about EUR 12.7 billions of tax benefits were requested, greater by 12.1% compared to 2016-2017. While data related to seismic interventions only, i.e. disaggregated from other types of building renovation interventions, is not available, detailed results on energy interventions are annually reported by the National Agency for New Technologies, Energy and Sustainable Economic Development. The last report (ENEA, 2020), shows that in the 2014-2019 period Eco-bonus supported about EUR 2.2 million interventions for a total investment of approximately EUR 20 billion. Energy saving were estimated as 7,100 GWh/year, mainly due to windows/shutters replacement (36%) and insulation of walls/slabs (29%). In 2019, Ecobonus supported 400,000 interventions (37% involving replacement of windows/shutters replacement, 37% addressing heating systems, and 19% installation of solar panels). The total investment amounts was EUR 3.5 billion, with energy savings in the order of 1,250 GWh/year.

As for Ecosisma-bonus, the latest available data (ENEA, 2019) shows that among over 500 requests of fiscal benefits related to multi-owner buildings, almost all involved energy-related interventions, while only 2.0% of interventions were devoted to increase also the seismic performance. This data highlights the greater difficulties in realising structural interventions in multi-owner buildings, mainly due to the approval process of the condominium board and, above all, the high impact of works which may result in occupancy disruption and reallocation of occupants. These measures are also deemed particularly good practice in the Commission's assessment of the LTRS (SWD(2021) 365 final/2).

Super-bonus measure appears to be more promising. Indeed, up to August 2021, about 38,000 interventions have been realised, corresponding to EUR 5.7 billion of public investments. In 2022, about EUR 6.5 billion of investments are estimated, resulting in 1% GDP growth.

13 Implementing measures in Malta

13.1 Overview

The Maltese Islands are considered to have a low seismicity (<0.10g but >0.04g).

The climate in Malta is mild all year, with 402 HDD and 672 CDD (Eurostat, 2021). Hence, both the heating season and the cooling season are not very demanding.

13.1.1 Strategies and programmes

13.1.1.1 Seismic strengthening

No strategies and programmes were found focussing on the seismic strengthening of existing buildings. Malta has not published any NA for the EN 1998 Parts (Athanasopoulou et al., 2018).

13.1.1.2 Energy upgrading

The energy policy in Malta is significantly influenced by EU energy and environmental policies. Hence, to comply with EU obligations, namely Directive 2012/27/EU (2012) and Regulation (EU) 2018/1999, different action plans have been implemented in Malta to promote energy upgrading of existing buildings:

- **Malta's National Energy Efficiency Action Plan** (OPM, 2017)

  The projections of Malta, by 2020, for the final energy consumption is 633 875 toe and for the primary energy consumption is 822 903 toe.

- **Maltese long-term renovation strategy** (MLTSR, 2017)

  In terms of renovation potential it is estimated that around 11,600 dwellings will be refurbished by 2030, resulting in an overall energy saving of 4 591 toe (53.4 GWh), representing savings in primary energy of 106.8 GWh and in CO_2 emissions of about 26,241 ton, over the 2017-2030 period; The updated LTRS for Malta include more ambitious goals of energy savings of 20% by 2030, 20% by 2040 and 25% by 2050 (60,000 GWh primary savings). To achieve these goals, increasing renovation rates in residential buildings to 5-6% per year from 2025 onwards is planned (SWD(2021) 365 final/2).

- **National energy and climate plan** (NECP) (MT NECP, 2019)

  For buildings this plan emphasises the promotion of small-scale renewable energy technologies, since investments on the energy renovation of buildings is not considered a priority due to low energy demands of housing. New schemes post-2020 will be launched in order to promote the installation of solar water heaters, air to water heat pumps and photovoltaic panels in housing for own consumption.

In order to achieve the above targets, different measures were introduced in Malta, focussing on energy efficiency, reduction of greenhouse gases and production of energy from renewable sources in buildings. These measures support the implementation of the above plans by providing funding and financial benefits. The most relevant ones are summarized in **Table 7**.

The timeframe of the above measures is shown in Table 8. Some of the listed programmes are foreseen to continue after 2020, and therefore, they are indicated in light grey.

Table 7. Summary of the different financing programmes in Malta

	Renovation			Technologies								
Programme	Low	Medium	High	Structural work	Walls insulation	Roof insulation	Improvement of glazed areas	Solar energy	Biomass	Geothermal	Ventilation	HVAC/heat pumps/other
Schemes for solar water heater [a]	■							√				√
Photovoltaic Grants [a]	■							√				√
Building envelope [a]	■	■				√	√					
Domestic appliance rebates[b]	■											√
Energy saving lamps [b]	■											√
Restore your home [c]		■	■		√	√	√					
Green energy loan (Banif) [d]	■	■				√	√	√				√
Green energy loan (HSBC) [e]	■	■				√	√	√				√
ECO Personal loan [f]	■	■			√	√	√	√				√
Eco loan [g]	■	■				√	√	√				√

[a] MRA (2014); [b] OPM (2017); [c] Irrestawra Darek (2020); [d] BANIF (2020); [e] HSBC (2020); [f] BOV (2020); [g] APS (2020)

Table 8. Timeframe of the different programmes in Malta

Programme	2004	2006	2008	2010	2012	2014	2016	2018	2020	2022	2024	2026	2028	2030
Schemes for solar water heater		■	■	■										
Photovoltaic Grants		■	■	■										
Building envelope		■	■	■										
Domestic appliance rebates		■	■											
Energy saving lamps				■										
Restore your home														
Green loan (Banif)				■	■	■	■	■	■					
Green loan (HSBC)														
ECO Personal loan														
Eco loan (APS)														

13.2 Best practices

13.2.1 Programmes and other measures

13.2.1.1 Seismic strengthening

No strategies were found focussing on the seismic strengthening of existing buildings.

13.2.1.2 Energy upgrading

In the following paragraphs, estimated results are provided for the different measures related to energy upgrading of buildings indicated in Table 8.

The main source for financing of energy efficiency measures in residential buildings in Malta are government supporting schemes, voluntary agreements and private banks products.

The most successful schemes in Malta are the ones promoting energy efficiency and renewable energy sources (Gatt & Yousif, 2018):

- ✓ Promotion of renewable energy sources (solar photovoltaics) applicable to both residential and public buildings – funds used so far: 39.1 million € (for PV systems) in the period 2010-2015; 11.405.188 € (energy efficiency and renewables) in the period 2009-2013, 17.623.421 € (installation of PVs) in the period 2010-2015;
- ✓ Grant scheme for domestic solar water heating – funds used so far: 3.5 million € (until end of 2015);
- ✓ Financial instruments for energy efficiency – funds used so far: 350.000 € (until end of 2015);
- ✓ Heat pump water heater – no values so far;

The national voluntary agreement scheme, the Energy Efficiency Partnership Initiative (EEPI), has been set up to foster, improve and create a roundtable for improved relations between Government and large enterprises with the aim of resulting in the uptake of energy efficiency practices. Voluntary agreements last for three years (SWD(2021) 365 final/2).

Different Maltese banking operators offer green loan facilities specifically aimed at facilitating the purchase and installation of energy efficiency products and renewable energy technologies in buildings and/or businesses. These schemes consist typically of loans with competitive interest rates. One of the popular schemes is the grant schemes to individual households provided by the Bank of Valletta (BOV), which has assisted over 2 500 households with total loans of circa 20 million Euro.

Finally, an important measure identified in the assessment of the Maltese LTRS is the "Energy Incentives Advice Scheme for Vulnerable Households", which was set up in 2018 (SWD(2021) 365 final/2). This measure is funded with 200,000 Euro per year and targets vulnerable households specifically, to reduce their energy and water consumption through the replacement of old and inefficient appliances.

13.2.2 General investments in renovation

According to data from the EU Buildings Database, in Malta, the building stock was composed, in 2016, by a share of 84% of residential buildings and 16% of non-residential buildings. Considering the time span 2012-2016, the average renovation rates related to non-energy renovations were 17.3% and 21.7% for residential and non-residential, respectively. For energy related renovations, the renovation rates were 13.0% and 18.4%, for residential and non-residential, respectively.

In terms of investments in renovation, the total volume for residential and non-residential buildings in provided in **Figure 4** for the time-span of 2012-2016; while, **Figure 5** represents the volume of energy related investments, for the same time-span.

Figure 4. Total volume of investments in renovation for residential and non-residential buildings in Malta (EU Buildings Database, 2019)

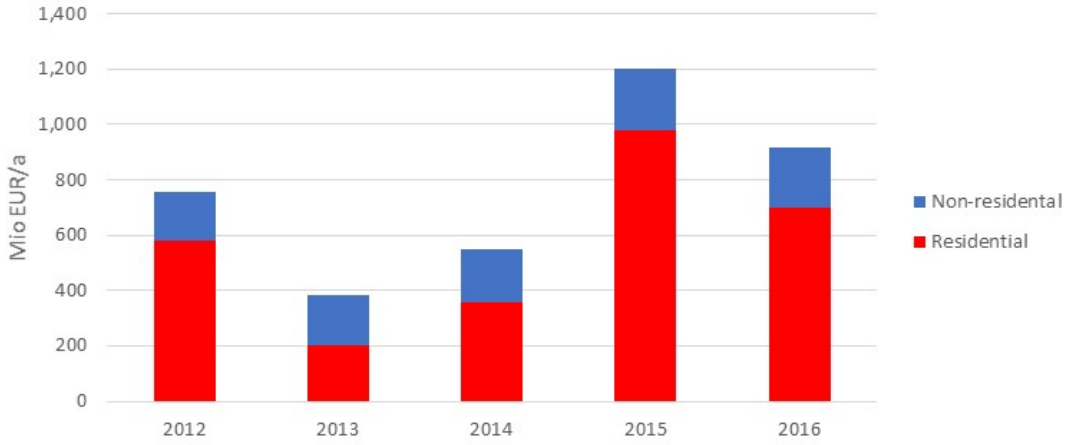
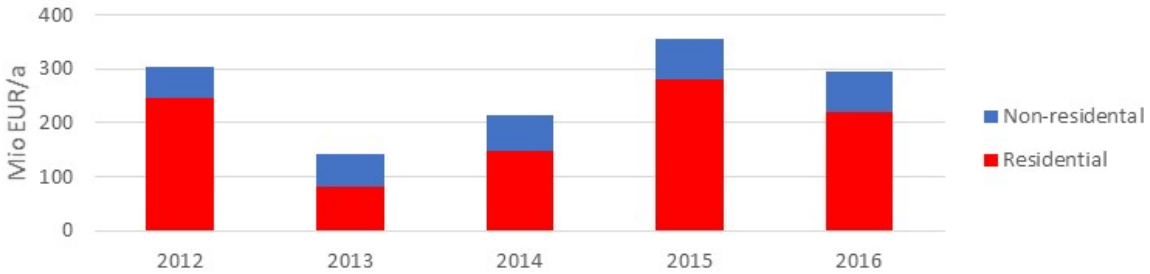


Figure 5. Total volume of energy related investments in renovation for residential and non-residential buildings in Malta (EU Buildings Database, 2019)



The energy related renovation led to a total primary energy savings (average), in the period of 2012-2016, of 2,122 toe for residential buildings and 2,611 toe, for non-residential buildings. This value represents the average reduction of the total annual primary energy use (from heating, cooling, ventilation, domestic hot water, lighting (only non-residential buildings) and auxiliary energy) that was achieved compared to the previous year, during the period 2012-2016, by means of energy related renovation.

With the updated LTRS, an updated investment need for the period 2020-2030 of EUR 800 million and of EUR 5.1 billion for the period 2020-2050 is foreseen. Of these, 33% shall be funds from government, and the remaining from the private sector (SWD(2021) 365 final/2). Cumulative savings of 60 000 GWh of primary energy, leading to emission reduction of 4.5 million tonnes CO_2 are expected in the LTRS.

14 Implementing measures in Portugal

14.1 Overview

The seismicity in Portugal varies across the country from low to high, and the safety of buildings against seismic events is mainly a concern in the southern and central part of the mainland and the Azores, particularly in densely populated areas with high seismic risk, such as the Lisbon region. The Portuguese National Annex of NP EN 1998-1 (2010) distinguishes six and five seismic zones for seismic action Types 1 and 2, respectively, with a maximum reference PGA on type A ground of 2.5 m/s^2. Seismic action Type 1 describes a long-distance earthquake scenario with epicentre in the Atlantic region, whereas seismic action Type 2 describes a short-distance earthquake scenario with epicentre in Portugal mainland or the Azores Archipelago.

The climate in Portugal is temperate with a hot-summer Mediterranean climate in the south, and warm-summer Mediterranean one in the north. The heating season in Portugal is more demanding than the cooling season with 1008 HDD and 267 CDD (Eurostat, 2021).

14.1.1 Seismic strengthening measures

Until 2019, rehabilitation of buildings was performed without the requirement to take into account the seismic capacity and potential need for seismic retrofit. However, a new law for the rehabilitation of buildings was published in July 2019 (Law 95/2019/PT), requiring the seismic retrofit of buildings, when these are located in vulnerable seismic areas.

Moreover, the publication of Law 95/2019/PT (2019), revoked the previous codes for the structural safety of buildings and approved the use of the Eurocodes. Hence, currently, the design of new buildings and the retrofitting of existing buildings are done according to NP EN 1998-1 (2010) and NP EN 1998-3 (2017), respectively.

To comply with Law 95/2019/PT (2019), the conditions under which rehabilitation works are subject to the preparation of a seismic vulnerability assessment report, as well as seismic strengthening, were laid out by Ordinance 302/2019/PT (2019), published in September 2019. According to the ordinance, a seismic vulnerability assessment report is required on the conditions that:

— there are clear signs of degradation of the building structure;

— the works to be carried out affect or alter the structural behaviour of the building;

— the intervention area, including demolitions and extensions, exceed 25% of the building's gross construction area;

— the construction cost exceed at least 25% the construction cost of a new equivalent building.

The seismic vulnerability report is also required for buildings of high importance (classes III and IV, defined according to NP EN 1998-1), whenever any of the above condition is met, but with a reduction of the limits described in the last two conditions to 15%.

If the report of the seismic vulnerability assessment indicates that the building does not comply with the safety requirements corresponding to 90% of the action provided by NP EN 1998-3 (2017), seismic retrofit design will be further required.

No current strategies and programmes focusing on the seismic retrofit of buildings have been identified.

14.1.2 Energy upgrading measures

Conversely, different strategies have been implemented over the years in Portugal, focussing on the energy upgrading of existing buildings, to comply with EU obligations, namely Directive 2012/27/EU (2012) and Regulation (EU) 2018/1999:

- **National Action Plan for Energy Efficiency** [*Plano Nacional de Ação para a Eficiência Energética* (PNAEE)] (Ministerial Decision 20/2013/PT, 2013).

The target for the primary energy consumption was set to 22.5 Mtoe by 2020, corresponding to a reduction of 25%, which is higher than the required 20% EU target. The degree of achievement of the 2020 primary energy target was already around 47% (corresponding to energy savings of about 1,130,131 toe) by 2014. For the

specific area of 'Residential and Services', the primary energy reduction, by 2020, is estimated to be about 1,098,072 toe.

- **Long-term strategy for mobilising investment in the renovation of the national stock of buildings** (*Estratégia nacional a longo prazo para a mobilização de investimento na renovação de edifícios*) (DGEG, 2017)

The Portuguese 2020 targets are more ambitious than those of the European Union: a reduction in primary energy of 25% for general buildings, and a reduction of 30% in the case public buildings are sought. With regard to renewable energies, the goal is that in 2020, 31% of final consumption will be provided by renewable sources.

- **Roadmap for carbon neutrality** [*Roteiro para a Neutralidade Carbónica* (RNC2050)] (Ministerial Decision 107/2019/PT, 2019)

The Portuguese global goal is to reduce about 85% - 90% of the GHG emissions, by 2050, compared to 2005. To achieve this goal, the intermediate targets are a reduction of about 45% - 55% by 2030, and 65% - 75% by 2040.

- **National energy and climate plan** [*Plano Nacional de Energia e Clima* (PNEC 2030)] (Ministerial Decision 53/2020/PT, 2020)

The national target for residential buildings is to reduce CO_2 emissions by 14% by 2020 (compared to 2005), and 35% by 2030. On the other hand, the targets for use of renewable energies in the final consumption are +34% by 2020, +36% by 2025 and +38% by 2030 (compared to 2005).

To support the implementation of the above action plans, there are several measures and incentives available to private and public building owners. Through financing programmes and financial benefits, it is possible to access financing and/or benefits to enable and promote the rehabilitation and valuation of a property. The most relevant measures are summarized in **Table 9**.

Table 9. Summary of the different financing programmes in Portugal

	Renovation approach			Technologies								
Programme	Low	Medium	High	Structural work	Walls insulation	Roof insulation	Improvement of glazed areas	Solar energy	Biomass	Geothermal	Ventilation	HVAC/heat pumps /other
Energy Efficiency Fund [a]					√	√	√	√				
PROENERGIA (2020)								√				
RpA-HA (2020)				√	√	√	√					
FNRE (2016)				√	√	√	√					
Casa Eficiente (2020)					√		√	√			√	
1º Direito [b]												
IFRRU (2920)				√	√	√	√	√			√	√

[a] FEE (2020); [b] Law 37/2018/PT (2018)

The timeframe of the above measures is shown in **Table 10**. Some of the listed programmes are foreseen to continue after 2020, and therefore, they are indicated in light grey.

Table 10. Timeframe of the different programmes in Portugal

Programme	2010	2012	2014	2016	2018	2020	2022	2024	2026	2028	2030
Energy Efficiency Fund											
PROENERGIA											
RpA-HA											
FNRE											
Casa Eficiente											
1º Direito											
IFRRU											

14.1.3 Seismic strengthening and energy upgrading measures

The recently published law for the rehabilitation of buildings (Law 95/2019/PT, 2019), apart from the seismic assessment and retrofit of buildings, addresses requirements for energy efficiency, fire safety, acoustics, and accessibility, thus creating a unique opportunity for the development of strategies and measures for the rehabilitation of buildings following a holistic approach.

Currently there are no specific financial incentives for the retrofitting of buildings taking into account both seismic strengthening and energy upgrading. However, the programme IFRRU - Financial Instrument for Urban Rehabilitation and Revitalization (IFRRU, 2019), is a financial instrument with public funding (European Funds from Portugal 2020, European Investment Bank and Council of Europe Development Bank) and private funding provided by selected commercial banks for granting the loans, which supports investments in urban rehabilitation, and may include integrated solutions considering both seismic and energy criteria.

This programme is included in **Table 9** and **Table 10**, as energy efficiency of buildings is the main focus.

14.2 Best practices

14.2.1 Programmes and other measures

14.2.1.1 Energy upgrading

The Institute for Housing and Urban Renovation (IHRU), is a public entity managing different public programmes for housing in Portugal, e.g. Rehabilitate for Rent – Affordable Housing (RpA-HA) and First Right – Programme to support access to housing. The entity has provided a list of subsidies, grants and financial support over the years; unfortunately, in available data no differentiation is made between what was granted for new construction and for rehabilitation.

In the assessment of the submitted LTRS (SWD(2021) 365 final/2), the introduction of a new digital version of the energy certificate was highlighted, serving as an aggregator of information. This includes the interconnection of the energy certificate with supply and demand platforms (of the 'one stop shop' type), such as, for example, the casA + Portal. Moreover, there will be adjustment of the energy certificate in order to reflect, in a more concrete way, the characteristics of the building susceptible to be in a situation of energy poverty.

14.2.1.2 Seismic strengthening and energy upgrading

The total number of rehabilitation operations of programme IFRRU, until the end of December 2019, were 190, at a total cost of 562,101,914 €. The expected results of this programme until the end of 2019 and the target values for 2023 are illustrated in **Table 11** for two of the indicators that are used to measure the success of the programme.

Table 11. Financial Instrument for Urban Rehabilitation and Revitalization (IFRRU, 2020)

Indicator		Estimated value	2023 Targets
To increase the quality of urban environment and revitalization of cities	Number of jobs	3019	207
	New residents	1256	253
Energy efficiency in private housing	Consumption of primary energy per dwelling (toe)	15324	5407

As observed from the **Table 11**, the programme IFRRU is being very successful as the estimated values until the end of 2019 are already overcoming the target values for 2023.

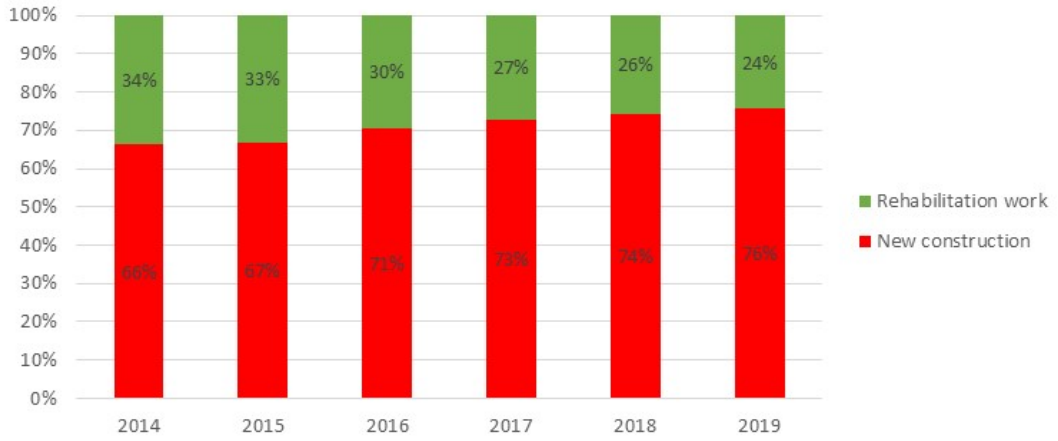
Moreover, until the 31st of March 2020, the programme has allowed the rehabilitation of about 1068 houses in urban areas, the establishment of 1604 new residents, the creation of 3056 jobs, and an annual reduction of the consumption of primary energy of about 28,067 toe.

14.2.2 General investments in renovation

In this section, an overview of the renovation activities in Portugal is provided, based on data provided by the EU Buildings Database and the National Institute of Statistics in Portugal.

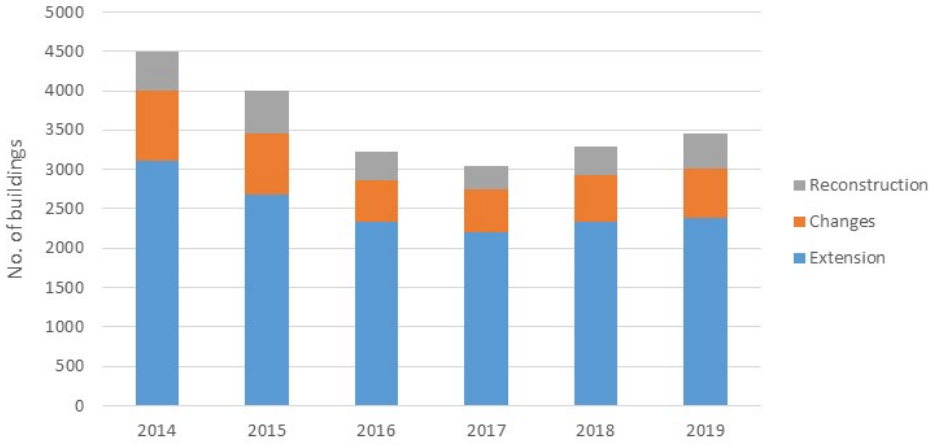
Taking into account the period between 2014 and 2019, illustrated in **Figure 6**, the number of rehabilitation works in buildings had been decreasing in relation to the number of new constructions, and the lowest value was reached in 2019 (24.4%) (INE, 2020). However, the number of new constructions and the number of rehabilitation works in 2019 increased in relation to 2018 by 5.4%, with a total of 3 462 rehabilitated buildings.

Figure 6. Share between new construction and rehabilitation works over the years (INE, 2020)



Considering the type of interventions in the same period (**Figure 7**), works leading to an increase of the building area (extension) were always dominant (INE, 2020). In 2019, the extension of buildings had a relative share of 69.1% (2 393 completed buildings). In the last three years, reconstruction works (rehabilitation works following the demolition of part of the building) had been gaining relative importance, increasing from 10.6% in 2017 to 13.0% in 2019 (451 buildings). In 2019, changes in buildings (rehabilitation without an increase of the building area) represented 17.9% of the total rehabilitation works (618 buildings).

Figure 7. Type of rehabilitation work (INE, 2020)



In terms of investments in renovation, the total volume for residential and non-residential buildings in provided in **Figure 8** for the time-span 2012-2016, while **Figure 9** represents the volume of energy related investments, for the same period.

Figure 8. Total volume of investments renovation for residential and non-residential buildings in Portugal (EU Buildings Database, 2019)

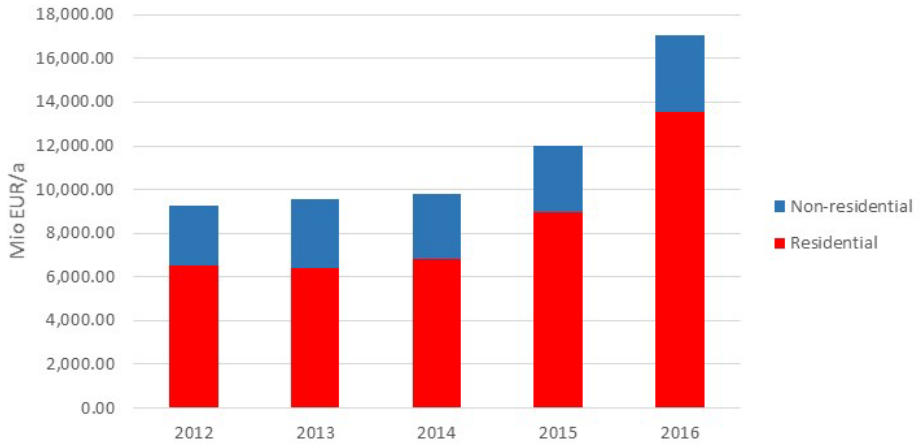
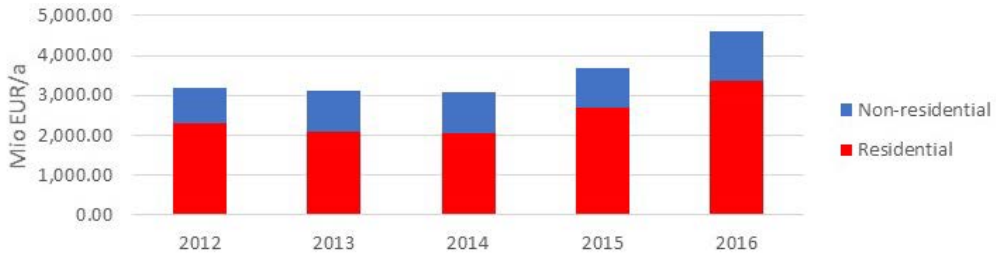


Figure 9. Total volume of energy related investments in renovation for residential and non-residential buildings in Portugal (EU Buildings Database, 2019)



The energy related renovation led to a total of primary energy savings equal to 19,208 toe for residential buildings, and 23,753 toe, for non-residential buildings, in the period of 2012-2016. These values represent the average reduction of the total annual primary energy during the period 2012-2016. Primary energy use is due to heating, cooling, ventilation, domestic hot water, lighting (only non-residential buildings) and auxiliary energy requirements. For the latest LTRS, investment needs by 2050 of EUR 143,492 million (Residential: EUR 113,579 million; Non-residential: EUR 33,414 million) are estimated (SWD(2021) 365 final/2).

15 Implementing measures in Romania

15.1 Overview

The seismic hazard of Romania is dominated by the Vrancea intermediate depth earthquakes in south-east of the country. In the Romanian seismic code P100-1/2006 (Ministry of Regional Development, Public Administration and Funds, 2018), the highest seismic zone has an associated PGA of 0.32g.

In terms of climate, Romania has in general a temperate climate, with 2666 HDD and 96 CDD (Eurostat, 2021). Hence, the heating season is significantly more demanding than the cooling season.

15.1.1 Seismic strengthening measures

15.1.1.1 Legislation & Standards

The first regulation, based on the Italian norm of 1938, dates from 1941. Norms for the design of civil and industrial structures in seismic regions were enforced in 1963 and revised in 1970. In 1977 the spectral curve and the seismic zonation map have been radically changed. The new seismic design codes P100-1991, revised 1992, introduced a seismic zonation with two maps (one related to PGA and another to the corner period of the design spectrum, with 3 values) (Crețu et al, 2006). In the period 2004-2010 the Eurocode 8 parts were translated and adopted as National Standards and the two National Annexes on Parts 1 and 3 were enforced (Craifaleanu, 2013). In 2006 the Romanian seismic code (P100-1/2006) was harmonized with EN 1998-1:2004. The National Code P-100-3/2018 provides for seismic assessment of existing buildings. The purpose of the code is to establish criteria and procedures for the seismic assessment of existing buildings and, as applicable, a basis for intervention work to reduce their seismic vulnerability. The provisions of the code are harmonised with the provisions of national standard SR EN 1998-3. The provisions of the code may also be applied in the case of heritage buildings if they do not run contrary to the concepts, approaches and procedures covered by the specific legislation. The regulatory environment in Romania posed considerable restrictions to the implementation of the Eurocodes (Athanasopoulou et al, 2018). There are quantitative differences between evaluations performed according to considered codes, but the general conclusions concerning building state are similar (Craifaleanu, 2013).

15.1.2 Energy upgrade

15.1.2.1 Legislations & Standards

The implementation of the EPBDs is ensured by the provisions of Law no. 372/2005 (later amended and supplemented). The Energy Efficiency Act (EEA-RO, 2014) transposes the provisions of the EED. The Regulation C107 issued in 2005 and subsequently amended is the main secondary legislation. In 2016, the Regulation was amended by setting the NZEB performance levels for primary energy demand, CO_2 emissions for different building categories, winter temperature zoning in Romania and a minimum required share of RES. A calculation methodology for energy performance of buildings has also been introduced (Georgescu et al, 2018). For all existing buildings that are being rehabilitated, expanded or upgraded it is already mandatory, since 2007, to present an EPC. Some other technical regulations for buildings thermal rehabilitation have been developed, such as framework solutions regarding the thermo-hygro-energy rehabilitation of the envelope of the existing residential buildings (Order no. 2280/2013).

15.1.2.2 Strategies

Romania duly developed and submitted the main strategic documents as requested by the European legislation, namely National Energy Efficiency Action Plans, the last one being for the period 2014-2020 (NEEAP-RO, 2017) containing a strategy for mobilising investments in the renovation of residential and commercial existing buildings, national plan for increasing the number of NZEBs till 2020 (NZEB-RO, 2013) and NECP 2021-2030 (NECP-RO, 2020). According to NEEAP-RO, 2017, for buildings undergoing major renovations, the energy performance of the building needs to be upgraded in the way it is technically, functionally and economically feasible. In case of major renovations, the thermal renovation of the building envelope is usually taken into consideration in the first instance and the improvement or replacement of the technical building systems is also considered. The measures for achieving the energy savings in the residential sector include, inter alia, thermal rehabilitation of multi-apartment buildings and of single-family houses, energy audit and energy management. Among the measures for the services sector, thermal rehabilitation in governmental buildings, other public

buildings (town halls, schools, etc.), buildings with public functions (offices, commercial spaces, etc.) and development of energy services shall be applied (2018-2020).

Several legal acts have been adopted with the aim to stimulate EE measures financed by: a) structural funds and funds from public finance institutions (for increasing EE especially in housing); b) state budget allocations; c) local budgets and d) multi-annual programmes (Tenea et al, 2018). However, the NEEAP-RO (2017) reports that the ESCO services market is just beginning in Romania, with less than 20 companies.

The NZEB requirements for existing single-family and multi-family houses, office buildings, and educational and health care facilities are the same as those for new buildings.

In the latest LTRS submitted to the European Commission, it is foreseen to gradually increase the annual renovation rates from the current 0.5% to 3.39% (2021-2030), 3.79% (2031-2040) and 4.33% (2041-2050). By 2050 77 % of the total floor area of the building stock shall be renovated or rebuilt, with a 23% increase in NZEB buildings and 26% decrease in worst performing buildings. Through increased renovation, a 9% reduction in final energy consumption by 2030 (0.83 Mtoe) is expected, corresponding to a cumulative 24% GHG emission reduction (2.34 Mton) from 2021 to 2030. By 2050, a 65% reduction of final consumption (6.14Mtep) and 80% cumulative GHG emission reduction over the 2021-2050 period are prognosticated (SWD(2021) 365 final/2).

15.1.2.3 Programmes & funding

Several funding programmes were dedicated to the installation of heating systems that use RES, such as 'Classic Green House for Individuals' (2010-2017), 'Classic Green House for Legal Entities' (2010-2017) and 'Photovoltaic Green House' (launched in mid-2018). In 2016 two other programmes were launched. 'Green House Plus for Individuals' and 'Green House Plus for legal entities' finance thermal insulation works for both, houses under construction and existing buildings. For individuals, up to 100% of the eligible project costs shall be granted, and up to 90% for the legal entities. Among the eligible expenses are also green roof systems, green walls, double-glazed windows with wooden carpentry, and the costs of installing, verifying and testing of technical systems, consulting expenses, documentation technical project and VAT, if it is non-deductible.

The 'Energy Efficient House 2020' Programme started in 2020. Its budget amounts to EUR 100 million, intended for energy upgrade at least one class of about 9,000 houses. The maximum grant is EUR 15,000 per house. Among the eligible costs are those for thermal insulation of building's envelope, solar thermal panels, joinery elements with glazing with solar control or external shading systems and expenses related to other interventions occasioned by the implementation of the above measures (increasing the air tightness of the building envelope and the installation of thermal insulation, repairing the roof, etc.), as well as elaboration of the EPCs before and after the intervention.

15.1.3 Seismic strengthening & energy upgrade measures

15.1.3.1 Legislation & Standards

According to the Ordinance nr. 20/1994 on measures to reduce the seismic risk of existing buildings there are obligations for the owners or legal persons who are in use, to monitor the behaviour of the buildings, to assign technical expertise and to get approval of the interventions. Special attention is paid to the owners/administrators of public buildings and multi-storey residential buildings, built before 1978. The intervention works may include other categories of works in the intervention areas, for instance waterproofing, thermal insulation, repair/replacement of installations etc., strictly necessary to ensure the functionality of the rehabilitated building. Multi-storey residential buildings classified by technical expertise report in class I seismic risk and presenting a public danger, shall be included in annual action programme on the design and execution of intervention works to reduce seismic risk. Homeowners and individuals of the vulnerable groups are exempted from paying monthly instalments and reimburse reduced amounts to the state budget through which the intervention works are executed.

In the scope of the Framework solutions regarding the thermo-hygro-energy rehabilitation of the envelope of existing residential buildings are both opaque and glazed areas of the building envelope that are subject of thermal rehabilitation. It is admitted that the EE works shall be carried out simultaneously with other major intervention works on existing buildings, such as those for seismic risk reduction and those for deep renovation and shall be accompanied by the functional and architectural modernisation of the building. Framework solutions are addressed to designers, technical experts, energy auditors, certified supervisors, contractors, technical executives, public authorities, professional associations and supervision and control bodies (Order no. 2280/2013).

15.1.3.2 Programmes

The national programme on increasing the energy performance of apartment buildings (Order nr. 18/2009) includes three periods: 2009 – 2011, 2011 –2018 and 2019-2021. It establishes the intervention works for the thermal insulation of the blocks of flats built in the period 1950-1990, the stages necessary for the accomplishment of the works, the way of financing them, as well as the obligations and responsibilities of the public administration authorities and associations of owners. During the first period, the measures related to the building envelope were funded. A change made in 2011 allows the closing of balconies/loggias with energy efficient carpentry. The tenants' association pays 20% of the total cost of the rehabilitation works. The remaining 80% is provided from the state and local budgets. The measures can be applied, as a matter of priority, to the dwellings belonging to disabled or low income persons. Additional repair works on the construction elements that present a potential danger of detachment and/or affect the functionality of the apartment building, if justified by technical expertise. However, if the technical expert decides there is a need for structural strengthening of the building, the local coordinator may: a) allow the measures required to reduce the seismic risk; b) terminate the design services contract on EE measures and c) implicitly, terminate the mandate contract concluded with the association of owners.

15.2 Best practices

15.2.1 Seismic strengthening

According to the changes made in 2018 to the Ordinance on measures to reduce the seismic risk of existing buildings (Ordinance nr. 20/1994), there are obligations for the mayors of municipalities, cities and communes to issue written notification of the owners/managers/users for their obligation to reduce the seismic risk of the buildings, as well as to draw their attention to the fact that they assume the risk and responsibility for the potential effects of the earthquakes if they do not comply with the legal obligations. By January 1, 2021, the managers of public institutions shall order the start of a technical evaluation, in order to classify them by seismic risk class and to substantiate the intervention measures, on the buildings for educational purposes, which were built before 1978. The technical evaluation shall be finalised by June 1, 2024.

The MRDPA and the municipalities regularly publish the updated lists of seismically assessed buildings in Bucharest and in all counties, with the corresponding risk classes (Craifaleanu, 2013). As per 15/06/2020, 349 buildings in Bucharest are classified in class I of seismic risk (constructions with high risk of collapse at the design earthquake corresponding to the limit state) (AMCCRS, 2021).

Several projects on disaster risk management, included earthquakes have been run: RO-RISK project (2014-2016) (Senzaconi, 2019), co-financed by ca. EUR 5,1 million under the European Social Fund (ESF), Strengthening Disaster Risk Management (2018 - 2024), funded by IBRD and Technical assistance to the Municipality of Bucharest for the "Seismic Risk Reduction Programme" (2019-2022), provided by the World Bank (2019).

15.2.2 Energy upgrade

The Romanian programme "Greenhouse Plus" promotes the use of organic-natural insulating materials, such as hemp, wool, cotton-recycled denim, cork, cellulose from recycled materials and other similar materials (technically approved), for both existing and new buildings. The EE grant for residential buildings is about EUR 8260, related to eligible expenses, but not more than EUR 25.2 per 1 m^2 of isolated and finished surface. The grant can cover up to 100% of the eligible costs. For legal entities, such as municipalities, public institutions, non-governmental organizations, the maximum financing is up to about EUR 105,000 per project. Up to 90% of the eligible project costs shall be granted.

The conditions of the third period of the National programme on increasing the energy performance of apartment buildings (2018-2020) foresee that when the owners perform intervention works at their own expense, they may benefit from exemption from the payment of the housing tax for a period of at least 7 years, based on the energy audit and EPC.

South-East Regional Development Agency (SE RDA) in Romania is the leader of the INTERREG Europe project, entitled "Preserve Traditional Buildings Through Energy Reduction (VIOLET)" (2017- 2021) which is 85% co-funded by the ERDF (overall budget of EUR 1,300,513). VIOLET addresses the challenge of energy upgrade of heritage buildings by development of tools for improving the regional public policy. Collaboration agreements were concluded with the Constanta, Buzau and Tulcea Counties Councils which support SE RDA in carrying out

the consultation activities, such as the development of an improved monitoring methodology for the projects that are under implementation of Regional Operational Programme (2014-2020).

15.2.3 Seismic strengthening & energy upgrading measures

In the framework solutions for energy upgrade of the envelop of existing residential buildings it is required to analyse with special attention the impact of works on energy upgrade to the structure of the building and their mutual interaction. For instance, the additional weight, resulting from the thermal rehabilitation works must not lead to exceeding the resistance capacity of the structural construction elements, both to the action of gravitational loads and to the seismic action; the thermal rehabilitation works must be executed in strict correlation with the intervention works in order to reduce the seismic risk of the existing building; the provision of additional thermal insulation layers on the outer face, creates favourable conditions in terms of the behaviour of the structure to the effect of temperature variation; the provision of additional thermal insulation layers on both sides of the construction elements (structural and non-structural) prevents the visualisation of possible defects that may occur over time under seismic action, uneven settlements or other actions or accidents (Order no. 2280/2013).

The IBRD is providing advisory services to the MRDPA to support the consolidation of its strategic planning capacity to renovate the national stock of buildings for the purposes of energy efficiency and preparedness to seismic risks. The project is co-financed by the ESF, through the OP "Administrative Capacity" 2014-2020. The project addresses in an integrated manner: 1) EE, in development of a new long-term renovation strategy of buildings and 2) Seismic Resilience, in development of national seismic risk reduction strategy and investment programme, monitoring system, awareness raising and citizen engagement and training (Sirvydis, 2019).

Participation of two Romanian partners in H2020 ProGETone project creates opportunity to build national experience on a multi-skin exoskeleton that can improve both the seismic and the thermal performance of the building. A social house, built in 1972 in Brasov is one of the ProGETOnE's feasibility studies.

The study "Seismic and Energy Renovation: A Review of the Code Requirements and Solutions in Italy and Romania" analyses some key combined renovation interventions and integrated renovation approaches. Some examples of negative impact of seismic upgrade of existing structures (steel plate jackets, RC-jacketing interventions, new structural shear walls) on the thermal performance of the buildings are discussed. It is outlined that any intervention devoted only to the energy upgrade could be nullified by the effect of earthquakes if the building is not seismically resistant. Existing buildings should always be assessed in terms of both, seismic and energy deficiencies. The challenge is to conceive, design and realise integrated, or combined, solutions (Georgescu et al.., 2018).

16 Implementing measures in Slovakia

16.1 Overview

Slovakia is a country with low to moderate seismic hazard with a maximum peak ground acceleration of about 1.1 m/s^2 on rock.

In terms of climate, Slovakia has in general a temperate climate, with 3047 HDD and 20 CDD (Eurostat, 2021), i.e. having a significantly more demanding heating than cooling season.

16.1.1 Seismic strengthening measures

In 1975 the low-level code standard ČSN 73 0036 (1965) was introduced and in 2009 the National Annex to Eurocode 1998-1 (2004) was implemented. A standard for the seismic retrofitting was introduced as National Annex STN EN 1998-3 /NA (2009) to Eurocode 1998-3 (2005).

16.1.2 Energy upgrading measures

Similar to other countries in Europe, the Slovak Republic has implemented NEEAPs under the Energy Efficiency Directive 2012/27EU. Most of the legislation and programmes documents, financial instruments are only available in regional languages. An overview of the concerted actions on energy performance of the buildings is given in Sternova et al. (2016).

The Slovakian LTRS analysed by the Commission (SWD(2021) 365 final/2) has a direct link to the adopted Integrated National Energy and Climate Plan for 2030 and the Low Carbon Strategy for the Development of the Slovak Republic up to 2030 with an outlook for 2050. In the LTRS, very ambitious renovation targets have been set-out for the residential sector, with aims of renovating all multifamily buildings by 2030 and all single family buildings by 2040. This will include a 40% share of deep renovations on total renovations by 2050. Investment needs by 2050 are estimated to be EUR 22.8 billion (cumulative), of which 630 million are allocated from the Recovery and Resilience Facility (NextGenerationEU).

16.1.2.1 Building energy code

The national standard for thermal protection sets the standard for the energy consumption for heating of buildings. From 2016, major renovations of the buildings should meet the requirements for ultra-low energy construction, if technically, functionally or economically feasible. The main challenges are deep renovations, the change of technical systems for heating, hot water generation and distribution as well as the cost-effectiveness of the implementing measures. However, no further specific technical requirements are defined for the system installations beside a minimum combustion efficiency of the boilers. In the case of large buildings, the owners are obliged to ensure suitable thermal insulation for the heat and domestic water network. If these requirements are not met, the building owner is susceptible for a fine from 200 EUR to 8,000 EUR.

16.1.2.2 Energy performance certificate (EPC)

The Energy Performance Certificate (EPC) of the building is a requirement as per the national building code. The legal base for the certificate is the EU Directive 2010/31/EU (2010). EPC was introduced in Slovakia for renting or selling an individual apartment or parts of the building in January 2017. The score on the EPC is granted based on the quality of thermal insulation and the performance of heating and domestic hot water system. The certificate is valid for 10 years. Since 2014 the number of buildings that are sold and rented with EPC are increasing every year. However, the number of buildings with EPC with respect to the total building stock in Slovakia is relatively low. It is a challenge for the government to successfully implement EPC, especially in the rural areas.

16.1.2.3 Inspection requirements- heating systems, air conditioning

As a part of the Energy Performance of Buildings Directive (EPBD), regular inspections both for heating and air-cooling systems are mandatory in Slovak Republic. The Ministry of Economy is responsible for the regular inspections. There are 200 licensed bodies and 255 experts registered for regular building inspections. This has created new job opportunities. The inspections have to be paid by the owner of the building. The inspection reports are monitored yearly by the Ministry. The licenced body is required to send the electronic report by the end of each year. If the bodies fail to do so they are fined up to 200 EUR. If the owners fail to do the inspection,

they are also susceptible for a fine. The quality control of the inspection is carried out by the ministry or other legal entities on their behalf. The results of the quality checks are utilized for the improvements of the training. Thus, the quality control has high impact on the improvement, and the ministry is keen on the improvement of the training and ultimately to improve the overall quality.

16.2 Best practices

There are several funding and subsidy programmes provided by the state for residential buildings upgrading (Gerőházi et al., 2015), which are briefly described in the following.

The State Housing Development Fund (SHDF) is a legal entity and a financial institution set up mainly to serve the implementation of financial instruments. Established in 1996, SHDF started to provide loans for renovation of the housing from 2000. Most of the loans are granted for the renovation of multi-family houses. The renovation can include modernization or reconstruction of certain common parts, thermal insulation of the external walls and roofs as well as the replacement of external windows and doors. To get the loan it is obligatory to implement complex interventions. For example, for thermal insulation at least 35% energy savings must be reached as a result of intervention. Different interest rate level exists for different types of interventions. It is also possible to combine interventions, reducing the interest rate, even up to 0%. The government is encouraging more complex interventions through this combined interest rate. In addition to the energy evaluation and the cost of experts there are other transaction costs to be paid by the owners, which results in 5,000 – 10,000 EUR per project. These costs are sometimes a burden for the owner. The SHDF fund is partially self-sustainable (60% of the funds are from the repayments of the previous loans).

The grant for elimination of systematic defects is provided by the Ministry of Transport, Construction and Regional Development as a subsidy. The aim is to eliminate certain types of conceptual defects of multi-family buildings mainly for energy efficient interventions. The scheme was introduced in 1998. According to this, up to 50% of the renovation costs can be financed by the state, if the goal of the intervention is to eliminate certain conceptual defects of multi-family buildings. The funds allocated to the grants are decreasing since 2012, and more funding is allocated for the loan programme (SHDF), thus reducing the state resources.

Sustainable energy financing facilities were developed by the European Bank for Reconstruction and Development (EBRD). SlovSEFF (2022) is the latest extension, co-funded by the Ministry of Environment of the Slovak Republic and the Ministry of Agriculture, Food and Environment of Spain that provides a credit line of up to €100 million to Slovak commercial banks. MunSEFF (2022) is an initiative that aims to develop and stimulate commercial bank financing to municipalities and their utility companies in Slovakia. In total the EBRD provides credits up to €40 million to Slovak commercial banks. Eligible projects within the residential sector are complex, major thermal rehabilitation projects of blocks of flats consisting of the thermal insulation of the building envelope, the minimum level of energy savings to be achieved is 30%. After successful completion and validation of the project, the building owner receives incentives as a percentage of loan amount, accounting about 20% of the construction costs, which can be used to repay the loan amount.

17 Implementing measures in Slovenia

17.1 Overview

The Republic of Slovenia is a country with a moderate seismic hazard. In the national seismic map, the maximum peak ground acceleration is 0.25g on rock.

In terms of climate, Slovenia has in general a temperate climate, with 2691 HDD and 30 CDD (Eurostat, 2021). Hence, the heating season is more demanding than the cooling season.

17.1.1 Seismic strengthening

17.1.1.1 Legislation & Standards

The first seismic code was adopted in 1963 in the former Yugoslavia. The response-history analysis was implemented in the seismic code adopted in 1981 (Fajfar, 2018). At present, Slovenia uses all six parts of Eurocode 8. National annexes to Part 1 and to Part 3 were published in 2009 and 2007, respectively. Regulations on the mechanical resistance and stability of structures (RMRSS-SLO, 2005) set out requirements to ensure the mechanical resistance and stability of buildings throughout their useful life. The rules apply to the design, construction and maintenance of new buildings, as well as to the reconstruction of existing buildings where the technical possibilities exist and does not contravene the protection of cultural heritage. After the strongest earthquake with the epicentre in Slovenia in the 20th century occurred on April 1998, a Post-Earthquake Reconstruction of Buildings and Stimulation of Development in the Posočje Act was published immediately (Posocje Act, 2005).

17.1.2 Energy upgrading measures

17.1.2.1 Legislation & Standards

The Energy Act (EA-SLO, 2019) transposes several EU directives into the legal system of the Republic of Slovenia, including EPBD, EED and that on RES. The action plan for NZEBs shall include policies and measures to encourage the energy rehabilitation of existing buildings into NZEBs. The act provides also promotion and incentives for EE use and RES: particularly, the amount of incentives in the case of integrated energy rehabilitation of existing facilities is relatively high, thus encouraging investors to integrated rehabilitation. The Rules on the efficient use of energy in buildings (PURES, 2010 and 2017) determine the technical requirements that must be met. They specify EE limit values for various types of buildings and the form and procedures related to the building EPC. These Rules shall apply to the reconstruction of a building where at least 25% of the surface of the thermal envelope is affected, if this is technically feasible. The "Technical Guidelines for Construction TSG-1-004: Energy Efficiency" define the construction measures (for minimizing thermal bridges impact, for reducing the overheating during the summer, for water vapour diffusion, for thermal protection of building structures) or solutions to meet the requirements of the PURES, and specifies the methodology for calculating the energy performance of a building. The use of technical guidelines is mandatory (TSG-1-004, 2010). The legislation is completed by the Rules on the methodology for producing and issuing EPCs for buildings (2019).

17.1.2.2 Strategies

The Republic of Slovenia duly developed and submitted the main strategic documents as requested by the European legislation, namely National Energy Efficiency Action Plans, the last one being for the period 2014-2020 (NEEAP-SLO, 2017), Strategies for mobilising investment in the field of building renovation in 2015 and 2021 (LTRS-SLO, 2021), National Plan for increasing the number of NZEB till 2020 (NZEB-SLO, 2015) and National Energy and Climate Plan, 2021-2030 (NECP-SLO, 2020).

The LTRS of Slovenia indicates a reduction of ca. 90% in CO_2 emission for the building sector by 2050 (SWD(2021) 365 final/2). By 2030, a 70% reduction in GHG emissions is foreseen, with 2/3 of the building energy use coming from renewable sources. In terms of renovations, Slovenia aims to renovate 74% of single dwellings and 91% of multi-apartment buildings by 2050.

17.1.2.3 Programmes & funding

Within ELENA Technical Assistance Projects, implemented by the European Investment Bank (EIB) in the framework of an agreement with the European Commission, the Programme "Energy renovation of Ljubljana" was implemented (2013-2016). Two tenders for Energy Performance Contracts (EPCo) to retrofit 76 public buildings, including deep retrofits, using the ESCO model, were launched. The measures consisted of wall insulations, replacement of old windows, boiler replacement, cooling and heating systems retrofits, installation of small RES (PVs). Investment in the implementation phase amounted to EUR 49 million (ELENA-SLO, 2020). The Government Deep Energy Renovation Project (2018-2020), is the first ELENA project supporting the realisation of deep energy renovation in ca. 150 governmental buildings (TFA of about 230 000 m^2). The investment to be mobilised amounts to EUR 48 million, implemented through EPCo/PPP where possible. In 2019 and 2020, the Ministry of Infrastructure published several calls for applications for co-financing from ELENA Technical Assistance funds (ELENA 2020), inviting potential beneficiaries to submit applications for obtaining ELENA grants for the preparation of economic and technical documentation for operations of integrated energy renovations of public buildings of the narrower and wider public sector. Approximately EUR 7.65 million of European Cohesion Policy grants were available under the Operational Programme for the Implementation of the EU Cohesion Policy (2014-2020) (MI-SLO, 2021).

ECO FUND, the Slovenian Environmental Public Fund, the largest financial institution of the Republic of Slovenia, has published many calls for EE of buildings. For 2019, EUR 50 million of subsidies were paid to various beneficiaries for renovation of residential buildings, construction of NZEBs and energy renovation of buildings owned by municipalities. For vulnerable groups, the grant might be up to 100% (ECO FUND, 2021).

Slovenian participants from the public and private sectors, NGOs and research centres have taken part in several European projects, such as AFTER (Cost Optimum and Standard Solutions for Maintenance and Management of Social Housing Stock under Intelligent Energy Europe Programme), Project NewBEE (Novel business model generator for energy efficiency in construction and retrofitting, under FP7-NMP), HAPPEN (Holistic Approach and Platform for the deep renovation of the residential Environment, under H2020) and LIFE IP CARE4CLIMATE Project, which creates favourable conditions for national know-how development and implementation of good and innovative practices.

17.1.3 Seismic strengthening & energy upgrading measures

17.1.3.1 Legislation & Standards

The Building Act, adopted in 2017 and further amended (BA-SLO, 2017) provides regulation on design, permitting, construction, use, maintenance and inspection control of buildings in Slovenia. It also applies to the reconstruction of existing buildings and requires satisfaction of the essential and other requirements, unless they are technically unfeasible or involve disproportionate costs. It is stipulated that when changing/renovating buildings, the structural conditions of the building must not deteriorate. In facilities protected as part of cultural heritage, the design or implementation solutions may deviate from or do not need to meet the prescribed essential and other requirements, if this arises from the opinion or conditions of the competent body in the field of cultural heritage.

In the LTRS of Slovenia, the introduction of the "building cards" instrument by 2024 is mentioned. This instrument will provide guidance on recommended and required measures for gradually wider renovation, including the energy, fire and seismic aspects of renovation (SWD(2021) 365 final/2).

17.2 Best practices

17.2.1 Seismic strengthening

The Post-Earthquake Reconstruction of Buildings and Stimulation of Development in the Posočje Act (Posocje Act, 2005) determines the forms and manner of implementing the assistance of the Republic of Slovenia in the implementation of post-earthquake reconstruction measures. Those measures include allocation of funds from the national budget, granting housing loans from the Housing Fund, organization of post-earthquake reconstruction tasks, development aid for municipalities and granting state guarantees. For cultural heritage buildings, so-called protection conditions shall be obtained and a representative of the competent service shall participate in the execution of the works. There are provisions in regard to the vulnerable groups of population such as providing grants to the municipality if the owner allows the municipality to register a mortgage right

for a period of 20 years. Grants may be awarded to the municipality for the final treatment (including, *inter alia*, thermal insulation) of residential premises as part of the post-earthquake renovation.

Two editions of the Manual for the design of building structures according to Eurocodes were issued by the Slovenian Chamber of Engineers in 2009 and 2017 (Beg and Pogačnik, 2009, 2017).

Within systematic and long-duration research projects, a database on the seismic resistance/seismic vulnerability of more than 1500 individually assessed buildings in Slovenia has been prepared. A Web-based application for the assessment of the consequences of the earthquake has been created as part of the measures to reduce the earthquake risk (ZAG, 2013, Jeraj, 2017, Lutman et al, 2018).

Systematic reports on different building types (unreinforced brick masonry apartment building, confined brick masonry house and rubble-stone masonry house) in Slovenia have been prepared as a part of the World Housing Encyclopaedia, established by the Earthquake Engineering Research Institute (EERI) and the International Association for Earthquake Engineering (IAEE). The main features, such as data on the structural system and building envelope, applicable codes or standards addressing this type of construction, damage patterns observed in each construction type, due to the strongest past earthquakes, retrofit Information, and additional comments on seismic strengthening provisions, are presented (Lutman and Tomazevic, 2011a, 2011b, 2011c).

A particular study "Heritage Masonry Buildings in Urban Settlements and the Requirements of Eurocodes: Experience of Slovenia" proposes solutions to attain the same level of seismic safety as required by Eurocode 8 - Part 1 for new construction, taking into consideration the effectiveness of economically acceptable retrofitting measures: improving the integrity of the structure and resistance of existing masonry walls and a reduction of design seismic loads, not exceeding 33 % of the code required value. A moderately increased amount of damage to structural walls may be expected, without risking collapse of the structure (Tomaževič and Lutman, 2007).

Analysing the measures applied on churches in the Posočje region, it was concluded that, although churches are mostly of better quality than ordinary buildings, because of their typical design, strengthening procedures are more complex and demanding and only carefully designed combinations of strengthening procedures can provide adequate behaviour of the structure during the an earthquake. Because churches are usually under cultural heritage protection, strengthening must be performed without substantial modifications of the basic structural system. Therefore, adequate seismic resistance is harder to achieve compared to ordinary buildings. Thus, the strengthening procedures should be carefully planned and implemented (Uranjek et al., 2011).

17.2.2 Energy upgrading measures

Since 2016, the Ministry of Infrastructure has issued a set of guidelines and instructions for performing operations for energy renovation of public buildings (NTUEPS, 2020, NDOPEPS, 2020, PUJPEPS, 2020, PUSEPS, 2020).

In 2016, the Ministry of Infrastructure granted around EUR 4 million to one proposal for carrying out a demonstration project on comprehensive energy renovation of a public building protected by cultural heritage regulations. As part of the call, the Ministry set criteria for evaluating operations including the contribution to energy efficiency, cultural heritage element, share of co-financing by a beneficiary and its contribution to social acceptance.

A project of complete energy renovation of buildings (PEP) has been introduced in Slovenia. Clients of an energy renovation project can be condominium owners' managers or managers of multi-apartment and other larger buildings. A lifecycle cost analysis (LCCA) is used to observe the net present value, calculated per unit usable building area. Procedures for detailed inventory of all necessary works for implementation, tender forms and the tender implementation procedure for the selection of the contractor are prepared. The usual tender procedure might be adapted to the needs of the client. After the completion of the tender, the received bids are analysed and a report is prepared serving as a basis for negotiations with the most favourable bidders. The consultant performs design supervision over the execution of works, thus ensuring quality of energy renovation measures in the building. In case of ambiguity in the implementation of details, the consultant finds new solutions and prepares the appropriate details. After the works are completed, a new energy certificate for the building is issued and new correction factors for the division of heating costs is determined. PEP allows carrying out the work for less money, as carefully prepared inventory of work have proven lower prices and, eventually, ensure lower energy consumption and lower maintenance costs. Experience shows that due to the preparation of the energy renovation project of the building, the costs of works due to the implementation and maintenance costs of the building are reduced by 10 to 25%, so PEP actually pays for itself. More than 30 offices give, free for the public, advice on energy efficiency improvement (ZRMK, 2020).

Further best practices from the submitted long-term renovation strategy of Slovenia include the development of sustainability criteria for buildings within the LIFE IP CARE4CLIMATE project (2019-2026). The project includes activities on quality assurance and efficiency improvement during building renovation in housing and private companies. The project foresees testing the first version of the sustainability indicator system, including the establishment of a supportive environment and the development of criteria for the evaluation of indicators. Development of financial instruments and activation of other sources of financing are planned. The national system for valuation of the quality of constructions or renovations shall be upgraded (establishment of the system, certification scheme, training, system maintenance, financing) and its visibility shall be increased.

Moreover, to tackle energy poverty, the ZERO500 programme from ECO FUND is seen as best practice in SWD(2021) 365 final/2. The programme ensures 100% funding to finance investments in energy efficiency measures (replacement of facades, windows, roof insulation, installation of ventilation and others) for 500 low-income households in single-dwelling buildings or apartments in double-dwelling buildings.

17.2.3 Seismic strengthening & energy upgrading measures

Guidelines for energy renovation of cultural heritage buildings were prepared by the Ministry of Infrastructure and the Ministry of Culture of the Republic of Slovenia (2016). The Guidelines provide technical support within the whole building energy renovation process. The guidelines contain a list of interim analyses, a selection of acceptable measures for improving EE with risk designation for cultural importance, and warnings and recommendations on implementing these measures. The energy renovation of cultural heritage buildings is considered as part of maintenance work, static and earthquake rehabilitation, change of purpose and use of the building, economic optimisation or integrated rehabilitation after emergencies (e.g. flooding). According to the guidelines, both structural and energy renovation must be in line with local characteristics to ensure the sustainability of the investment. It is outlined that, within the scope of possible interventions, the most advanced products and techniques are to be used, having long-lasting effectiveness (Ministry of Infrastructure and Ministry of Culture, 2016).

A brochure entitled “Interventions in the bearing structures of buildings” aims to draw the attention of potential investors and contractors on the appropriate measures for renovating buildings and interventions in their load-bearing structures. The renovation is considered as an opportunity to consolidate the structure of the building and improve its resistance, in particular to earthquakes. It is stated that at the time of renovation, care should be taken to ensure that the structure of the building is not damaged, weakened or additionally loaded, e.g. by installing of a heavier thermal insulation on the façade. For each intervention in the load-bearing structure, a design project must be prepared and a building permit must be obtained (Ministry of Environment and Spatial Planning, 2017).

One of the specific approaches of Slovenia is the plan to create sustainability criteria for buildings by: a) establishing an appropriate regulatory environment for the sustainability evaluation of buildings (establishment of a system, certification scheme, training, maintenance of systems, financing); b) drawing up the bases for the promotion and financing of sustainable renovation and the extension to the sustainable renovation of buildings (which, in addition to energy renovation, also takes into account all other important criteria for the renovation of buildings: earthquake and fire safety, radon issues, etc.); c) carrying out model projects for the sustainable renovation of public buildings. The financing plan for the sustainable renovation of buildings is under development within the LIFE IP CARE4CLIMATE Project (2019-2026).

18 Implementing measures in Spain

18.1 Overview

The seismicity in Spain is, in general, classified as low, except the southern-east areas, which may be classified as moderate. The national seismic map in NCSR-02 (Law 997/2002/ES, 2002) distinguishes five zones, with the maximum design PGA of 0.16g.

The climate in Spain has a huge variability across the country: Mediterranean climate, continental climate, maritime climate, desert climate, high mountain climate and even a subtropical climate. In general, the heating season is more demanding than the cooling season with 1554 HDD and 279 CDD (Eurostat, 2021).

18.1.1 Seismic strengthening measures

Given that the seismicity is low in most of the country, there is no global national strategy for the seismic strengthening of buildings. However, in the areas where the seismicity is moderate and where recent seismic events took place (e.g. Lorca in 2011, and Melilla in 2016), different strategies were implemented to increase awareness of the general public and administrative authorities to such events. Two of such plans are the municipal action plan towards the seismic risk in Benalmádena (*Plan de actuación local ante riesgo sísmico en Benalmádena*) (AB, 2019) and in Granada (*Plan de Actuación municipal ante el riesgo sísmico de Granada*) (AG, 2019). However, in both cases, the aim of such plans is to provide an action plan to mitigate the damage and to guide people in case of a seismic emergency. These plans do not provide any preventive action for buildings and/or infrastructures.

18.1.2 Energy upgrading measures

To comply with EU obligations, namely Directive 2012/27/EU (2012) and Regulation (EU) 2018/1999, different action plans have been implemented in Spain to promote the energy efficiency in new and existing buildings:

- **National Energy Efficiency Action Plan** [*Plan Nacional de Acción de Eficiencia Energética* (PNAEE)] (METAD, 2017)

Spain estimated the consumption of the primary energy, by 2020, as 122.6 Mtoe, which represents a reduction of 24.7%, above the 20% required by the European Union. In terms of final energy, the value estimated in 2017 was 87.2 Mtoe. The implementation of the measures of these plans (PNAEEs) contributed to an improvement in energy efficiency, which was reflected during the period 2004 to 2016 and quantified as an annual decrease of 2% in final energy intensity.

- **Long-term strategy for energy renovation in the building sector** [*Actualización de la Estrategia a largo plazo para la rehabilitación energética en el sector de la edificación* (ERESEE)] (MF, 2017)

The goals set by this strategy are ambitious and aim to reduce the energy consumption of renovated buildings from 60% to 90%.

- **National energy and climate plan** [*Plan Nacional Integrado de Energía y Clima* (PNIEC)] (MTERD, 2020)

Two types of measures are considered in this plan for buildings: (i) energy efficiency in existing buildings, aiming to reduce the energy consumption of existing residential buildings used for housing through energy upgrade activities; and (ii) renewal of residential equipment, aiming to reduce energy consumption through the improved energy efficiency of household appliances.

The targets for the energy upgrading of buildings until 2030 are: (i) energy efficiency improvement (thermal envelope) throughout the decade for a total of 1,200,000 homes; and (ii) energy efficiency improvement of 300,000 homes/year. These measures will lead to a cumulative final energy saving, in the building sector, of about 6.7 Mtoe. By 2050, 7.1 million houses are expected to undergo deep renovation. The strategy aims for a 37% reduction in energy use and a 99% reduction in GHG emissions In the residential sector by 2050 compared to 2020 levels (SWD(2021) 365 final/2).

In order to achieve the above targets, different measures were introduced in Spain, focussing of energy efficiency, reduction of greenhouse gases and production of energy from renewable sources in buildings. These measures support the implementation of the above plans by providing funding and financial benefits. The incentives are provided at the central administrative level (central government) and at the local level (autonomous communities). The most relevant ones are summarized in **Table 12**.

Table 12. Summary of the different financing programmes in Spain

	Renovation			Technologies								
Programme	Low	Medium	High	Structural work	Walls insulation	Roof insulation	Improvement of glazed areas	Solar energy	Biomass	Geothermal	Ventilation	HVAC/heat pumps/ other equipment
BIOMCASA/BIOMCASA II [a]									√			
SOLCASA [b]								√				
GEOTCASA [b]										√		
State Housing plan [c]					√	√	√	√	√	√		√
PAREER/PAREER-CRECE/PAREER II [d]					√	√	√		√	√		
PIMA SOL [e]					√	√	√	√	√	√		
DUS (2020)					√	√	√	√				

[a] Ordinance 12th December 2012/ES (2012); [b] Ordinance 6th April 2020/ES (2020); [c] Law 106/2018/ES (2018); [d] IDAE (2019); [e] Law 635/2013/ES (2013)

The timeframe of the above measures is shown in **Table 13**. Some of the listed programmes are foreseen to continue after 2020, and therefore, they are indicated in light grey.

Table 13. Timeframe of the different programmes in Spain

Programme	2008	2010	2012	2014	2016	2018	2020	2022	2024	2026	2028	2030
BIOMCASA												
BIOMCASA II												
SOLCASA												
GEOTCASA												
State Housing plan												
PAREER/PAREER-CRECE/PAREER II												
PIMA SOL												
DUS												

18.2 Best practices

18.2.1 Programmes and other measures

18.2.1.1 Energy upgrading

In the following paragraphs, available estimated results are provided for the different measures indicated above. It is noteworthy that specific performance indicators for the different programmes were not found. Hence, the values provided in the next paragraphs are the values considered or estimated in the most recent versions of the most relevant strategies:

- The results of programme BIOMCASA were: 64 qualified companies, 18 companies with funded projects, 71 financed projects, 23 MW installed and 9.7 million € investment; while BIOMCASA II resulted in 40 qualified companies, 31 projects approved, 11.4 MW installed, 5.2 million € investment, and 4.1 million € in financing.
- The results of programme SOLCASA were: 42 qualified companies, 17 projects approved, 2.25 MW installed, 2.25 million € investment, and 2 million € in financing.
- The results of programme GEOTCASA were: 23 qualified companies, 12 projects approved, 1.3 MW installed, 1.88 million € investment, and 1.82 million € of financing.
- Final energy savings as a result of programme PIMA SOL were estimated to be equivalent to 0.8 ktoe in 2014 (METAD, 2017).
- The most recent version of the programme State Housing Plan (2018-2021) is still in execution and no results were found for Programme 5 related to the improvement of the energy efficiency of buildings. The total financing of the State Housing Plan, in the period 2018-2021, is 1,770,253,601 € (MITMA, 2020).
- Maybe the most successful programme was PAREER, PAREER-CRECE and PAREER II (MITMA, 2020):

  The programme PAREER-CRECE had about 2488 submissions, from which 1513 were approved, corresponding to an investment of 303 million €. The aid provided in this programme included the following activities: (i) actions related to the building envelope (87%), (ii) actions in thermal installation and illumination (10%), (iii) replacing boilers using fossil fuel by boilers using biomass (2.6%), and (iv) replacing boilers using fossil fuel by boilers using geothermal energy. The approved submissions allowed to improve the energy efficiency of about 42,358 dwellings, 8,398 rooms in hotels and 15 residences, saving about 33,661 toe/year in terms of final energy, and avoiding the emission of about 96,204 tCO_2/year.

  The most recent version of the programme - PAREER II (until 31 March 2020) included 1566 applications submitted, of which 950 were evaluated, and 800 were approved; mobilizing an investment of about 224 million € (with an average investment ratio of 280,000€/ submission). This aid was related in most cases (98%) to the rehabilitation of the building envelope. The 800 submissions that were approved will allow to improve the energy efficiency of about 29,600 dwellings, to save about 12,800 toe/year in terms of final energy, and avoid the emission of about 40,800 tCO_2/year.

18.2.2 General investments in renovation

According to the information from the EU Buildings Database (2019), the building stock in Spain, in 2016, was composed by a share of 76% of residential buildings and 24% of non-residential buildings.

Considering the time span 2012-2016, the average renovation rates related to non-energy renovations were 20.3% and 8.7% for residential and non-residential buildings, respectively. For energy related renovations, the renovation rates were 17.0% and 11.2%, for residential and non-residential buildings, respectively.

In terms of investments in renovation, the total volume for residential and non-residential buildings is provided in **Figure 10** for the time-span of 2012-2016; while, **Figure 11** represents the volume of energy related investments, for the same time-span

Figure 10. Total volume of investments in renovation for residential and non-residential buildings in Spain (EU Buildings Database, 2019)

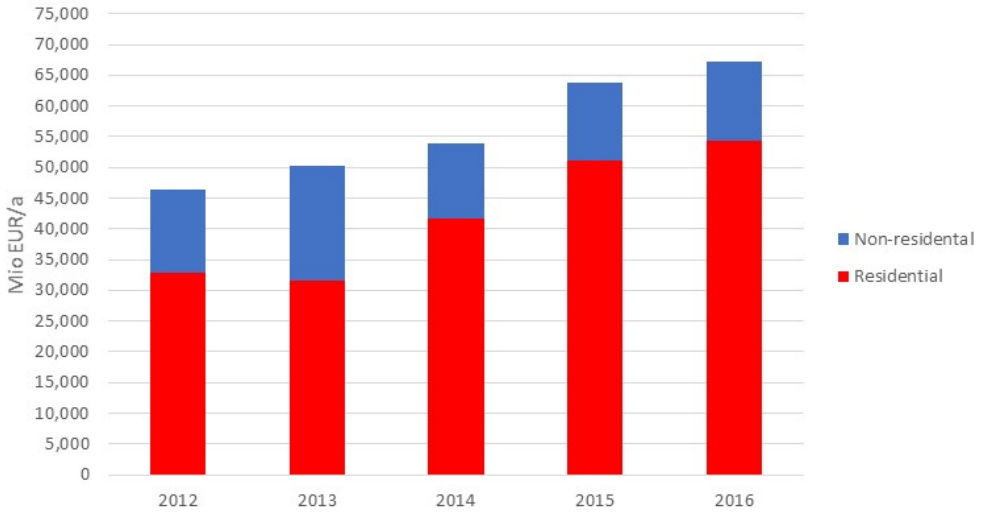
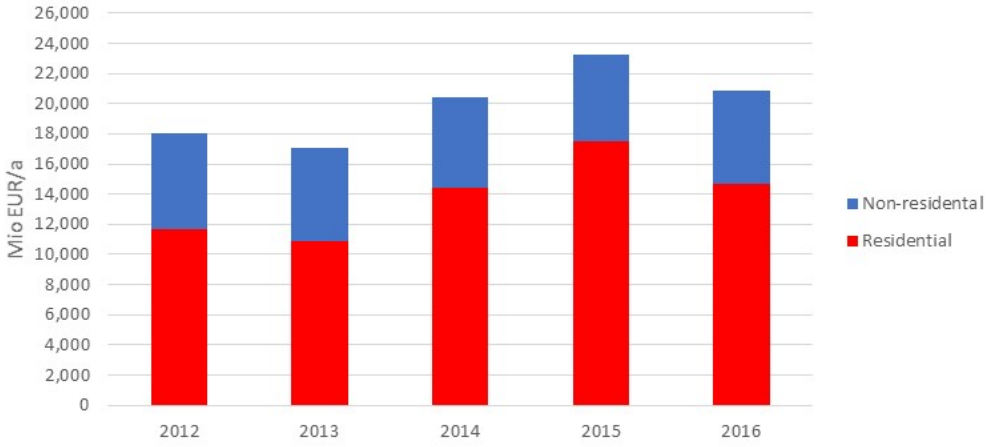


Figure 11. Total volume of energy related investments in renovation for residential and non-residential buildings in Spain (EU Buildings Database, 2019)



The energy related renovation led to a total primary energy savings (average), in the period of 2012-2016, of 164,003 toe for residential buildings and 161,456 toe for non-residential buildings. This value represents the average reduction of the total annual primary energy use (from heating, cooling, ventilation, domestic hot water, lighting (only non-residential buildings) and auxiliary energy) that was achieved compared to the previous year, during the period 2012-2016, by means of energy related renovation.

Investments required for the latest LTRS for 2020-2030 would be about EUR 41 billion, of which public investment constitutes 25% for installations and 50% for building stock renovation.

19 Implementing measures in Sweden

19.1 Overview

Sweden is a country with very low seismic hazard. The seismic map of Scandinavia shows that the maximum peak ground acceleration in Sweden is lower than 0.25 m/s^2 (Wahlström and Grünthal, 2001).

With a cold Nordic climate, Sweden has 4593 HDD and 0 CDD (Eurostat, 2021). Hence, a very demanding heating season and no significant cooling season.

19.1.1 Seismic strengthening measures

There are no specific measures or guidelines for seismic strengthening available in Sweden. Eurocode 8-3 (2005) is not introduced in Sweden and a National Annex to this document is not existing. According to Eurocode 8, areas with PGA less than 0.39 m/s^2 are regarded as areas of very low seismicity, where the provisions of Eurocode 8 need not be considered. Sweden is a part of the Union Civil Protection Mechanism according to the Decisions of the European Parliament and of the Council 2013/1313/EU and 2019/420.

19.1.2 Energy upgrading measures

Sweden introduced building regulations to stipulate essential technical requirements for buildings, including energy efficiency requirements. The measures in the regulations are continuously updated and aim to improve the energy efficiency of buildings. The new building regulations have higher demands on buildings energy efficiency and apply to new buildings as well as to renovation measures. The environmental target is to lower the energy use per square metre by 20% from 1995 to 2020 and by 50% to 2050.

Under the Energy Performance of Buildings Directive (EPBD), Sweden has implemented legislations such as Energy Declaration of Buildings Act. This building legislation demands inspections and an energy declaration when the buildings are constructed, sold or rented out. Furthermore, the information regarding the buildings energy consumption and indoor environment has to be declared. The aim is to reduce the buildings' energy consumption, operating costs and greenhouse gas emissions. The purpose is to facilitate property owners to recognise the energy performance of the building and to better understand which energy-saving measures are profitable and provide a better indoor environment. The energy declarations will have high impact in several aspects:

- The owner has the opportunity to reduce the costs for energy use through the measures proposed in the energy declaration
- For owners of buildings, energy declaration can be valuable in the sales point of view
- The energy declaration will have an economic value for a person who buys the building as it is valid for ten years from when it was drawn up.

Therefore, Sweden introduced an Energy Performance Certificate (EPC) in 2014 that is intended for people who are planning to purchase or rent a building or a part of a building, and also for those who visit larger buildings frequently visited by the public. It can be used to compare different buildings with each other. It is the responsibility of the owner of the building to show the energy performance certificate. A detailed description of the EPC in Sweden is given on the website by Boverket (2022): "The performance certificate contains information about the heated area of the building, energy consumption for heating, comfort cooling, hot tap water and the property electricity in the building, energy performance, energy requirement for a new building and the building's heating and ventilation systems. The certificates also contain other information, such as suggested measures, if the energy expert has given any, to reduce energy consumption".

Within the LTRS, Sweden sets out to cut its net greenhouse gas emissions to zero by 2045 and achieve negative emissions after that (SWD(2021) 365 final/2). To achieve this, ambitious building renovation targets of increasing renovation rates from 2.5% to 5% in 2016-2019 and from 2.5% to 10% after 2019 were laid out. EPCs are used as a metric for the definition of milestones, where every 10 years, the proportion of buildings in the A-C EPC class should be higher than in the previous reference year, and the proportion of buildings in the E-F EPC class should be lower than in the previous reference year.

19.2 Best practices

In Sweden, tax deductions were introduced in 2008 for labour costs for house repairs, renovation, maintenance, conversions and extensions. The tax deductions can be seen as an incentive for property owners to carry out renovations. In 2016 the tax reduction was cut from 50% to 30% of the labour costs, with a maximum value of SEK 50,000 per person per year (SWD(2021) 365 final/2). Next to tax incentives, the issuance of green bonds is seen as one of the best practice examples in Sweden in the assessment of it's LTRS (SWD(2021) 365 final/2). A green bond is a bond where the capital is used for "green" projects and activities, i.e. those that contribute to improving environmental sustainability. In Sweden, such green bonds are a particular success (Torvanger et al., 2021).

Sweden has imposed the carbon tax in 1991. The building heating is taxed with the carbon tax and the fossil fuel use for energy is subjected to energy and carbon tax. The method is to impose heavy tax on the people thus to reduce the carbon emissions. This measure has a long-term influence. The taxation policy aims at improving the efficiency of energy use, encouraging the use of renewable energy, creating incentives for companies to reduce their environmental impact and creating favourable conditions for domestic production of electricity. It is commonly considered that the carbon tax has played a pivotal role in the switch of energy consumption by Swedish households towards non-fossil alternatives.

The purpose of the investment support for photovoltaic cells is to encourage the use of solar heating technology for heat supplies to detached houses and apartment buildings and to promote an efficient and environmentally beneficial utilization of energy. The scheme was funded by SEK 736 million in 2019.

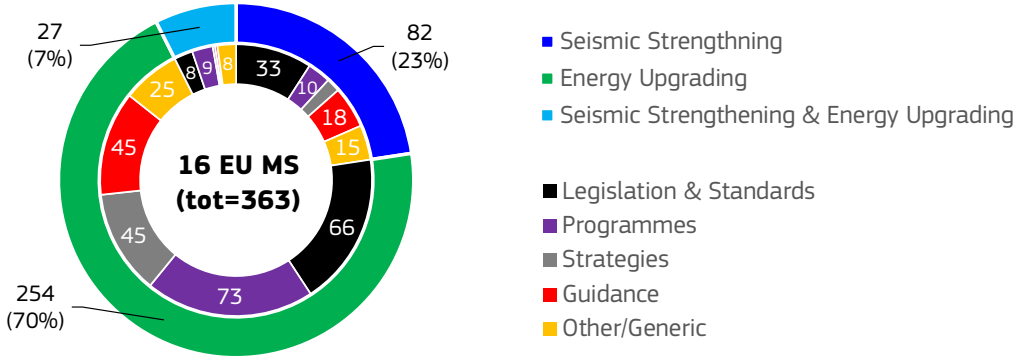
Furthermore, Sweden starts intensively with the transition to fully renewable and fossil-free energy production by adapting the electricity systems to the new requirements. Detailed information is given on the platform Smart City Sweden, which is a state-funded initiative and export platform for smart & sustainable city solutions (Smart City Sweden, 2022). The aim is the development of a smarter electricity grid with innovative technical solutions and new players on the market. The grid should enable the storage of energy by grid-connected, customer-owned distributed energy resources such as solar panels, which are already financially supported. One proposed solution is to support the use of electrical power when electricity is abundant and to store energy locally with new energy storage techniques.

20 Conclusions and discussion

Given the significant impact of the building sector on the overall energy demand and greenhouse gas emissions in the EU, renovation of the existing, energy inefficient building stock is a priority. Through policies and initiatives of the EU Green Deal, such as the Renovation Wave and the implementation of the EPBD, MS are encouraged to increase renovation rates to achieve the climate-neutrality targets set-out for 2050. The Pilot Project 'Integrated techniques for the seismic strengthening and energy efficiency of existing buildings' aims to promote a new holistic perspective on building renovation, integrating energy upgrading with structural interventions to protect buildings from earthquakes.

The importance of the seismic and energy efficient renovation measures is reflected in standards, legislation, norms and incentives. In this report, implementing measures related to building renovation in 16 EU MS were collected, to gain better understanding of best practices which may serve as a point of reference for further implementation. A distribution of the measures collected in the Pilot Project by sector (seismic strengthening, energy upgrading or both sectors) and class (legislation and standards, programmes, strategies, guidance, and other) is provided in **Figure 12**. Although the figure addresses more measures than those explicitly described in the present report (for economy of space), it clearly illustrates that the overwhelming majority of implementing measures in the 16 MS are related to energy upgrading. Significantly less measures refer to seismic strengthening and even less to both sectors, noting here that a measure was classified as "seismic strengthening and energy upgrading" when reference to both sectors was made, without necessarily including provisions for combined renovation.

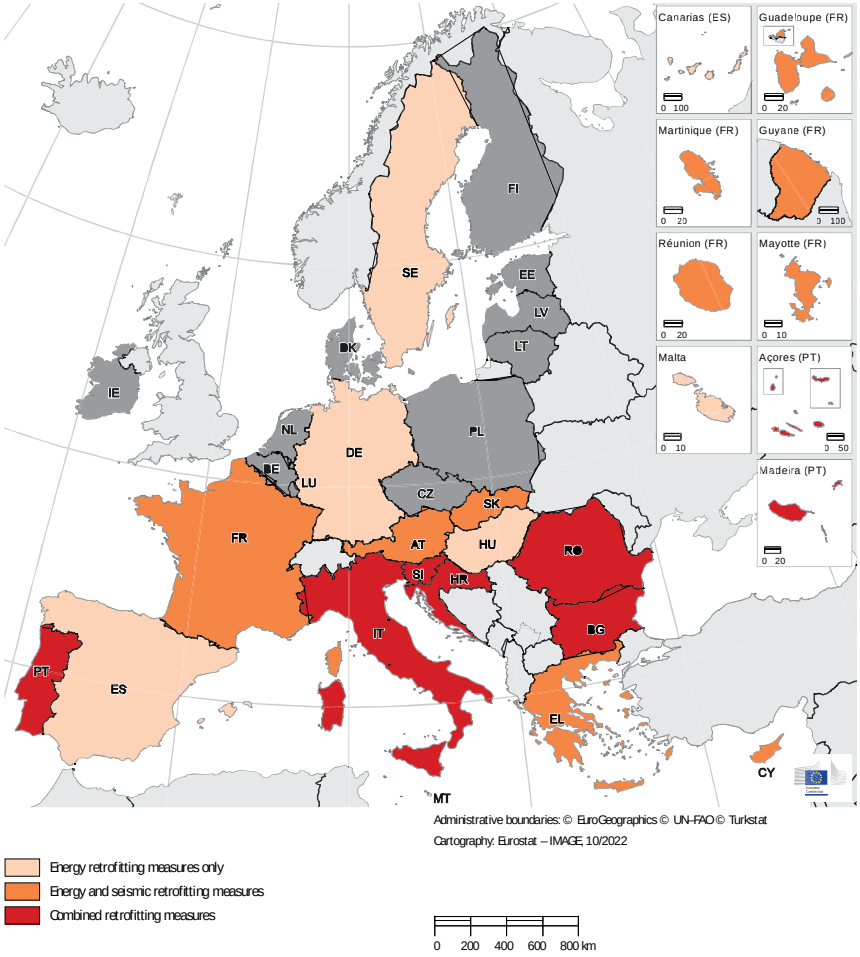
Figure 12. Distribution of collected implementing measures in 16 EU Member States (MS) by sector and class



Source: Gkatzogias et al. 2021

As a summary of the identified measures, **Figure 13** presents an overview of the measures implemented for building renovation in the 16 EU member states that included seismic risk in their 2015 national risk assessment. While measures for promoting energy upgrading are present in all of the 16 MS, specific measures for seismic strengthening (e.g. the implementation of Eurocode 8 Part 3, or specific programmes seismic retrofitting) are not found in all of these MS. Finally, in only five MS specific measures that target seismic and energy renovation at the same time were identified. Note however, that these are not necessarily measures that promote integrated retrofitting, but mainly measures that ensure energy retrofitting is only applied after structural safety is verified.

Figure 13. Overview of collected implementing measures for building renovation in the 16 EU Member States that included seismic risk in their 2015 national risk assessment.



Significant advances in **energy upgrading implementing measures** may not come as a surprise, given that all MS have to comply with and transpose EU directives for energy efficiency (EED) and performance (EPBD) into national legislation. Looking ahead, as set forth in the EPBD all EU MS have recently prepared their latest LTRS for improving the energy performance of their existing building stock, setting out clear objectives and milestones on their way to full decarbonisation by 2050. The success of this approach is reflected on each country by the increased number of national strategies and programmes implemented over the years, with increasingly higher targets in terms of energy efficiency and ambitious cuts in carbon emissions. Overall, many relevant strategies and programmes have been implemented over the years in all countries, and are currently available for enhancing the energy efficiency of existing buildings, fostering the implementation of energy performance certificates, building renovation passports and nearly zero-energy buildings. Additionally, different financial instruments (e.g. loans with low interest rates, reduced taxes, etc.) have been introduced to enable building owners to renovate.

In the case of **seismic strengthening** of buildings, the picture is less homogenous across the studied Member States. This is of course related to the differences in seismicity between the countries. For instance, it can be seen that there is a lack of direct legislation, guidelines and standards for the considered countries located in low seismic hazard regions. However, to date, even in countries with higher seismic risk, implementing measures for seismic retrofitting are generally less extended than in the case of energy upgrades. Reconstruction and inspection programmes, and updates in seismic codes are often triggered by significant earthquakes. In countries that are vulnerable to the seismic hazard, renovation activities, considering not only energy upgrading but also the seismic retrofit of buildings, are needed. This could be promoted by using regulatory frameworks and financial tools similar to those for energy renovation. For such instruments to succeed, information and awareness campaigns should be developed and put in place, addressing not only professionals in the building sector but also building owners and tenants. Such campaigns are needed to inform on the current effective risk, and thus to create a greater demand for deep renovations of buildings.

Combined seismic strengthening and energy upgrading measures are not addressed in most countries under consideration, although the two issues are covered independently by the same building code. The lack of measures to simultaneously address seismic strengthening and energy efficiency in Member States may be a cause of the combined effect of diverse seismic hazard, limited technical knowledge on the implementation of integrated renovation, and low awareness of the issue and the potential benefits. The issue of seismic safety is recognised in the national recovery and resilience plans of Croatia, Italy, France, Romania, and Slovenia, and the 2020 long-term renovation strategies of Croatia, Cyprus, Hungary, Italy, Romania, Slovenia, and Spain.

In Italy, since the 1980s several building codes and programmes were introduced to improve the seismic and energy performance of buildings. Nowadays, the most comprehensive measures for combined retrofitting can be found there. Financial incentives (tax deductions), such as the "Ecobonus" and "sismabonus" (Law 2016/232), were recently combined to the "Ecosisma bonus" (Law 2017/205) to further promote combined interventions by providing an increased amount of benefits. In Portugal, recently published legislation for the rehabilitation of existing buildings (Law 95/2019/PT, 2019) provides, among others, requirements for energy efficiency and seismic performance of the building, thus offering an opportunity to develop solutions complying with both requirements simultaneously.

In Bulgaria, while no specific legislation or standards for combined retrofitting exist, the majority of renovation programmes may include considerations for structural rehabilitation in their funding mechanisms. Implementing measures target mainly energy upgrading and address measures to improve the structural/seismic performance of the building implicitly, as long as these are technically justified (e.g. the Energy Efficiency of Multi-Family Residential Buildings National Programme). A similar situation can be seen in Romania, where the national programme for building renovation, introduced in 2009, was conceived mainly for energy renovation works, but was extended in 2015 to include requirements for a detailed seismic evaluation of buildings prior to carrying out energy upgrading works. Finally, in Slovenia, the "building cards" instrument will be introduced by 2024, which will provide guidance on recommended and required measures to promote gradually wider renovation, including energy, fire and seismic aspects.

As legislation, standards and guidelines for seismic strengthening are missing in many Member States, integrated renovation may not be easy to implement. However, as shown in recent studies on priority regions and impact of renovation scenarios (Gkatzogias et al., 2022a, b), in many regions of the EU it would appear reasonable to implement combined measures to enhance both the seismic safety level and the energy efficiency of buildings. Based on the observations made for the 16 MS considered in this report, the following general comments can be made with regard to implementing measures for (integrated) building renovation:

— Prioritisation of buildings for retrofit should consider several aspects, including use (public, private, multi-family, etc.), local seismic and climatic conditions, age, target energy efficiency and seismic performance level, technical and economic feasibility of the renovation, etc.

— Implementation of seismic standards and renovation programmes is often linked to the occurrence of seismic events and/or the establishment of new seismic hazard maps based on updated scientific models and earthquake catalogues. In a similar context, such valuable information should be integrated in risk mitigation studies (e.g. Gkatzogias et al., 2022a, b) to identify regions or countries of high priority for seismic and/or integrated renovation measures and complement already existing energy upgrading measures.

— Upgrading the energy performance of seismically deficient buildings deserves special attention. Coupling funding for energy efficiency interventions and structural/seismic retrofitting, particularly in seismic regions of moderate and high seismicity (e.g. Ecosisma-bonus in Italy) will ensure the structural integrity of the renovated building and safeguard the relevant investments. Even in regions with low seismic risk, integrating structural and energy renovations may still be beneficial to avoid investing energy funds on buildings that are not structurally sound due to ageing etc.

— The amount of provided funding for energy-related renovations should be a function of the improvement in the energy performance of buildings, confirmed by Energy Performance Certificates (e.g. Austria, Cyprus, Greece, Italy etc.). The latter may also serve as measures of the impact of energy renovation policies, as done in the LTRS of Sweden. Classifications similar to those of the Energy Performance Certificates can be adopted certify the seismic capacity of buildings, as in the case of Italy, considering simple classification criteria, a small number of risk classes, measurable targets and various levels of improvement.

— Tax incentives for renovation works appear to be particularly suitable measures, as also indicated by the Commission's assessment of the LTRS (SWD(2021) 365 final/2). These may include VAT reductions (e.g. Cyprus) or income tax deductions (e.g. Italy, Sweden). Investments in energy interventions from the banking

sector or financial institutions through green bonds (e.g. Sweden) or green loans (e.g. Malta) may also be used to gather further capital for renovation measures. Such financial tools may be extended to seismic upgrading in countries prone to earthquakes, coupled with seismic insurance.

— Measures targeting vulnerable and low-income households should be considered at a larger extent, addressing energy poverty and housing quality simultaneously. Notable examples include the Energy Incentives Advice Scheme for Vulnerable Households in Malta, but also the ZERO500 programme in Slovenia. Split-incentive barriers may be overcome through linking the ability to rent properties to minimum energy or seismic performance requirements. For instance in France, dwellings exceeding certain limits in final energy consumption, may no longer be rented. Measures specifically targeting multi-owner buildings were identified in Italy and Slovakia, amongst others.

— Member States may benefit from transnational cooperation, e.g. between neighbouring countries that face similar challenges in the implementation of energy policies and the real estate market. A transnational approach may lead to faster and more effective solutions. For instance, similar approaches may be sought for developing renovation measures among Greece and Cyprus, or Austria and Germany.

— Measures for integrated renovation of buildings should benefit from the digital transition in the building sector, for instance, by including in technical building passports harmonised information on the energy and seismic performance, before and after renovation. Smart sensors monitoring the energy consumption and structural health of buildings, may provide useful real-time information to interested actors, and activate systems for seismic protection in case of earthquakes.

— Together with implementing measures, training and certification of professionals, along with further scientific development will be required to ensure adequate know-how in integrated renovation methods. Web-based applications can further support professional development, awareness and wider uptake of solutions for integrated renovation. Expert trainings at the regional level in all the countries may be instrumental in the creation of new job opportunities, as illustrated for instance by programmes in Germany.

— Finally, social awareness campaigns at the national and European level are required to attract more building owners, tenants and others for the combined upgrading strategies. The benefits, both financial and structural and the importance of the energy efficient and seismic resistant buildings needs to be communicated through proper channels.

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List of abbreviations and definitions

ADEME	Agence de la transition écologique (France)
AKNZ	Academy for Crisis Management, Emergency Planning and Civil Protection
APN	Agency for Legal Transactions and Real Estate Brokerage
BAFA	Federal Office for Economic Affairs and Export Control
BBK	Federal Office of Civil Protection and Disaster Assistance
BMI	Austrian Ministry of Internal affairs
BMWi	The German Ministry for Economic Affairs and Energy
BNB	Construction Rating System
BOV	Bank of Valletta
CDD	Cooling Degree Days
CITE	Le crédit d'impôt pour la transition énergétique (France)
COM	Communication
CPM	European Civil Protection Mechanism
DGEG	Direção Geral de Energia e Geologia (Portugal)
DHW	Domestic Hot Water
DIPAD	Common Ministerial Decision (Greece)
DRR	Disaster risk reduction
eaD	Bundesverband der Energie- und Klimaschutzagenturen Deutschlands
EAK	Greek Seismic Code, Greece
EAL	Expected Annual Loss
EC	European Commission
EE	Energy Efficiency
EEA	Energy Efficiency Act
EED	Energy Efficiency Directive
EEWärmeG	Renewable Energies Heat Act (Germany)
EIB	European Investment Bank
ELENA	European Local ENergy Assistance
EnEV	German: Energieeinsparverordnung
EPC	Energy performance certificates
EPCo	Energy Performance Contracting
EPEEF	Environmental Protection and Energy Efficiency Fund (Croatia)
EPPO	Earthquake Design and Protection Organization (Greece)
ERDF	European Regional Development Fund
ERESEE	Long-term strategy for energy renovation in the building sector (Spain)
ESG	Energy efficiency strategy for buildings
ESCO	Energy Service Company
ESF	European Social Fund
ESHM	European Seismic Hazard Model

ETEK	Cyprus Scientific and Technical Chamber
EU	European Union
EUR	Euro
GDP	Gross Domestic Product
GHG	Greenhouse Gas Emissions
H2020	Horizon 2020
HAMAG	Croatian Agency for Small Business and Investments Invest guarantee programme.
HAPPEN	Holistic Approach and Platform for the deep renovation of the residential Environment (project)
HBOR	Croatian Bank for Reconstruction and Development
HDD	Heating Degree Days
HPE	High performance energy
HVAC	Heating, Ventilation, And air Conditioning
IBRD	Intrenational Bank for Research and Development
IEE	Intelligent Energy Europe programme (Greece)
IFRRU	Financial Instrument for Urban Rehabilitation and Revitalization (Portugal)
IHRU	Institute for housing and urban renovation (Portugal)
INE	Instituto Nacional de Estatística - National Institute of Statistics (Portugal)
JRC	Joint Research Centre
KAN.ΕΠΕ	Code of Structural Interventions (Greece)
KENAK	Building Energy Performance Regulation (Greece)
KEHOP	Environmental and energy efficiency operative programme
KfW	Support programme for energy-efficient building renovation
KIDSF	Kozloduy International Decommissioning Support Fund
LCCA	Life Cycle Cost Analysis
LPB	Large Panel Buildings
LTECV	Loi de la Transition Énergétique pour la Croissance Verte (France)
LTRS	Long-term renovation strategy
MECIT	Ministry of Energy, Commerce and Industry (Cyprus)
MED	Mediteranean
MEDDE	Ministère de l'Écologie, du Développement durable et de l'Énergie
MEEM	Ministère de l'environnement, de l'énergie et de la mer (France)
METAD	Ministerio de Energia, Turismo y Agenda Digital (Spain)
MS	Member State
MTERD	Ministerio para la Transición Ecológica y el Reto Demográfico (Spain)
MTES	Ministry of Ecological Transition (France)
NAPE	National Action Plan on Energy Efficiency
NCSE	National Center for Seismic Engineering (Bulgaria)
NEEAP	National Energy Efficiency Action Plan
NECP	National Energy and Climate Plan

NewBEE	Novel Business Model Generator for Energy Efficiency in Construction and Retrofitting project
NGO	Non-governmental organisation
NN	Narodne Novine (Official Gazette of Republic of Croatia)
NZEB	Nearly zero-energy building
OG	Official Gazette
OP	Operational Programme
OPRG	Operational Programme "Regions in Growth"
PADF	Partnership Agreement for the Development Framework (Greece)
PE	Primary Energy
PGA	Peak Ground Acceleration
PNAEE	National Action Plan for Energy Efficiency (Portugal and Spain)
PNEC	National energy and climate plan - Plano Nacional de Energia e Clima (Portugal)
PNIEC	National energy and climate plan - Plan Nacional Integrado de Energía y Clima (Spain)
PPP	Public-Private Partnership
PREH	National Plan for Housing Thermal Renovation (France)
PSHA	Probabilistic Seismic Hazard Assessment
PrioritEE	Prioritise Energy Efficiency (EE) Measures In Public Buildings (project)
PURES	Rules on the efficient use of energy in buildings (Slovenia)
PV	Photo Voltaic
RC	Reinforced Concrete
RES	Renewable Energy Sources
RNC2050	Roadmap for carbon neutrality - Roteiro para a Neutralidade Carbónica (Portugal)
RO-RISK	National Disaster Risk Assessment , 2014-2016, Romania
RpA-HA	Rehabilitate for Rent – Affordable Housing (Portugal)
SE RDA	South-East Regional Development Agency in Romania
SHDF	Loan from the State Housing Development Fund
SME	Small And Medium Enterprize
SWD	Staff Working Document
TEE	Technical Chamber of Greece
TFA	Total Floor Area
THW	Federal Agency for Technical Relief
TOTEE	Technical Instructions/Guides of the Technical Chamber of Greece
TPB	Technical passports of buildings (Bulgaria)
UACEG	University of Architecture, Civil Engineering and Geodesy
VAT	Value Added Tax
WB	World Bank
YPEN	Ministry of Environment and Energy of Greece
ZRMK	Building and Civil Engineering Institut (Slovenia)
ZS	Seismic Zone

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