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Sustainable housing and real estate markets

Mapping of Existing Energy Efficiency Standards in Buildings in the UNECE Region (draft for the consideration of the Committee)

Note by the Secretariat

Summary

At its seventy-sixth session in 2015, the Committee endorsed the establishment of the ECE Joint Task Force on Energy Efficiency Standards in Buildings (ECE/HBP/184, paras. 38 and 39 ECE/HBP/2015/2).

In 2017 two projects were launched with the financial support received of the Governments of Denmark and the Russian Federation to carry out the activities of the Joint Task Force.

The first output of the Group is the study on “Mapping of existing energy efficiency standards in buildings in the UNECE region”. The study was carried out from October 2017 to July 2018 and was discussed and validated during the First and Second Meeting of the Joint Task Force (Geneva, Switzerland 30-31 October 2017 and Yerevan, Armenia, 14-15 May 2018.

The Committee is invited to take note of this study and provide feedback if needed.

UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE
Joint Task Force on Energy Efficiency Standards in Buildings

Mapping of Existing Energy Efficiency Standards and Technologies in Buildings in the UNECE Region

GENEVA, 2018

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- The UNECE Joint Task Force on Energy Efficiency Standards in Buildings and its Co-Chair Burkhard Schulze-Darup;
- The Bureau of the Committee on Housing and Land Management and its Real Estate Markets Advisory Group (REM);
- The UNECE Group of Experts on Energy Efficiency, its Bureau, and its Chair Aleksandar Dukovski;
- Respondents to the survey on Mapping of existing energy efficiency standards and technologies in buildings in the UNECE region;
- Participants of the First Meeting of the Joint Task Force on Energy Efficiency Standards in Buildings (Geneva, 30-31 October 2017) and the Workshop on Validation of Results of Mapping of Energy Efficiency Standards in Buildings in the UNECE Region - Second Meeting of the Joint Task Force on Energy Efficiency Standards in Buildings (Yerevan, 14-15 May 2018);
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[1] Relevant information on the project available at http://www.unece.org/housing/eestandardsinbuildings.html

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Acronyms and Abbreviations

CE Marking	Conformité Européene or European Conformity Marking
CHLM	Committee on Housing and Land Management
EPBD	Energy Performance of Buildings Directive
EPC	Energy Performance Certification
EU	European Union
GEEE	Group of Experts on Energy Efficiency
HVAC	Heating, ventilation, and air conditioning
IEA	International Energy Agency
IPMVP	International Performance Measurement & Verification Protocol
ISO	International Organization for Standardization
NGOs	Non-governmental organizations
SDGs	Sustainable Development Goals
SEforALL	Sustainable Energy for All
UNECE	United Nations Economic Commission for Europe

Signs and Measures

kWh	kilowatt hour
m^2	square metre
Pa	Pascal
µm	micron
W/mK	watts per metre Kelvin
W/m^2K	watts per square metre Kelvin
$kWh/m^2/yr$	kilowatt hour per square metre per year
W/liter/sec	watt per liter per second
lm/W	lumen per watt
g^{tot}	solar factor for the combination of glazing and solar protection device (EN 13363-1+A1)

EXECUTIVE SUMMARY

The use of energy in buildings represents a large share of the total end use of energy. In the United Nations Economic Commission for Europe (UNECE) region, buildings are responsible for approximately one third of total energy consumption and account for almost 40 percent of CO_2 emissions from combustion. Existing building energy standards in the UNECE region vary from voluntary guidelines to mandatory requirements, which may apply to one or many building types. Their development is typically a complex decision-making process that can involve several stakeholders. Building energy standards are difficult to classify and the standards that are stringent for one country may be ineffective in another country, depending on climate conditions, occupant behavior, existing building stock, and construction practices.

In response to these challenges and for a better understanding of the status of deployment and implementation of energy efficiency standards in buildings in the UNECE region, the Committee on Housing and Land Management (CHLM) and the Committee on Sustainable Energy developed a study on "Mapping of existing energy efficiency standards and technologies in buildings in the UNECE region". The objectives of this study are to identify which energy efficiency standards in buildings the UNECE member States are using and also to evaluate the most effective policies and highlight the best practices to help countries learn from each other and achieve greater savings. This report presents the results of this study and looks at building energy standards in the UNECE

Furthermore, this report provides a snapshot of the legal status and coverage of building energy standards inthe UNECE region, and lays out the status of building energy standards stringency, technical requirements, enforcement and compliance, use of energy efficient building materials and products in selected countries of the UNECE region. Finally, it highlights some national best practices for each of the above elements. With the exception of a few countries, all countries have now embedded regulations for newly constructed, renovated residential and non-residential buildings.

The study benefitted from four different but inter-related steps which included:

- Data collection on the status of energy efficiency standards and technology in buildings in the UNECE region using a survey, complemented by desktop research and stakeholder consultations;
- Analysis of the survey results;
- Gap analysis of the building energy codes effectiveness; and
- Initial assessment of energy efficiency technologies in buildings in relation to the existing standards.

Analysis of the survey results

The analysis of the survey results was carried out for the UNECE region with references to different sub-regions:

A. European Union (EU) Member States prior to 2004 (EU15),[2] Norway, and Switzerland;
B. EU enlargement - the 13 countries that joined the EU after 2004 (EU13);[3]
C. Eastern Europe, the Caucasus, Central Asia, and the Russian Federation;[4]
D. North America;[5] and
E. South-Eastern Europe.[6]

The following countries were excluded from this study due to the lack of information available: Cyprus, Malta, Iceland, Liechtenstein, Andorra, Monaco, San Marino, Israel and Turkey.

Gap analysis of the building energy codes effectiveness

[2] It alphabetically includes Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden and the United Kingdom.
[3] It alphabetically includes Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia.
[4] It alphabetically includes Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Republic of Moldova, the Russian Federation, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan.
[5] Canada and the United States.
[6] It alphabetically includes Albania, Bosnia and Herzegovina, Montenegro, Serbia, and the former Yugoslav Republic of Macedonia.

In 2018, UNECE submitted a survey to the representatives of the Committee on Housing and Land Management and its Real Estate Market Advisory Group; the Committee on Sustainable Energy and its Group of Experts on Energy Efficiency; and the members of the Joint Task Force on Energy Efficiency Standards in Buildings. Data collected from the survey responses was complemented by the results of the online research of already published documents. The data was analyzed and presented in a tabular form for selected countries from all sub-regions across individual metrics to provide a comparative gap analysis of energy efficiency standards in buildings in the UNECE region. This analysis also included case studies and highlighted best practices in countries from the above-mentioned sub-regions and identified gaps among the countries of the region concerning the implementation, enforcement and use of energy efficiency standards in buildings.

The analysis of the coverage and stringency of building energy codes across the UNECE member States indicated that some countries still apply building energy codes only to specific types of buildings, such as single- or multifamily buildings in the residential sector. For example, Azerbaijan and Kazakhstan do not currently have provisions to cover single family buildings types. Building energy codes in Georgia cover only new residential buildings while in the Republic of Moldova they only cover existing residential and commercial buildings.

It has been observed that, while many member States have now technical requirements in place in their building energy codes, there is still a small number of countries that are yet to implement requirements on heating, cooling, lighting and ventilation.

The results of the gap analysis also pointed to a large disparity between the Energy Performance Certificates (EPC) implementation across UNECE member States, with sub-region C lagging behind on the use, stringency and coverage, as well as the quality and monitoring of the EPC. Furthermore, a number of responses and some studies[7] have indicated that the quality of the EPC is not satisfactory in some countries. There are also some inconsistencies across UNECE member States on the choice and design of the assessment methodology which hinders the EPC implementation process. The successful implementation of the EPC is also constrained by a lack of enforcement, training and monitoring mechanisms. In the former Yugoslav Republic of Macedonia, Kazakhstan, Georgia, Albania and Belarus the EPC is not currently used.

The results of this survey have also evidenced/pointed to a lack of knowledge, inconsistencies in statistics and a lack of appropriate studies on energy performance gap. This leads to one or more of the following conclusions the calculation methods are flawed, the enforcement regime is not being undertaken sufficiently rigorously or designers and builders are failing to satisfactorily deliver the outcome intended. Closing the energy performance gap between design intent and regulatory requirement is likely to become an important issue over the next decade if countries fail to meet the climate and environmental targets related to buildings. In Switzerland, for example, this is currently being researched, with initial findings suggesting a 30-300 percent performance gap measured compared to predicted energy performance in residential buildings. Other countries, e.g. Albania stated 30-40 percent energy performance gap, while the former Yugoslav Republic of Macedonia stated that energy performance gap was not currently recorded and only predicted/calculated energy performance was being used.

The gap analysis also suggests that the compliance with and enforcement of building energy codes are being undertaken with less rigor and attention to detail in some countries. Specific incentives and enforcement mechanisms are currently not widely used in building energy codes in countries in sub-region C. At present, Azerbaijan, Albania, Belarus, Croatia, Kazakhstan, Republic of Moldova Montenegro, Russian Federation, Serbia, Turkmenistan and Ukraine do not have provisions for incentives for improving compliance in their building energy codes.

Although most of the countries have now inspection schemes for boilers and/or air conditioning systems, data collection on the number of inspections done by each member State is still scarce and, in several cases,

[7] More information is available at: http://bpie.eu/wp-content/uploads/2015/10/Energy-Performance-Certificates-EPC-across-the-EU.-A-mapping-of-national-approaches-2014.pdf and Alexander Gusev (2013) Comparison of Energy Efficiency Measures in Russia to Those Implemented by Developed Countries (Including IEA Measures), German Institute for International and Security Affairs (SWP), available at: http://www.europarl.europa.eu/meetdocs/2009_2014/documents/d-ru/dv/dru_20131017_11_/dru_20131017_11_en.pdf.

unreliable. Insufficient data makes it difficult to formulate an appropriate evaluation on the effectiveness of these schemes. A number of countries, e.g. Finland, France, Ireland, the Netherlands, Slovenia, Sweden, and the United Kingdom do not include in their building energy codes requirements for inspection of boilers in place.

Some member States still show a low level of implementation of requirements for the use of energy efficient materials and products, with some countries being more stringent than others when it comes to materials certification and testing. A number of countries from sub-regions C and E, e.g. Albania, Georgia, Republic of Moldova, Turkmenistan, Ukraine, and the former Yugoslav Republic of Macedonia, showed a relatively low level of implementation for this metric, while other countries, e.g. Bosnia and Herzegovina, Kazakhstan, Montenegro, Russian Federation, Serbia, and Uzbekistan, include requirements for the use of certified energy efficiency materials and products in their building energy codes.

Initial assessment of energy efficiency technologies in buildings in relation to the existing standards

The study has provided a preliminary analysis of the selection of the energy efficiency technologies deployment in countries of the UNECE region. The preparation of this initial assessment was based on the data collected using the survey responses[8] (see **Annex I**) and the desktop study on the recent trends in deployment of the energy efficiency technologies as well as the information contained in previous UNECE documents.[9] This preliminary analysis of the energy efficiency technologies deployment and trends covers the main building envelope components, photovoltaic systems, and selected space and water heating and cooling equipment.

The study has demonstrated that a number of countries have achieved significant progress in the deployment of energy efficiency technologies, resulting from a holistic and consistent policy approach to developing and implementing building energy codes with the support of effective financial and enforcement mechanisms. A significant improvement has been noted in increasing energy efficiency of heating and cooling equipment in many countries. However, market maturity for high-priority building envelope components varies significantly between the countries of the UNECE region.

Many countries, particularly countries of sub-region C, still have difficulties in increasing the deployment of energy efficiency technologies on the market. This may stem from the wrong signals sent by incoherent polices vis-à-vis financial incentives, lack of consumers awareness on the benefits of such technologies, insufficiently developed building energy codes, lack of technical expertise, all of which have negative impacts on the energy efficiency technology cost reduction, ease of installation and market conditioning.

Recommendations

Based on the findings of this study, UNECE member States should:

<u>Recommendation 1:</u> Continue the process of harmonization[10] of building energy codes by ensuring comprehensive coverage of all types of buildings[11] in their regulations.

<u>Recommendation 2:</u> Lay down measures to include in the national building energy codes a national energy efficiency target, based either on primary or final energy consumption, or on primary or final energy savings, or on energy intensity.

<u>Recommendation 3:</u> Continue the process of harmonization through further strengthening the requirements for insulation, ventilation and technical installations, in particular they should:

[8] The questionnaire was available on the UNECE website for the period from 26 January to 12 February 2018 in English and Russian, with deadline further being extended to 28 February 2018.

[9] United Nations Economic Commission for Europe (UNECE) (2013) Good Practice for Energy Efficient Housing in the UNECE region, Geneva. Available at: https://www.unece.org/fileadmin/DAM/hlm/documents/Publications/good.practices.ee.housing.pdf

[10] With the term "harmonization" it is meant that member States should adopt strategic principles based on recognized best international practices which are applicable to their national energy building codes facilitating their advancement in the field of energy efficiency in buildings, taking into consideration the particularities of each country, without attempting to apply one fit for all uniform approach.

[11] Includes new and existing residential and non-residential buildings, single family, apartments, commercial and public buildings.

- *Pay more attention to air-tightness of the envelope;*
- *Ensure inclusion of the requirements for air conditioning, lighting, active solar, renewables and natural lighting in the national building codes;*
- *Make mandatory the requirement for the inspection of boilers and air-conditioning systems to improve the quality and precision of EPC in multi-apartment buildings; and*
- *Follow a holistic approach in building energy codes based on overall building performance, including requirements for technical systems such as HVAC and lighting.*

Recommendation 4: Consider introducing or strengthening quality assurance measures, especially during the early stage of the certification process, in particular:

- *Make sure the requirements for the certifying experts are harmonised across member States;*
- *Make sure the certifier is physically present onsite;*
- *Make sure the procedure of the quality check of the EPC is harmonized among the UNECE countries;*
- *Harmonize the EPC through the integration of ventilation, cooling and lighting into the certificate; and*
- *Develop guidance for the centralisation of EPCs databases and digitalisation of the EPC process.*

Recommendation 5: Consider challenges of the energy performance gap in existing buildings and data collection on actual energy use as a priority area for research in the respective country.

Recommendation 6: Establish or strengthen proper (electronic) monitoring systems of compliance, enforcement and quality control processes through qualified experts to ensure compliance with international building energy codes and standards.

Recommendation 7: Establish a regular inspection of boilers and air-conditioning systems in building energy regulations.

Recommendation 8: Continuously monitor, analyze and adjust energy usage in building energy codes.

Recommendation 9: Consider creating incentives for improving energy efficiency through appropriate policies, tax incentives and low-interest loans for energy efficiency projects, particularly for countries with economies in transition.

Recommendation 10: Facilitate the process of harmonization of energy efficient materials and products testing and certification using best practices employed by other countries of the UNECE region. When developing and harmonizing building energy codes in lower-middle income economies of the UNECE region, attention should be paid to the types of construction that these countries can afford. This will ensure that building energy codes effectively promote manufacture of local traditional materials, research and development for improving local traditional techniques, materials testing, and quality control, and do not create dependency on imported building materials that may stifle local innovation.

Recommendation 11: Ensure that the materials and products used in construction are subject to rigorous quality control processes to meet the requirements for energy efficiency while maintaining robust combustion performance, fire and seismic resistance, ensuring they do not cause threat to the safety of people and property.

Recommendation 12: Consider funding collaborative international research to assist in the establishment of new harmonized building materials test mechanisms and to ensure that independent organizations beyond the manufacturing community can play a key role in developing market-neutral procedures.

Recommendation 13:

a) *Consider the opportunity to improve transparency in information access and exchange by making full-featured versions of their building energy codes accessible and available free of charge with the applicable calculation methods on the relevant websites, particularly countries with economies in transition;*

b) *Provide methodological or other assistance to countries that need it, especially those countries who have already developed their building energy codes in detail and are at the stage of their practical implementation with real positive effects; and*

c) *Consider developing common approaches to building energy codes reflecting specifics relevant to energy exporting countries and specifics relevant to the countries importing energy and fuel for primary energy generation, particularly countries with economies in transition.*

Recommendation 14: Develop policies based on well-founded identification of the energy efficiency technology options that can best assist national energy aims and carry out an in-depth review of economic and non-economic barriers to progress as a baseline for future policies.

Recommendation 15: Develop policies to increase awareness and understanding within the national and local governments, property developers, local funders, and the international financial community on the feasibility of significant investments in energy efficiency technologies, particularly countries with economies in transition.

Recommendation 16: Develop policies to educate government officials in ministry offices and targeted municipal offices on the business environment necessary to attract investments in energy efficiency in buildings and how to translate private sector requirements into effective policy measures and/or government initiatives, particularly in countries with economies in transition.

Recommendation 17: Develop policies to facilitate the deployment of energy efficiency technologies in the market place by improving coherence of the energy efficiency technologies programs and other government policies to meet public policy goals.

Opportunities for further studies:

a. *Carrying out further studies on mapping of national approaches to EPC deployment based on more detailed metrics and criteria to provide a more in-depth analysis of the stringency of the EPC across the UNECE region, particularly in countries with economies in transition. The future study should focus on the quality, availability and usability of EPC data and provide examples for best practice approaches;*

b. *Carrying out further studies on mapping of national requirements for U-values for wall, roof and floor in new and existing buildings in building energy codes to ensure they are not below the economic optimum and recommend U-values for maximum cost effectiveness, particularly in countries with economies in transition; and*

c. *Carrying out further studies on the stringency of building energy standards in the UNECE region based on climate conditions, occupant behavior, existing building stock, and construction practices, taking into consideration the turnover of old buildings and rate of new constructions in each member State.*

INTRODUCTION

In the UNECE region, buildings are responsible for approximately one third of total energy consumption and account for almost 40 percent of CO_2 emissions from combustion. Achieving energy efficiency remains a challenge for countries in the UNECE region. At the same time, there are solutions: existing technology can reduce a building's energy consumption by 30 to 50 percent without greatly increasing investment costs[12]. Moreover, improving the energy performance of a residential building goes hand-in-hand with an increase in living comfort and a reduction of energy bills. It also contributes to reducing fuel poverty and mitigating greenhouse-gas emissions, while also creating employment[13].

Standards are documents based on voluntary compliance, established by consensus, and approved by a recognized body.[14] They provide, for common and repeated use, rules, guidelines or characteristics for activities or their results. Standards are aimed at the achievement of the optimum degree of order in a given context, and should be based on the consolidated results of science, technology and experience, and aim to promote community benefits.[15] Standards are an effective instrument for addressing energy efficiency in buildings and to support the achievement of the targets set by several international initiatives such as energy-related Sustainable Development Goals (SDGs), the Sustainable Energy for All (SEforALL), the Paris Agreement, the Geneva UN Charter on Sustainable Housing and the Framework Guidelines on Energy efficiency Standards in Buildings. However, effective enforcement of building energy standards which can be ensured through compliance checks, incentives and other supporting instruments, is critical and remains an issue in a number of countries.

Building energy codes,[16] also known in some countries as "energy standards for buildings", "thermal building regulations", "energy conservation building codes" or "energy efficiency building codes" are the key policy instrument used by governments to limit buildings' pressure on the energy sector and environment while providing occupants with comfort and modern living conditions.[17] In general, building energy codes are more effective when include mandatory requirements designed to reduce the energy consumption of buildings. Building energy codes are used as mandatory tools to stipulate desired energy efficiency characteristics for building. Countries may use different approaches in the design of their building energy codes. A prescriptive approach sets minimum energy performance requirements for each component of the building – windows, walls, and heating and cooling equipment. A performance approach requires an integrated design based on a holistic assessment of the building's energy performance. Building energy codes can be mandatory or voluntary and are often complemented by other energy efficiency building incentives.

Building technologies and design elements that can be included in a building energy code are: the building envelop; heating, ventilation, and air conditioning (HVAC) systems; lighting; and service water heating systems.[18]

In this study, the word "standard" is referred interchangeably to what also might be called codes, criteria, guidelines, norms, laws, protocols, provisions, recommendations, requirements, regulations, rules, or standards. Depending on the country, the "standard" may be contained in one document, be part of another larger document (such as a general building code) or comprise several documents.

Existing building energy standards in the UNECE region vary from voluntary guidelines to mandatory requirements, which may apply to one or many building types. Their development is typically a complex

[12] Metz, B., Davidson, O.R., Bosch, P.R., Dave, R. and L.A. Meyer (eds.) (2007): Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, United Kingdom and New York, NY, United States, Available at: http://www.ipcc.ch/publications_and_data/ar4/wg3/en/ch6.html.
[13] UNECE (2013) Good Practice for Energy Efficient Housing in the UNECE region, Geneva, available at: https://www.unece.org/fileadmin/DAM/hlm/documents/Publications/good.practices.ee.housing.pdf.
[14] ISO website: www.iso.org/sites/ConsumersStandards/1_standards.html#section1_
[15] Ibid.
[16] The terms "building energy codes" or "energy standards" for new buildings generally refer to energy efficiency requirements for new buildings whether they are set in building codes, specific standards or other ways, unless otherwise stated.
[17] IEA (2013) Modernising Building Energy Codes. Available at: https://www.iea.org/publications/freepublications/publication/PolicyPathwaysModernisingBuildingEnergyCodes.pdf.
[18] Cox, Sadie (2016) Building Energy Codes Policy Overview and Good Practices, Clean Energy Solutions Centre, available at: https://www.nrel.gov/docs/fy16osti/65542.pdf.

decision-making process that can involve any combination of participants from a range of institutions, including government, academia, utilities, industry groups, and professional associations.[19] Although standards can be a flexible and low-cost approach to energy conservation, they are complicated to develop and difficult to assess. There is some evidence indicating a lack of information and knowledge with regards to building energy standards in some countries which makes it difficult to harmonize data and standards across the UNECE region.

To strengthen understanding about the status of deployment and implementation of energy efficiency standards in buildings in the UNECE region, the Committee on Housing and Land Management and the Committee on Sustainable Energy made a decision to develop a study on "Mapping of existing energy efficiency standards and technologies in buildings in the UNECE region" with the objective to identify which energy efficiency standards in buildings the UNECE member States are using.

Rationale for the study

Countries of the UNECE region differ greatly in the area of building energy standards. They remain a key vehicle for advancing energy efficiency but are difficult to translate directly from state-to-state as they are inherently customized to local environmental and market conditions. Therefore, it is important that building energy standards are regularly reviewed and updated. Understanding building energy standards however requires specific technical expertise which makes monitoring and evaluating the progress of what is happening particularly difficult from the policy makers point of view.

Energy standards are difficult to classify because no established nomenclature clearly identifies policies that might be considered "energy standards." A single country may have several standards published by different entities, and they may be self-contained or subsumed within another document (such as a general building code)[20]. Building energy standards that are stringent for one country may be ineffective in another country, depending on climate conditions, occupant behavior, existing building stock, and construction practices. To make reasonable judgments about the impact of existing standards in different countries, all of these variables plus the turnover of old buildings and rate of new construction would need to be gathered, normalized and compared. Such an analysis would be valuable, but it is beyond the scope of most studies, including this study.

However, a directory with information compiled from different countries would enable exchanges between countries with effective existing standards and countries seeking to update their standards or develop new ones. A common descriptive context to researchers, builders, and policy makers across the UNECE region and beyond could address the need for detailed information and become a descriptive source for building energy standards information.

Aims of this study

In March 2015, the UNECE Committee on Housing and Land Management and the Committee on Sustainable Energy conducted a survey on building standards and regulations in the region, whose outcomes[21] indicated that one of the main activities that UNECE could support its member States with was to establish a Joint Task Force, coordinated by the secretariats of the two Committees, to guide the UNECE work on energy efficiency standards in buildings. When the Joint Task Force on Energy Standards in Buildings was established in 2016, it suggested undertaking a study on "Mapping of existing energy efficiency standards and technologies in buildings in the UNECE region" as one of the initial activities that the countries could benefit from.

This study has the objective to identify which energy efficiency standards in buildings UNECE member States are using.

[19] Kathryn B. Janda and John F. Busch (1994) Worldwide Status of Energy Standards for Buildings, Energy Vol. IV, No. I, pp. 27-44. 1YY4, available at: http://www.eci.ox.ac.uk/research/energy/downloads/janda04-wsesb.pdf.
[20] Ibid.
[21] Available at http://www.unece.org/housing-and-land-management/housingpublications/housing-and-land-management-hlm/2015/outcomes-of-the-survey-on-building-standards-and-building-regulations-in-the-unece-region/doc.html.

This study does not seek to identify one best practice amongst the building energy codes and standards. Instead, it aims to improve the knowledge of UNECE member States of existing energy efficiency standards in buildings, to collect best practices related to existing standards, and to provide a gap analysis and harmonization of data and standards with the final goal to develop and implement more effective energy efficiency policies in buildings in the UNECE region. This study also provides findings of an initial assessment of energy efficiency technologies in buildings in relation to the existing standards.

Structure of the report

The report consists of four chapters:

Chapter 1 describes the results and analysis of the survey questionnaire responses.

Chapter 2 provides a detailed gap analysis of the status of energy efficiency standards in buildings in the UNECE region for selected countries, identifies gaps and opportunities for improvement as well as includes references to the best practices in countries from different sub-regions.

Chapter 3 presents the results of the preliminary analysis on the recent trends in the energy efficiency technologies deployment in the countries of the UNECE region. This chapter provides information on the recent trends in the energy efficiency (EE) technologies deployment in countries of the UNECE region, with main focus on the status of the building envelope elements, photovoltaic systems, space and water heating and cooling equipment.

Chapter 4 outlines conclusions and recommendations following the results of the gap analysis of the status of energy efficiency standards and technologies in buildings in countries of the UNECE region.

Study methodology and approach

UNECE developed a questionnaire to gather a detailed information about the activities undertaken by its member States to develop and implement energy efficiency standards in buildings. The full version of the questionnaire can be found in **Annex I.**

The first draft of the questionnaire was presented at the First Meeting of the Joint Task Force on Energy Efficiency Standards in Buildings on 30-31 October 2017 in Geneva, where comments from the member of the Joint Task Force where collected and taken into account to finalize the final set of questions to be disseminated to the focal points of 56 member States of the UNECE. The questionnaire was available online from 26 January to 12 February 2018 in English and Russian, with deadline further being extended to 28 February 2018. In total, more than 300 stakeholders were sent the questionnaire by the secretariats of the Committee on Housing and Land Management and the Committee on Sustainable Energy, including the members of the UNECE Group of Experts on Energy Efficiency (GEEE) and of the Real Estate Market Advisory Group and the members of the Joint Task Force on Energy Efficiency in Buildings, national and international experts, and representatives of intergovernmental and non-governmental organizations, the private sector and academia.

The study was carried out in four different but inter-related steps. Below is a summary of the major methodological steps:

- **Data collection on the status of energy efficiency in buildings in the UNECE region**

  a. Questionnaire survey

A questionnaire was developed in consultation with the members of the Joint Task Force on Energy Efficiency Standards in Buildings. The questionnaire included 40 questions and was divided into six parts:

1. General information;
2. Building energy codes:
   - Performance-based requirements in building energy codes;

- Energy performance gap; and
- Prescriptive technical requirements in building energy codes.

3. Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building;
4. Building Materials and Products;
5. Requirements for Enforcement and Compliance:
   - Penalties, incentives and other mechanisms for improving compliance; and
   - Monitoring of energy performance in building energy codes.
6. Energy Efficiency Technologies

The full version of the questionnaire can be found in **Annex I.** Most questions were multiple choice questions with a box ticked for each attribute in place. Questions that required direct text entry were limited to numbers, names, and brief descriptions of a policy program or energy efficiency technology trends.

b. Desktop Study

A desktop study also has been carried out to complement the results of the survey and to gain a better understanding of the status of energy use and applications of energy efficient technologies and practices. Relevant policy documents, schemes and legislation, as well as technological developments and their implementation modalities in the focus countries, were examined and best practices identified.

c. Stakeholder Discussions

The consultation workshops were held on 30-31 October 2017 in Geneva and on 14-15 May 2018 in Yerevan with the participation of various stakeholders. At the Geneva workshop, the preliminary approach and methodology for this study were discussed. At the Yerevan workshop, the findings of the draft study were presented and reviewed, data gaps were identified, and preliminary results were validated by the workshop participants.

d. Countries Profiles

Countries profiles were prepared for individual countries where the level of information gathered through the desktop study and the survey responses was sufficient to prepare a country summary profile. Coverage of the topics depended upon the extent to which respondents in individual countries filled out the surveys.

The profiles contain a number of metrics for energy efficiency in buildings and detailed information for each country. These can be found in **Annex III**[22] of this report. The metrics included in the profiles are:

- Main regulatory documents;
- Building Energy Codes stringency and coverage;
- Performance-based requirements in Building Energy Codes;
- Prescriptive requirements in Building Energy Codes;
- Energy Performance Certificates;
- Requirements for enforcement and compliance; and
- Requirements for building materials and products.

- **Analysis of the survey results**

The analysis of the survey results was carried out for the UNECE region with some references to different sub-regions.

- **Gap analysis of the Building Energy Codes effectiveness**

Data collected from the survey responses was complemented by the results of the online research of already published documents. It was analyzed and presented in a tabular form for selected countries from all sub-regions across individual metrics to provide a comparative gap analysis of energy efficiency standards in buildings in the UNECE region. This analysis also included examples of the case studies and highlighted some the best practices in countries from different sub-regions. Furthermore, a number of recommendations have been suggested to address the identified gaps.

[22] Annex III contains information for each country presented by sub-regions from sub-region A to E.

In order to analyze these differences, the results of the analysis were presented by sub-regions as follows:

A. European Union (EU) Member States prior to 2004 (EU15),[23] Norway, and Switzerland;

B. EU enlargement - the 13 countries that joined the EU after 2004 (EU13);[24]

C. Eastern Europe, Caucasus, Central Asia, and the Russian Federation;[25]

D. North America;[26] and

E. South-Eastern Europe.[27]

The following countries were excluded from this study due to the lack of information available: Cyprus, Malta, Iceland, Liechtenstein, Andorra, Monaco, San Marino, Israel, and Turkey.

This distinction will enable to better determine the specific challenges and needs of these five groups of countries, paying particular attention to the countries of the sub-region of the Eastern Europe, the Caucasus, Central Asia, and Russian Federation (sub-region C) and the South-Eastern Europe (sub-region E). Moreover, the results of the questionnaire will also help to identify those countries that are in the process of developing their building standards. For the purpose of this questionnaire, Norway, and Switzerland are included in sub-region A, even though they are not EU Member States. This is due to economic and social development similarities with the original EU15.

- **Initial assessment of energy efficiency technologies in buildings in relation to the existing standards**

An initial assessment of energy efficiency technologies in buildings was based on the data collected using the survey responses and the desktop study on trends in deployment of energy efficiency technologies. Best practices in countries from different sub-regions were also identified.

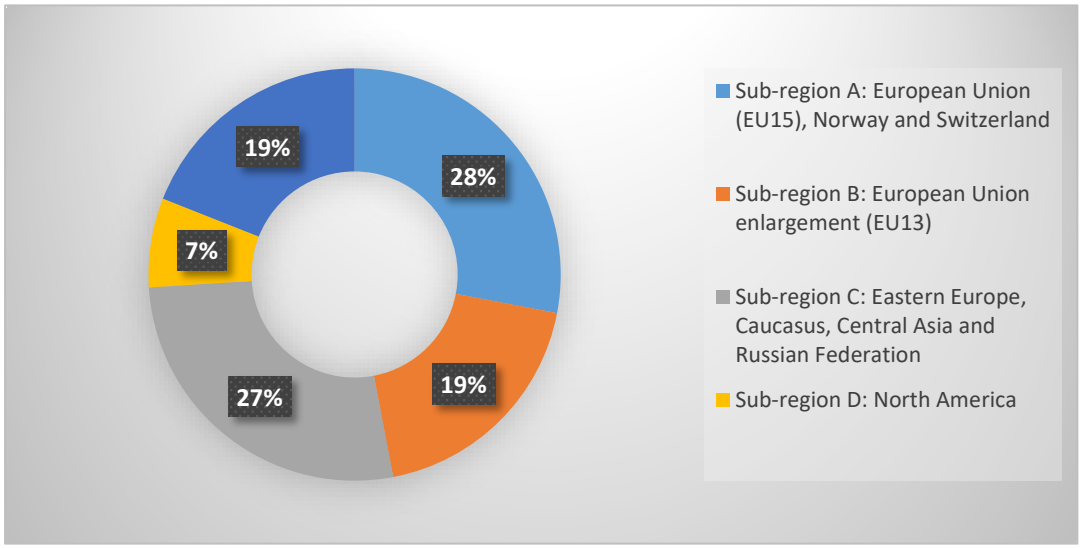
[23] It alphabetically includes Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, and the United Kingdom.
[24] It alphabetically includes Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, and Slovenia.
[25] It alphabetically includes Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Republic of Moldova, Russian Federation, Tajikistan, Turkmenistan, Ukraine and Uzbekistan.
[26] Canada and the United States.
[27] It alphabetically includes Albania, Bosnia and Herzegovina, Montenegro, Serbia, and the former Yugoslav Republic of Macedonia.

CHAPTER 1: ANALYSIS OF THE SURVEY RESULTS

1.1 Part One – General Information (Q.1-7)

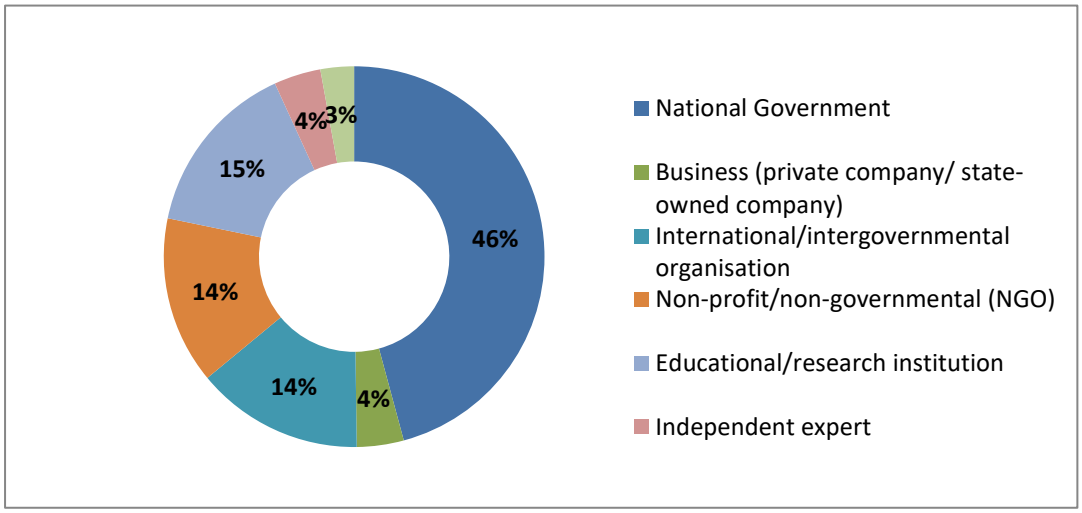
This section includes questions related to the personal details of the respondents, such as name, address, contact details, country, etc. A total of **62** responses were given from **28** countries, of which **34** respondents fully completed the questionnaire. Approximately one-quarter of the respondents were female. As shown in **Fig.1**, most of the respondents (28 percent) belong to the countries of sub-region A, followed by sub-region C (27 percent) and sub-regions B (19 percent) and E (19 percent), and only 7 percent of respondents are from sub-region D.

Figure 1: Respondents by sub-region



The type of organization that respondents represent is shown in **Fig. 2**. The majority of respondents (46 percent) represent government agencies, followed by almost equally distributed educational and research institutions (15 percent), non-governmental organizations (NGOs) (14 percent) and international organizations (14 percent). Smaller share of respondents represent business (4 percent) and independent experts (4 percent).

Figure 2: Type of organization represented by respondents



1.2 Part Two – Building Energy Codes (Q.8-26)

The next part of the questionnaire had the purpose to assess the status of building energy codes stringency, coverage, existence of specific standards and technical requirements.

In some countries, building energy codes and standards for energy efficiency are set at the national level. In countries with large climatic differences, national building codes might include values which are adjusted to the local conditions. These are referred to as national building codes. In other countries, local states or regions establish energy efficiency requirements in buildings. This applies in particular to large countries with a federal government, e.g. Canada and the United States. In this case, a model building code is often developed to cover the whole country, either on a public or as a private initiative[28]. Individual states or regions then modify the national model standard to local conditions; and must adopt this legislation, before it becomes mandatory.

Different standards cover different regions or climatic conditions and different types of buildings, such as residential or simple buildings, commercial buildings and more complicated high-rise buildings[29]. Finally, some countries delegate the establishment of energy efficiency requirements for buildings to local authorities. Countries where codes are set on a local level will usually have a standard set on national level and the recommendation to adopt or adjust the standard locally.

Existing specific standards (question 10)

Figure 3: Existing specific standards

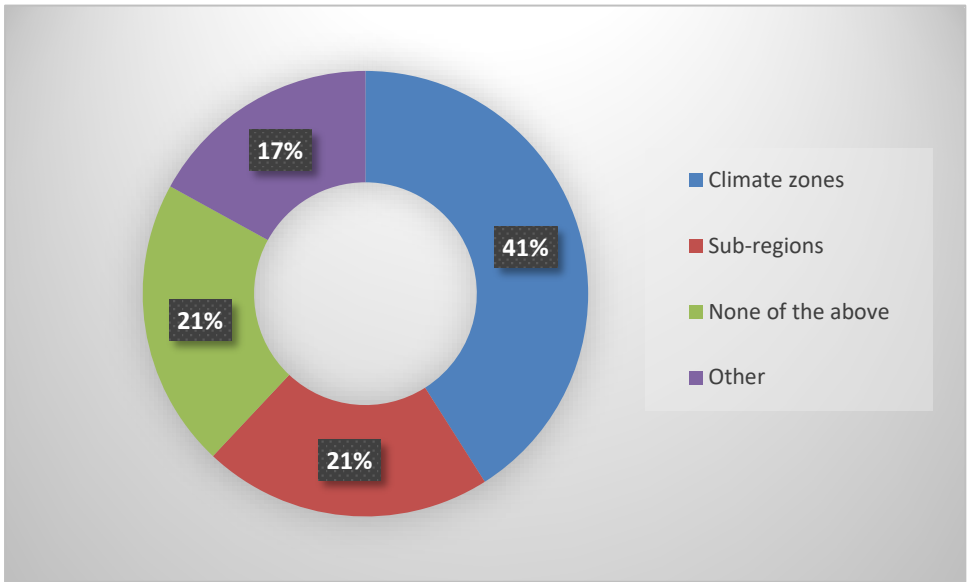


Fig. 3 above shows the presence of specific standards for climate zones, sub-regions, etc. The rate of responses to this question was 56 percent, and the responses received confirmed the existence of specific standards for climate zones (41 percent), followed by sub-regions (21 percent). For example, Montenegro indicated that climate data is used for calculation of total primary energy consumption in buildings by three climatic zones, Bosnia and Herzegovina reported two climatic zones. The territory of Albania is divided into three climatic zones: zone A is the mildest along the sea, zone B is the medium zone and zone C is the coldest in the mountainous area. About half of the buildings are located in climate zone B, while climate zone A has about one third of the buildings. The least buildings, about 16 percent of the stock are located in climate zone C.[30]In the United States, many states require additional energy calculation compliance based on localized climate requirements. Canada also has specific standards for climatic zones and sub-

[28]IEA (2008) Energy Efficiency Requirements in Building Codes, Energy Efficiency Policies for New Buildings, available at:https://www.iea.org/publications/freepublications/publication/Building_Codes.pdf.
[29] Ibid.
[30] Gjergji, Simaku (2017) Albanian Building Stock Typology and Energy Building Code in Progress Towards National Calculation Methodology of Performance on Heating and Cooling, European Journal of Multidisciplinary Studies, Vol.5, Nr.1, available at: http://journals.euser.org/files/articles/ejms_may_aug_17/Gjergji.pdf.

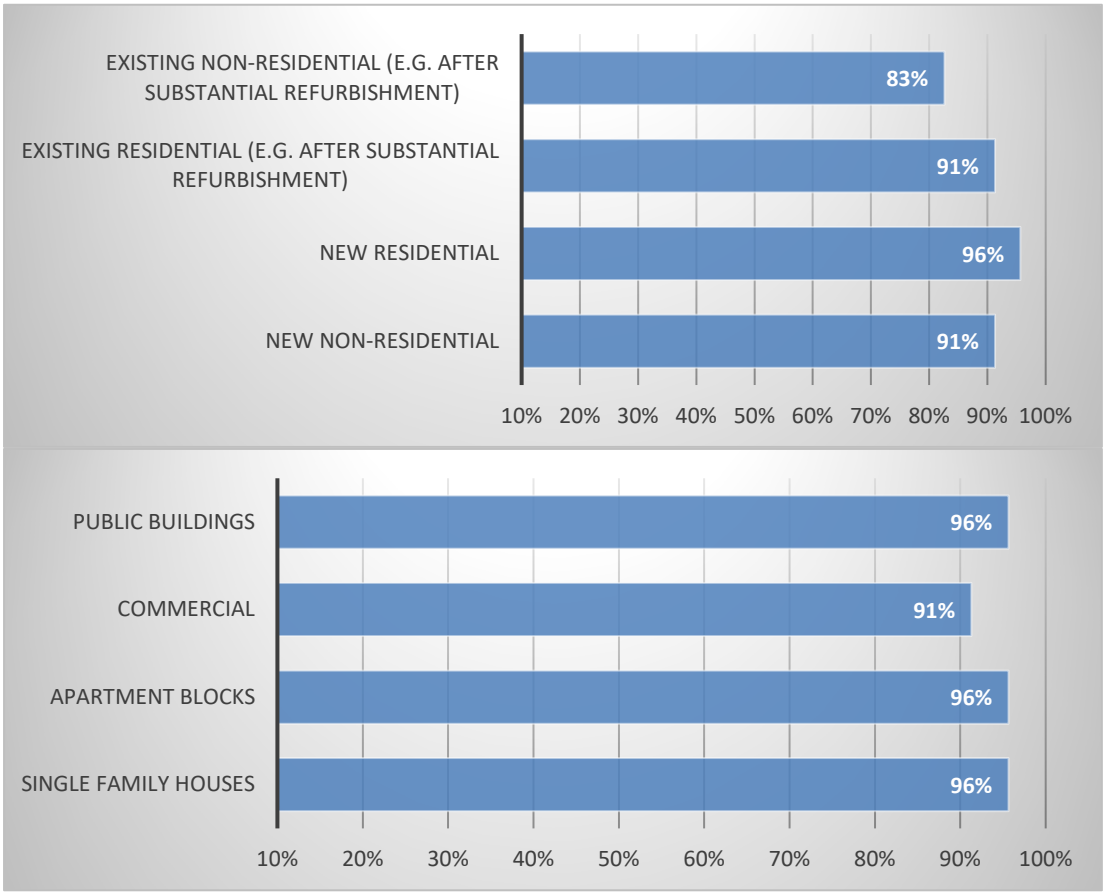
regions thus provinces and territories may adopt the federal model code with some modifications, creating some differences between provinces or sub-regions.

Types of buildings covered by the building energy codes (questions 11a-11b)

The next two questions focused on investigating the coverage of building energy codes in countries of the UNECE region. The way in which a standard is developed and used depends on the kinds of buildings it is expected to cover. Different measures are appropriate for different building types, vintages, physical sizes, fuel uses, and an abundance of other possible building characteristics. The more specifically a standard has described its applicability, the more effective coverage it is likely to provide.[31]

Fig. 4 illustrates the results received from 59 percent of total respondents showing the coverage of building energy codes for different types of buildings. The results suggest that the majority of buildings covered by building energy codes are new residential (96 percent), followed by equally distributed existing residential and new residential buildings (91 percent). Existing non-residential buildings represent the lowest percentage (83 percent percent) of coverage. Public buildings, apartment blocks and single-family houses represent equally 96 percent coverage, with commercial buildings having a slight lower share of 91 percent in the UNECE region.

Figure 4: Type of buildings covered by building energy codes in all countries of the UNECE region



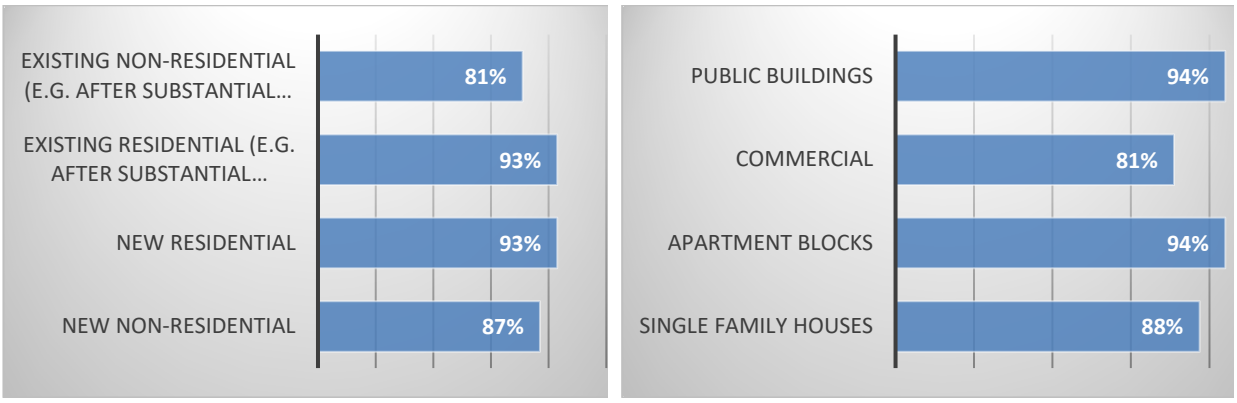
For comparison, we have analysed the same situation in sub-region C, where almost the same ratio of responses has been received. **Fig. 5** below illustrates that the results from respondents indicate that new residential and existing residential both share the same percentage (93 percent), while the coverage of new non-residential and existing non-residential buildings is slightly lower (87 percent and 81 percent respectively) in sub-region C compared to the UNECE region. For example, building energy code in the Republic of Moldova does not contain provisions to cover new residential buildings, while building energy

[31] Kathryn B. Janda and John F. Busch (1994) Worldwide Status of Energy Standards for Buildings, Energy Vol. IV, No. I, pp. 27-44. 1YY4, available at: http://www.eci.ox.ac.uk/research/energy/downloads/janda04-wsesb.pdf.

codes in Georgia do not cover new and existing non-residential buildings. Public buildings and apartment blocks in sub-region C present an equal (94 percent) coverage which is slightly lower compared to the UNECE region, with commercial buildings representing 81 percent. Some countries, e.g. Azerbaijan and Kazakhstan, do not currently have provisions to cover single family buildings types.

The responses received from countries of the EU15 and the United States indicated that the building energy codes covered all types of buildings, while Canada has provisions to cover only new residential and non-residential buildings in its building energy codes. The new national building strategy 2017 of Canada is designed to dramatically improve building efficiency and have code requirements apply to all buildings, both new and existing.

Figure 5: Type of buildings covered by building energy codes in sub-region C



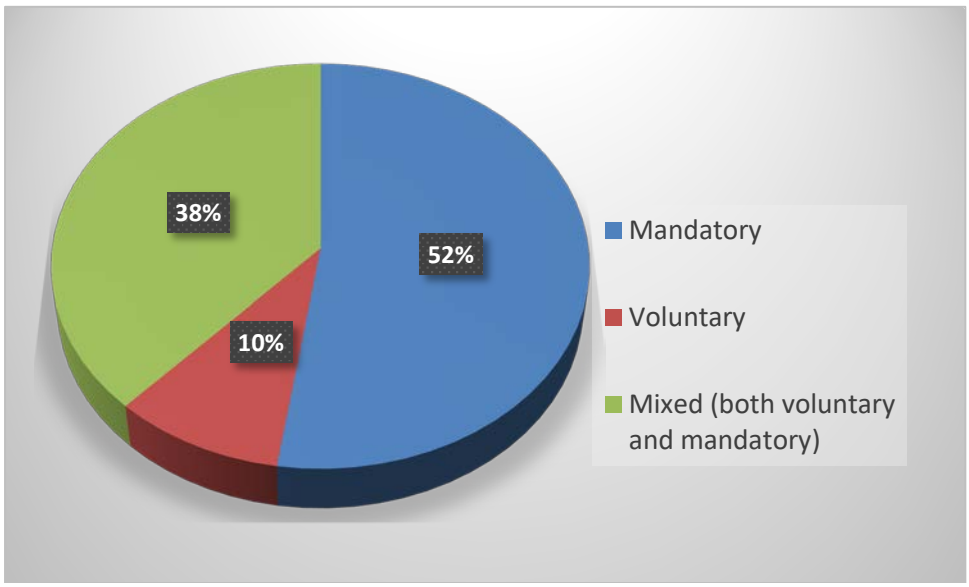
Stringency of building energy codes (question 12)

The next question aimed to provide understanding of the level of stringency of building energy codes. Countries can implement codes with various levels of stringency: voluntary codes, mandatory codes, or some mixture depending on the region or state. The stringency metric is a basic reporting of the status of the building energy codes in a country. According to respondents, 52 percent of building energy codes are mandatory, followed by mixed (38 percent) and voluntary (10 percent) (see **Fig. 6**). In Canada and the United States, for example, the national government does not have authority to pass mandatory building energy codes; however, many states and provinces have adopted codes[32]. In contrast, many countries create mandatory building energy codes that cover the entire country. We received responses from 22 countries with standards that cover both residential and non-residential buildings; 13 of these countries have the mandatory building energy codes and 1 voluntary (Azerbaijan). The full analysis of the comprehensiveness of the building energy codes for each country can be found in **Chapter 2** of this report.

From the analysis of the coverage and stringency of building energy codes across member States it is possible to conclude that most countries have mandatory building energy codes in place while some countries still apply building energy codes only to specific types of buildings, such as single- or new multifamily buildings in the residential sector. The more comprehensive the code, the more types of buildings the code should apply to.

[32]Rachel Young (2014) Global Approaches: A Comparison of Building Energy Codes in 15 Countries. https://aceee.org/files/proceedings/2014/data/papers/3-606.pdf.

Figure 6: Stringency of building energy codes in the UNECE region



Performance-based requirements in building energy codes (question 13)

In addition to defining the types of buildings a standard covers, it is important to look at the methodology employed in the standard to calculate energy use. For example, prescriptive building energy codes set minimum energy performance requirements for each building component. These types of codes usually include permissible levels of heat loss for windows, roofs and walls, and/or efficiency levels for heating, cooling and lighting equipment.[33] Prescriptive standards have the advantage of being simple to follow and assess, but they tend to be inflexible. Performance building energy codes require the overall building to be considered as one single system. Factors to consider in the calculation methodology include: the building form and orientation; daylight, solar gains and shading; the share of glazed areas; building inertia; thermal bridges; natural and mechanical ventilation; indoor comfort; internal loads from appliances, equipment and occupants; the performance of different building components and equipment; and the use of renewable energy sources and automatic controls. Performance standards are more complicated but allow a designer to vary building characteristics and still comply with the overall requirements.

Many building energy efficiency regulations started with requirements for the building shell, and nearly all efficiency regulations for new buildings include requirements for the building envelope. As the building's envelope improves, regulations focus on the energy efficiency of HVAC systems. Finally, when all parts of building and HVAC systems are covered, regulations address other installations and renewable energy.

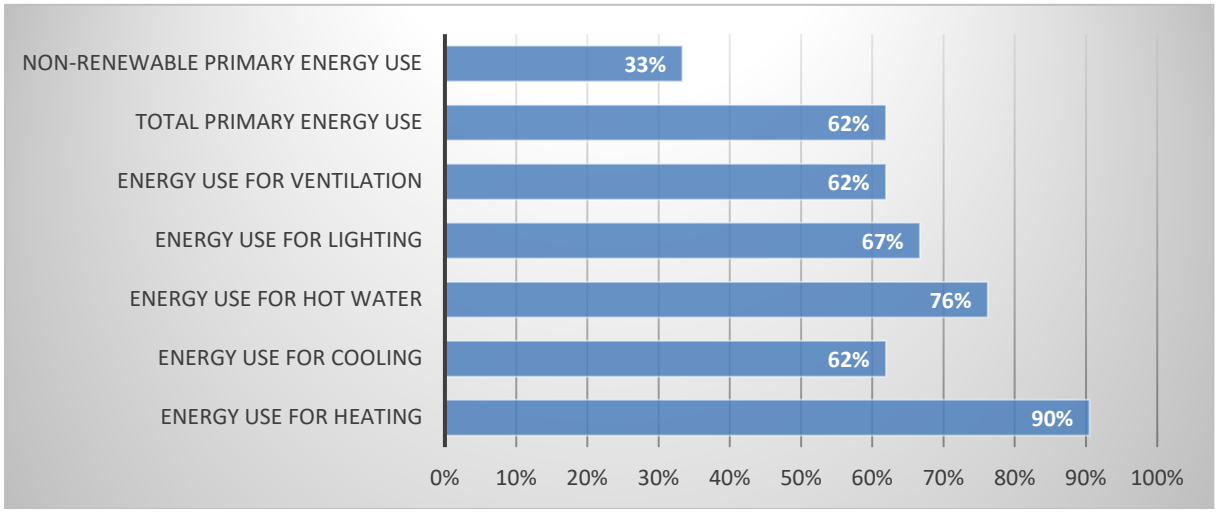
According to the survey results, 90 percent of respondents confirmed the existence of performance-based requirements for new buildings, followed by 77 percent for existing buildings and 33 percent for energy efficiency development systems.

Energy levels considered when defining energy performance of a building (question 14)

Fig. 7 below presents the usage of different energy levels considered when defining energy performance of a building, with 90 percent energy use attributed to heating, hot water (76 percent) and lighting (67 percent).

[33] IEA (2013) Modernizing Building Energy Codes. Available at: https://www.iea.org/publications/freepublications/publication/PolicyPathwaysModernisingBuildingEnergyCodes.pdf.

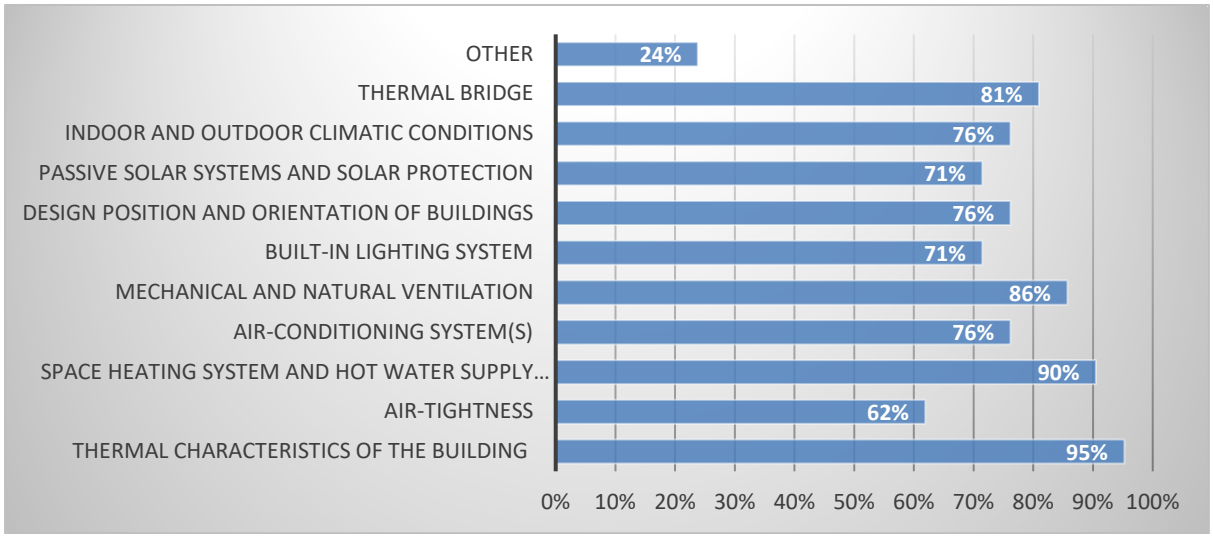
Figure 7: Energy levels considered when defining energy performance of a building



Elements taken into account for energy performance calculation (question 15)

The next question focused on identifying what elements had to be taken into account for the calculation of the energy performance of a building in countries building energy codes. As shown in **Fig. 8** below, a number of elements are taken into account, with thermal characteristics of the building representing a large majority of the results (95 percent), followed by space heating system and hot water supply (90 percent) and mechanical and natural ventilation (86 percent).

Figure 8: Energy taken into account for energy performance calculation



Energy performance gap (questions 17-22)

Building owners and managers need reliable information on the energy performance information of their buildings. It is particularly important to be able to quantify the impact of investments in energy efficiency, on reducing energy consumption and improving thermal comfort and health.

Energy performance gap is a term commonly used to denote the disparity that is found between the energy use predicted in the design stage of buildings and the energy use of those buildings in operation; the difference between anticipated or predicted at the design stage energy consumption and actual operational energy performance of buildings when already occupied (in-use energy consumption) is known as the

performance gap.[34] When referring to 'The Performance Gap' the results from simplified energy models generated at design stage are compared against operational performance.[35]

The results of the survey indicate that only 46 percent of respondents answered the questions about energy performance gap. 61 percent respondents have indicated that the International Performance Measurement & Verification Protocol (IPMVP) as a compliance verification tool to measure the actual performance of the buildings is not used, 17 percent of respondents indicated the IPMVP was used, and 50 percent of respondents have confirmed the existence of software used for compliance verification. 68 percent of respondents pointed to the absence of a mandatory requirement to assess post-construction requirement of the thermal bridge and 74 percent indicated that there was no mandatory requirement for the air tightness testing.

The responses received suggest a significant variation of the mean percentage gap between predicted and actual performance levels. Around 50 percent of respondents didn't know the average percentage gap. Switzerland indicated that this was currently under analysis, with initial findings 30-300 percent measured compared to predicted energy performance in residential buildings. Albania, for example, stated 30-40 percent energy performance gap, while the former Yugoslav Republic of Macedonia stated that the energy performance gap was not currently recorded with only predicted/calculated energy performance being used. In the Russian Federation, individual studies have shown large discrepancies between calculated thermal performance of buildings and that measured through infrared cameras. Such studies have shown that buildings used twice the amount of energy (when measured) compared to the energy consumption calculated during the design process.[36]

There is an increasing evidence of a performance gap between design intent (i.e. theoretical performance as modelled using national calculation methods) and the actual energy performance in-use. This may suggest one or more of the following issues: the calculation methods are flawed; the enforcement regime is not being undertaken with sufficient rigour; or designers and builders are failing to satisfactorily deliver the outcome intended.[37]

Closing the performance gap between design intent and regulatory requirement is likely to become an important issue over the next decade if countries are to deliver the climate and environmental targets related to buildings.

As can be seen in **Fig. 9** below, 53 percent of responses do not consider that the existing standards for determining the energy characteristics of the buildings in operation are sufficiently accurate to compare the energy characteristics with the projected values.

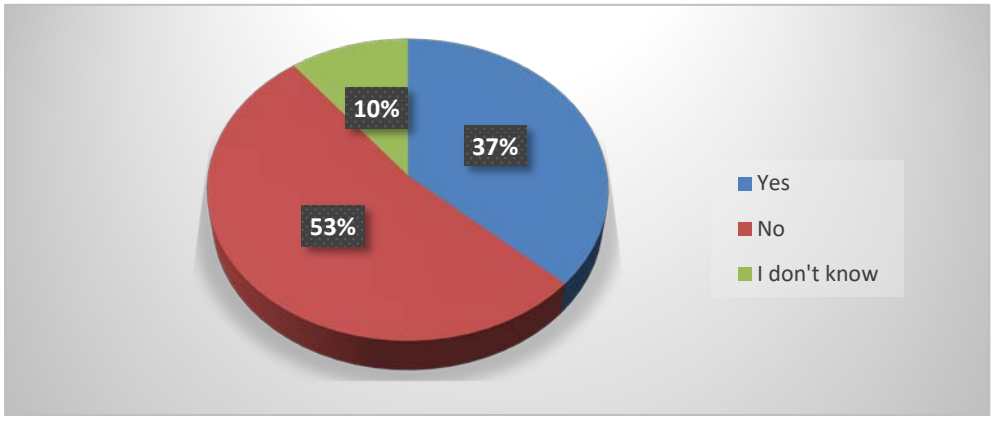
[34] Rory V. Jones, Alba Fuertes, Pieter de Wilde (2015) The Gap between Simulated and Measure Energy Performance: A Case Study across Six Identical New-Build Flat in the UK.THE GAP, Proceedings of BS2015: 14th Conference of International Building Performance Simulation Association, Hyderabad, India, Dec. 7-9, 2015, available at: https://pdfs.semanticscholar.org/722e/e437b59aba0a94b193e290a7ed465f045052.pdf.

[35] Anna, C. Menezes (2012) Mind the Gap, CIBSE Home Counties North West Region Event 18th October, 2012, available at: https://www.cibse.org/getmedia/4be5e37f-2821-4d26-b0c3-dd8b183cfffd/hcnwCIBSE_HCNW_presentation_-_Anna_Menezes.pdf.aspx.

[36] Alexander Gusev (2013) Comparison of Energy Efficiency Measures in Russia to Those Implemented by Developed Countries (Including IEA Measures), German Institute for International and Security Affairs (SWP), available at: http://www.europarl.europa.eu/meetdocs/2009_2014/documents/d-ru/dv/dru_20131017_11_/dru_20131017_11_en.pdf.

[37] BPIE (2011) Europe's Buildings under the Microscope, A country-by-country review of the energy performance of buildings, available at: http://bpie.eu/wp-content/uploads/2015/10/HR_EU_B_under_microscope_study.pdf.

Figure 9: Energy performance accuracy in buildings



Prescriptive technical requirements in building energy codes (questions 23-26)

When using the prescriptive method, energy efficiency requirements are set for each component of the building. This could be a thermal value (U-value) for windows, roofs or walls. The prescriptive method can include efficiency values for technical installation, ventilation, orientation of buildings, solar gains, the number and size of windows. To comply with a prescriptive standard, each part of a building must meet its specific value. A simple version of a prescriptive building energy code set thermal values for the essential 5–10 building parts. In the most complicated systems, energy efficiency requirements are set for all parts of building and installations, including heating installation, cooling units, pumps, fans, and lighting. In some cases, these requirements are even adjusted according to size of the equipment or the size or percentage of windows based on floor area or the outer wall.

This section of the questionnaire focused on the specific elements of prescriptive technical requirements. Respondents were asked to provide information on all elements that form the prescriptive technical requirements in their country's building energy code. 43 percent of respondents provided their responses to this question. **Fig. 10** below demonstrates that the large majority of the UNECE countries have requirements for thermal insulation including U-values (94 percent), followed by boiler/AC system (88 percent) and ventilation or air quality (82 percent). Lighting density, daylighting and solar gains (G-values) are equally distributed (65 percent) with both renewables and thermal bridges representing 53 percent.

Figure 10: Prescriptive technical requirements in building energy codes

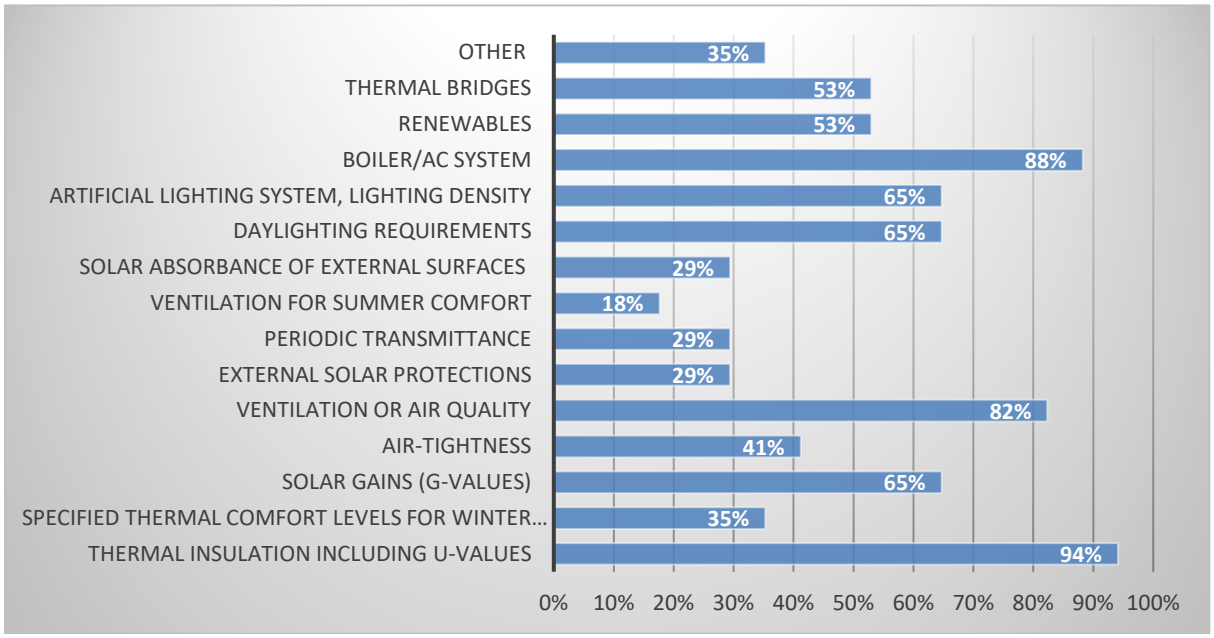
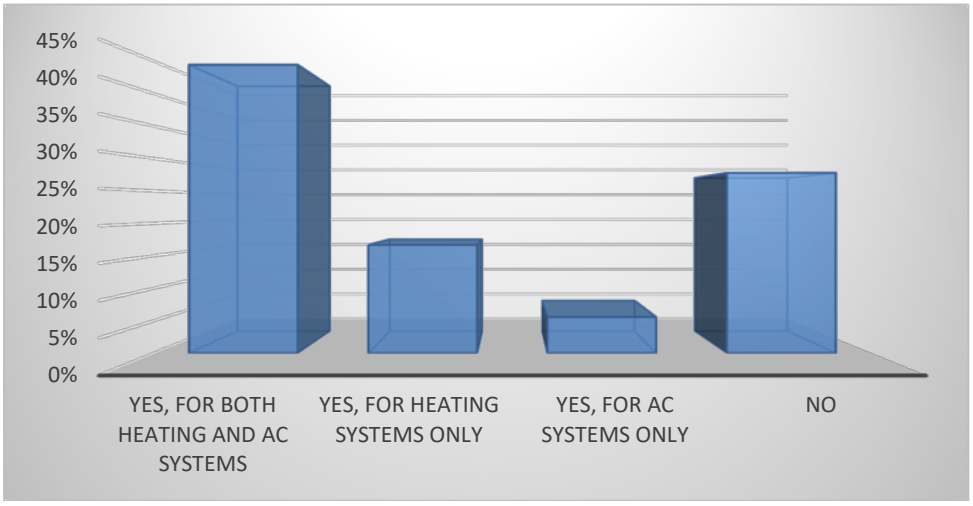


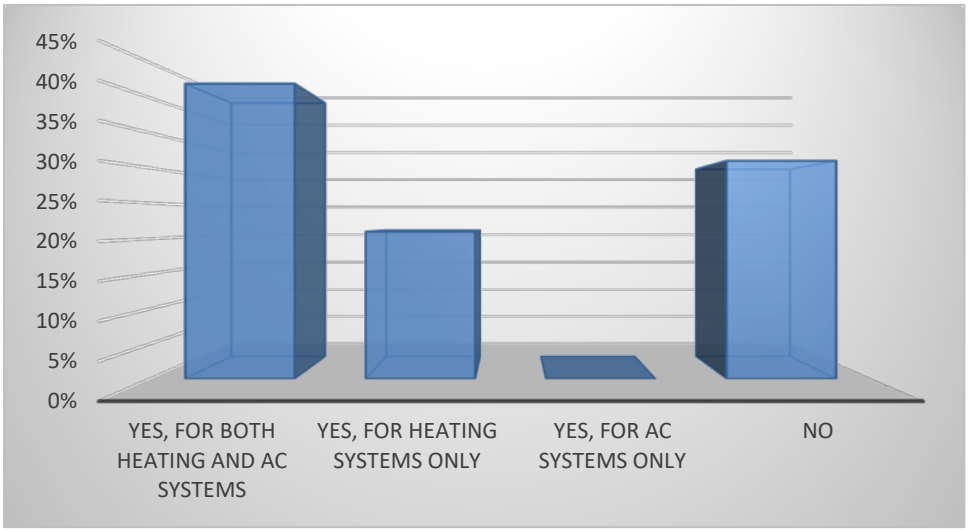
Fig.11 below illustrates the findings across the UNECE region where 44 percent of respondents confirmed the existence of the requirement for regular inspection of heating and AC systems, while 28 percent stated that such requirement was not included in their country's building energy code. 66 percent of responses indicated that it was a mandatory requirement.

Figure 11: Requirements for regular inspection of heating and AC systems in all countries of the UNECE region



Compared to results for the whole UNECE region, sub-region C shows a slightly different picture. As shown in **Fig.12** below, 42 percent of respondents from sub-region C conformed to the requirement for a regular inspection of heating and AC systems, while 31 percent stated that such requirement did not exist, which compared to the UNECE region results, represent a higher percentage of responses. 71 percent of responses indicated that it was a mandatory requirement in the countries of sub-region C.

Figure 12: Requirements for regular inspection of heating and AC systems in sub-region C



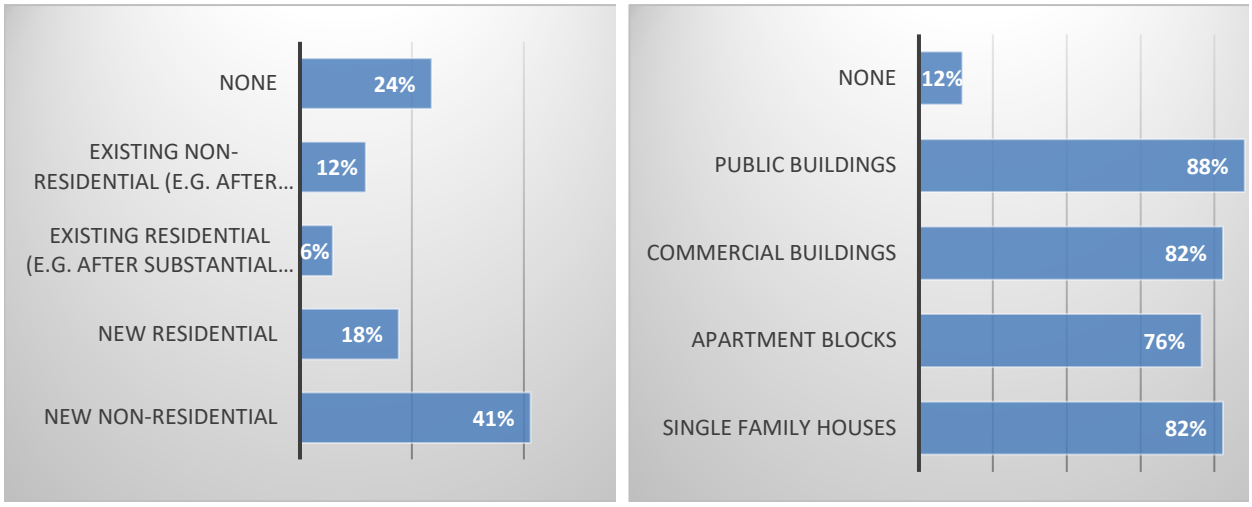
1.3 Part Three – Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building (Q.27-32)

Types of buildings covered by the EPC (questions 28a-28b)

The aim of this part of the questionnaire was to establish the country's coverage and stringency of energy performance certifications. **Fig. 13** presents the results received to questions 28a and 28b with a response rate of 43 percent, showing the coverage of the EPC for different types of buildings. The results suggest

that most of buildings covered by the EPC are those new non-residential (41 percent). 24 percent of responses indicated that none of the building types were covered by EPC, followed by new residential buildings (18 percent). Existing residential buildings represent the lowest percentage (6 percent) of coverage. Public buildings represent 88 percent coverage, followed by equally distributed single-family houses (82 percent) and commercial buildings (82 percent), with apartment blocks having a slight lower share of 76 percent in countries of the UNECE region. According to the responses received, in some countries, e.g. Albania, Belarus, Georgia, Kazakhstan and the former Yugoslav Republic of Macedonia, the EPC is not currently used.

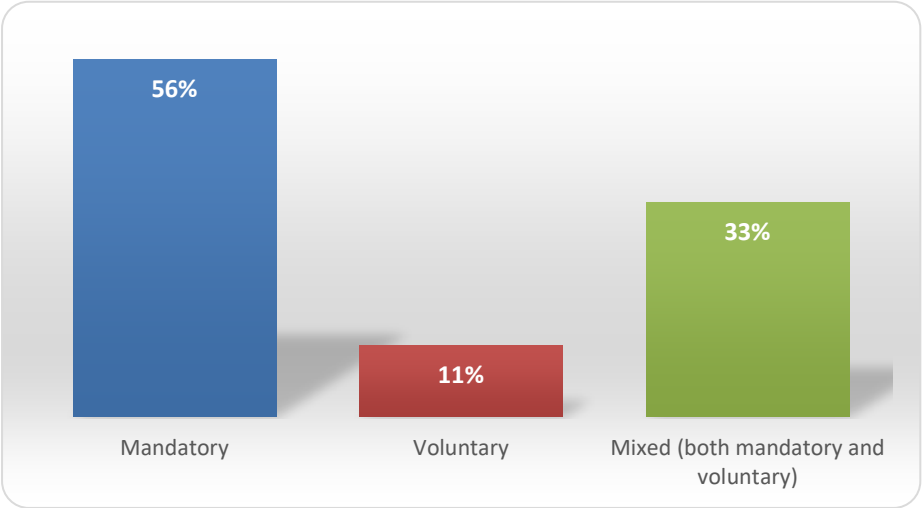
Figure 13: Type of buildings covered by EPC in countries of the UNECE region



Policy requirement level for EPC (question 31)

As it can be seen in **Fig. 14**, the responses addressing the EPC policy requirements levels suggest that in the countries of the UNECE region the majority of the EPC requirements are mandatory (56 percent), followed by mixed (33 percent) and voluntary requirements (11 percent).

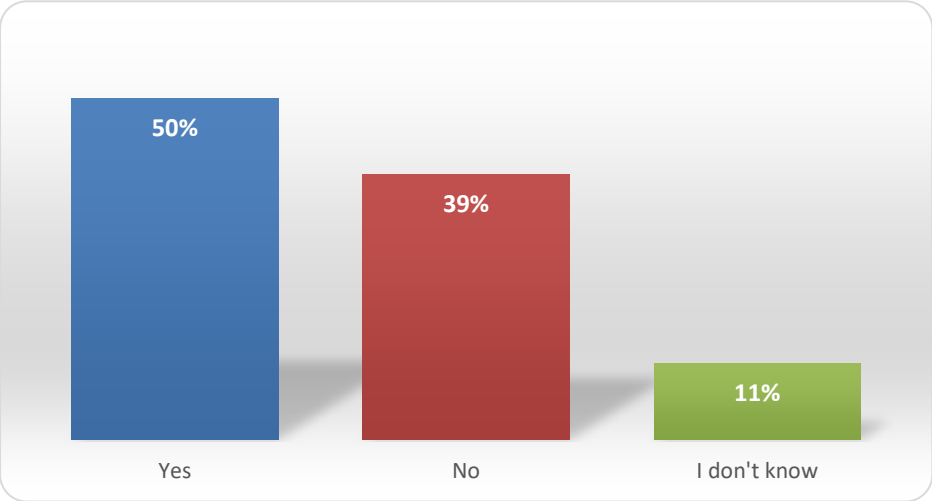
Figure 14: Policy requirement level for EPC



National registry database (question 32)

Fig. 15 below illustrates that 50 percent of respondents confirmed the existence of a national registry database for EPC, followed by 39 percent who replied that it does not exist and 11 percent who did not know. In Spain, for example, there is no national registry database for EPC, although the policy level requirement for EPC is mandatory in this country.

Figure 15: National registry database for EPC



1.4 Part Four – Building Materials and Products (Q.33-35)

The next set of questions was intended to assess the requirements for building materials and products. Firstly, the respondents were asked whether in their country there were requirements to have building materials certified. The vast majority of responses (72 percent) confirmed the existence of such requirements in their country's building energy code.
In addition, 75 percent of responses indicated that these requirements were harmonized with the European Union standards used for CE Marking, while 31 percent of respondents used International technical specifications, such as those prepared by International Organization for Standardization (ISO).
The large majority (71 percent) of responses indicated the existence of the requirements to test building materials and products by certified test laboratories.

1.5 Part Five – Requirements for enforcement and compliance (Q.36-39)

Penalties, incentives and other mechanisms for improving compliance (questions 36-37)

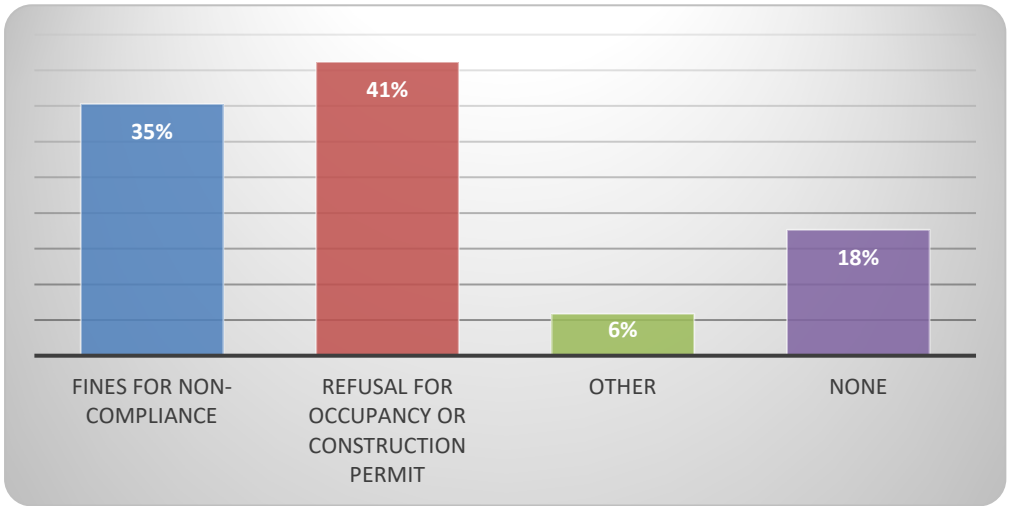
Part five of the questionnaire requested the respondents to provide information on penalties, incentives and other mechanisms that complement or motivate compliance with building energy codes in the country. The majority of responses (65 percent) confirmed the existence of specific incentives for compliance in country's building energy code, while 35 percent indicated otherwise. At present, some countries, e.g. Albania, Azerbaijan, Belarus, Croatia, Kazakhstan, Montenegro, Republic of Moldova, Russian Federation, Serbia, Turkmenistan, and Ukraine, do not have incentives for improving compliance. In Italy, there are fiscal detractions if someone goes beyond the minimum requirements (about 60 percent), but also if someone just does a retrofit work (50 percent). In Switzerland, financial incentives are given to improve the thermal efficiency of the envelope and heating systems. The Swiss Buildings Program[38] supports measures to improve the energy efficiency of real estate assets, such as roof and façade insulation, heat recovery, optimization of technical facilities and the use of renewable energy. A number of responses

[38] More information is available from: http://www.bfe.admin.ch/energiestrategie2050/06447/06457/index.html?lang=en.

indicated that the compliance and enforcement of building energy codes is currently undertaken with less rigour and attention to detail.

Fig. 16 shows the penalties each country uses for non-compliance with the regulations. In particular, a large proportion of responses (41 percent) indicated that refusal for occupancy or construction permit was widely used, followed by fines for non-compliance (35 percent). Much smaller proportion of responses (18 percent) stated that penalties for non-compliance were not used.

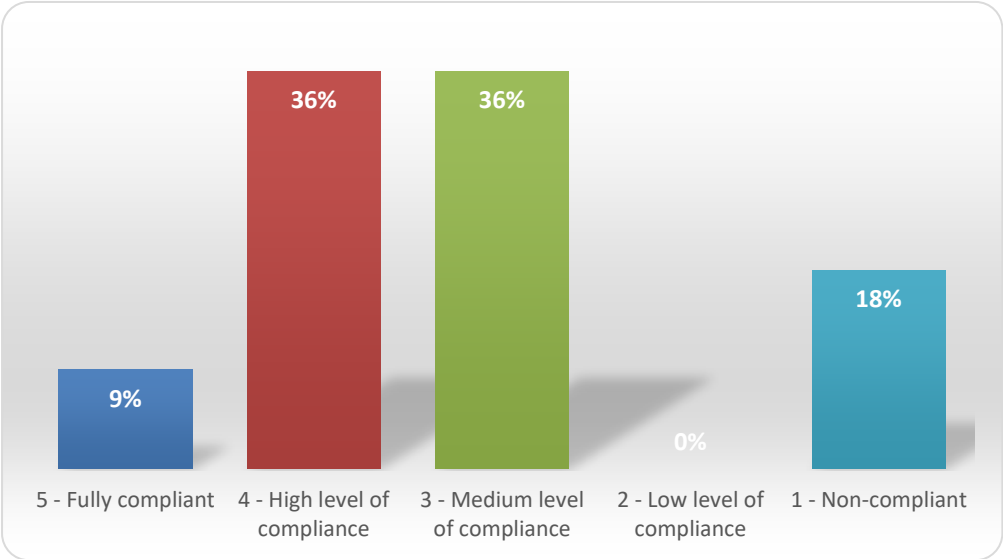
Figure 16: Penalties for non-compliance



Monitoring of energy performance in building energy codes (questions 37-39)

According to respondents, the requirements for energy performance monitoring were confirmed by 50 percent of responses, with 45 percent indicating that these requirements for monitoring were mandatory. The respondents also were requested to assess (on a scale from 1 (non-compliant) to 5 (fully compliant) the level of compliance with energy performance monitoring contained in building energy codes. As can be seen in **Fig. 17**, only 9 percent of respondents thought that energy performance monitoring was fully compliant, while high and medium levels of compliance equally received 36 percent each. 18 percent of respondents considered that monitoring in their country was not compliant with the requirements set in country's building energy code.

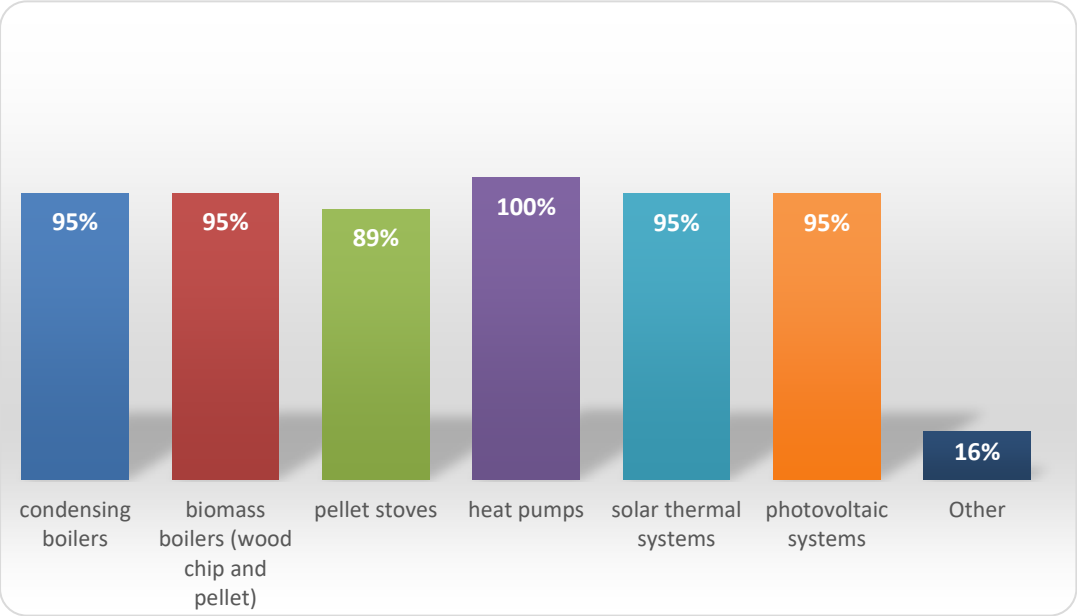
Figure 17: Level of compliance with monitoring



1.6 Part Six – Energy Efficiency Technologies (Q.40)

Part six of the questionnaire focuses on determining the status of energy efficiency technologies deployment in countries of the UNECE region. The respondents were asked to provide information on which energy efficiency technologies were present in the country. **Fig. 18** demonstrates that there was a very small difference in responses, indicating that the majority of these technologies were already playing an active role in the countries of the UNECE region.

Figure 18: Energy efficiency technologies deployment



The respondents were also asked to provide brief details on the recent trends in the energy efficiency technologies deployment in the country. A more detailed analysis of the recent trends in the energy efficiency technologies deployment in countries of the UNECE region is reported in **Chapter 3** of this report.

CHAPTER 2. GAP ANALYSIS OF THE STATUS OF ENERGY EFFICIENCY STANDARDS IN BUILDINGS IN THE UNECE REGION[39]

The gap analysis of the status of energy efficiency standards in buildings in the UNECE region has focused on key elements related to the implementation of building energy standards with the final goal to develop and implement more effective energy efficiency policies. The analysis has been undertaken using a number of specific metrics in the following five steps:

1. Analysis of the comprehensiveness and stringency of the building energy codes;
2. Analysis of the technical requirements of the building energy codes;
3. Analysis of the comprehensiveness and stringency of the EPC;
4. Analysis of the enforcement mechanisms, including incentive packages and penalties; and
5. Analysis of the energy efficiency materials and products requirements in building energy codes.

This report intends to determine which countries are embracing energy efficiency through highly effective building energy standards. To this end, this report has showcased status and implementation of building energy codes across sub-regions, highlighting any existing gaps, and includes good practices to increase energy efficiency in buildings.

The objective of this analysis is to evaluate the most effective policies and identify best practices to help member States learn from one another and achieve greater savings. Specific metrics used to evaluate building energy codes in individual countries have been presented to demonstrate which countries are performing at the highest level in each category with some examples of best practice.

Assumptions and limitations

While every attempt has been made to ensure the accuracy of the information and analysis presented, data gaps still exist. It is hoped that these gaps can be addressed with ongoing engagement from participating countries and the network of experts.

The gap analysis has been presented in a tabular form and based mainly on information gathered through the questionnaire responses received from the UNECE member States. It is noted that a few participating countries do not have mandatory building energy codes at present. Further, many countries have a federal form of governance. In these countries, only the subnational jurisdictions can adopt and enforce building energy codes (often when this is the case, not all local jurisdictions have a building energy code). In other countries, a building energy code may be nominally mandatory, but enforcement may be dependent on self-certification. This has presented some difficulty in assigning the scoring for some metrics.

For the purpose of this study, a number of countries representing different sub-regions, for which sufficient data was collected and verified, were selected to build an overall picture of the status of building energy codes and to provide a comparative evaluation of the effectiveness of building energy codes to reflect the diverse nature of countries of the UNECE region.

2.1 Analysis of the comprehensiveness and stringency of the Building Energy Codes

Description

Different building energy standards cover different regions or climatic conditions and different types of buildings, such as residential or simple buildings, commercial buildings and more complicated high-rise buildings.[40] Countries can implement codes with various levels of stringency: voluntary codes, mandatory codes, or some mixture depending on the region or state.[41] This stringency metric is a basic reporting of the status of the building energy codes in a country. For the purpose of this study, we have looked at the

[39] The preparation of gap analyses is part of the work of the JTF, reference at http://www.unece.org/fileadmin/DAM/hlm/projects/EE_in_buildings/ToR_Joint_Task_Force__2018-2019.pdf

[40] IEA (2008) Energy Efficiency Requirements in Building Codes: Policies for New Buildings. Available at: https://webstore.iea.org/energy-efficiency-requirements-in-building-codes-policies-for-new-buildings.

[41] Rachel Young (2014) Global Approaches: A Comparison of Building Energy Codes in 15 Countries, American Council for an Energy-Efficient Economy. Available at: https://aceee.org/files/proceedings/2014/data/papers/3-606.pdf.

comprehensiveness of the building codes for individual countries from different sub-regions to make a comparative analysis.

To broadly characterize the UNECE wide status of energy efficiency standards in buildings, we have combined previously published information with the results of the survey. **Table 1** shows a general overview of the legal status and coverage of building energy standards in selected countries. Each individual country in the table has been awarded points to provide an indicative scoring how well each country performs against specific criteria included in the metric.

Out of the 5 possible points, countries are awarded 1 point if their building energy codes are mandatory, 0.5 points for mixed and voluntary, and 0 points for no code, giving a total possible point allocation of 1 for stringency.[42] Countries can also earn up to 2 points for building energy code coverage. For example, for residential 1 point is allotted for coverage for both single- and multifamily housing. For commercial, the code must include all commercial[43] and public buildings[44] to receive 1 point. If the coverage is partial in either commercial or residential, countries get 0.5 points (e.g., Azerbaijan and Kazakhstan).

Results

Table 1 below shows the stringency of adherence to the building energy codes and the types of buildings subject to the building energy code "coverage" for the residential and commercial sectors. The more comprehensive the code, the more types of buildings the code applies to.

This analysis suggests that building energy codes in sub-regions A and B provide greater coverage and stringency compared to sub-regions C and D, although it is noteworthy that countries of the sub-region C have made a considerable progress to ensure that building energy codes apply to different types of buildings. The average scores for this metric do not differ significantly across sub-regions, with countries in sub-regions A and B having an average score of 4.9, followed by sub-region E (4.6), D (4.5) and C (4.2). Many countries employ mandatory or mixed stringency while Azerbaijan has a voluntary requirement for compliance.

Table 1. Building Energy Codes coverage in individual countries

Selected countries	Coverage				Stringency	Points (Max 5)
	New build	Existing	Residential	Commercial		
Sub-region A - European Union (EU15), Norway, and Switzerland						
Germany	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mandatory	5
France	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mandatory	5
Italy	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mandatory	5
Portugal	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mandatory	5
Switzerland	Residential;	Residential;	Single Family;	Commercial;	Mixed	4.5

[42] In Canada and the United States, the national government does not have authority to pass mandatory building codes; however, many states and provinces in those countries have adopted codes. 1 point was awarded for 'mixed' to reflect these countries' specifics in the scoring.
[43] In the commercial sector, "commercial" means offices, retail and wholesale outlets, hotels, hospitals, and educational buildings, unless otherwise specified.
[44] "Public buildings" means public offices, hospitals, and educational buildings, unless otherwise specified.

	Non-Residential	Non-Residential	Apartments	Public Buildings		
Spain	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mixed	4.5
United Kingdom	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mixed	4.5
Sub-region B - European Union enlargement (EU13)						
Bulgaria	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mandatory	5
Croatia	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mandatory	5
Czech Republic	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mandatory	5
Slovakia	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mandatory	5
Sub-region C – Eastern Europe, Caucasus, Central Asia and Russian Federation						
Belarus	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mandatory	5
Turkmenistan	Residential Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mandatory	5
Uzbekistan	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mandatory	5
Kazakhstan	Residential; Non-Residential	Residential; Non-Residential	Apartments	Commercial; Public Buildings	Mandatory	4.5
Armenia	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mixed	4.5
Russian Federation	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Public Buildings	Mixed	4.5
Ukraine	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Public Buildings	Mixed	4.0
Azerbaijan	Residential;	Residential;	Apartments	Commercial;	Voluntary	4.0

	Non-Residential	Non-Residential		Public Buildings		
Republic of Moldova	Non-Residential	Residential; Non-Residential	Single Family; Apartments	Public Buildings	Mixed	3.5
Georgia	Residential				Mandatory	1.5
Sub-region D - North America						
United States	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mixed	5.0
Canada[45]	Residential; Non-Residential		Single Family; Apartments	Commercial; Public Buildings	Mixed	4.0
Sub-region E – South-Eastern Europe						
Bosnia and Herzegovina	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mandatory	5
Montenegro	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mandatory	5
Serbia	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mixed	4.5
The former Yugoslav Republic of Macedonia	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mixed	4.5
Albania	Residential; Non-Residential	Residential;	Single Family; Apartments	Commercial; Public Buildings	Mixed	4.0

Best Practices

France

France has established a mandatory and comprehensive code system. As a member of the European Union, France was required to comply with the Energy Performance of Buildings Directive (EPBD) passed in December 2002.[46] France implemented the Directive in 2005 by updating their National Building Regulation. The 2005 regulation set a 15 percent efficiency rate, and a 40 percent efficiency rate goal, aimed to be met by 2020. France's building regulation also sets minimum standards for existing buildings and defines the necessary renovations for them. In addition to the mandatory building energy codes, France established complementary categories for efficient buildings and "White Certificate Trading,"[47] requiring energy suppliers to meet mandated targets for energy savings through their customers.

United States (California)

[45] Right now, there is no national model energy code that applies to existing buildings. Federal, provincial, and territorial governments will work to develop a model code for existing buildings by 2022, with the goal that provinces and territories adopt the code.
[46] For more information, see here: http://www.epbd-ca.eu.
[47] The white certificates represent marketable documents issued by the Energy Market Administrator testifying the energy saved by the energy distribution companies – as well as by their controlled partnerships – and by the Energy Service Companies (ESCO).

In the United States, California has a long-standing history of building energy code development with a continuous increase in stringency and enforcement. California's building standards in 2016 (to be enforced as of 2017) set net-zero energy requirements for all new residential buildings by 2020, for new commercial buildings by 2030, for new state buildings and half of major retrofits by 2025, and for half of existing commercial buildings by 2030. The new standards include: a basic set of mandatory requirements for all buildings, a set of performance requirements that vary by building type and climate zone, and a set of prescriptive packages as an alternative to the performance-based approach.[48]

Armenia

Armenia introduced in 2016 a mandatory building energy code with the adoption of a new regulation "Thermal Protection of Buildings", which was developed based on Russian Building Energy Code from 2003 (updated in 2012) with application of some methodologies and approaches of European standards, e.g. EN 15217:2007; EN15316-1:2007; EN15603-1:2007; ISO 16818:2008; and ISO 23045-2008. It links building envelope components and heat losses with established energy limits, taking into account differences in climatic conditions. It also includes a requirement for issuing a building energy passport and an energy efficiency label with energy efficiency classes.[49] Armenia has developed two National Standards AST 362-2013 "Energy conservation. Building energy passport. Basic rules. Standard form" and AST 371-2016 "Methodology for performing energy audit in residential and public buildings".[50]

2.2 Analysis of the technical requirements in Building Energy Codes

Description

For the technical requirements different energy uses and functions covered by the country's building energy codes have been analyzed. Below are the elements selected to evaluate the technical requirements for each country:

- Thermal insulation;
- Heating and hot water;
- Air conditioning systems;
- Natural and mechanical ventilation;
- Solar gains (G-values);
- Lighting efficiency;
- Design, position and orientation;
- Air-tightness;
- Thermal bridging;
- Renewables;
- Indoor and outdoor climatic conditions; and
- Passive solar systems and solar protection.

Results

Nearly all of the respondents indicated that their energy efficiency standards incorporated provisions for the building envelope which influenced design choices for the roof, walls, floor and windows. While some building energy codes include energy consumption of installed equipment and appliances, some include lighting and others do not (e.g. Kazakhstan, Serbia, Turkmenistan and the former Yugoslav Republic of Macedonia). The treatment of renewable energy systems in building energy codes also varies. Building energy codes in countries for sub-regions A and B tend to consider more the renewable energy systems compared to sub-regions C, D and E. **Table 2** below demonstrates examples for the renewable energy systems requirements in individual countries.

[48] Global Alliance for Buildings and Construction (GABC) (2016) Towards zero-emission efficient and resilient buildings – Global status report 2016. Available at: http://www.buildup.eu/en/practices/publications/towards-zero-emission-efficient-and-resilient-buildings-global-status-repor-0
[49] Ibid.
[50] For more information, see here: http://www.nature-ic.am/en/projects/Improving-Energy-Efficiency-in-Buildings/2#section7

Table 2. Examples of the renewable energy requirements in country's Building Energy Code

Selected countries	Renewables in building energy codes
Norway	Buildings > 500m^2 shall be designed and constructed so that a minimum of 60 percent of the net energy need for space and water heating may be met by energy supply other than direct acting electricity or fossil fuels. For buildings < 500m^2 the requirement is a minimum of 40 percent other than direct acting electricity or fossil fuels.
Spain	Solar thermal energy or other renewable for water heating.
Denmark	Solar heating systems must be provided when the expected hot water consumption exceeds 2000 liters per day and able to meet 95 percent of demand.
Sweden	The building's specific energy use may be reduced by solar energy.
Greece	60 percent of domestic hot water (DHW) from solar energy.
Montenegro	Obligation for new buildings in climate zone I to cover 30 percent of their annual energy needs for domestic hot water with renewable sources (solar thermal systems). In case of open swimming pools, this percentage is increased to 100.

Many countries have requirements associated with the minimum performance of boilers and air-conditioning systems. Examples include minimum boiler efficiency levels and, in some cases, like Germany, ban of old inefficient boilers. Additionally, many building energy codes require minimum levels of daylight to be achieved within buildings, whilst ensuring that solar gains do no result in significant overheating and/or the requirement for air conditioning.[51]

Most countries have introduced requirements to ensure minimum levels of ventilation within buildings. These are generally based upon metabolic rates and activity within the building.[52] Given the increasing use of mechanical ventilation system, the fan power requirement in low energy buildings is becoming an increasingly important issue. A number of countries (e.g. Austria, Bosnia and Herzegovina, Czech Republic, Denmark, Estonia, France, Poland, Spain and Turkmenistan) have therefore introduced minimum requirements for specific fan power (generally expressed in W/l/s or kW/m^3/s). Non-quantitative requirements also exist in some countries like Hungary and Latvia and this is an issue which needs to be addressed in several countries. As excessive or insufficient ventilation can lead to considerable energy wastage and uncomfortable conditions, many countries have introduced requirements to limit the air permeability/airtightness of buildings.

Most of the countries also include requirements for airtightness in their building energy codes, with the exception of a few countries (e.g. Slovakia and Turkmenistan).

Although most of the countries have now inspection schemes for boilers and/or air conditioning systems, data collection on the number of inspections done by each member State is still at a very low level.[53] Insufficient data makes it difficult to formulate an appropriate evaluation on the effectiveness of these schemes. Several countries, e.g. Finland, France, Ireland, the Netherlands, Slovenia, Sweden and the United Kingdom do not have requirements for inspection of boilers in place.

Table 3 shows technical requirements within each country's building energy code. Each country is allotted 0.25 points per technical requirement. Due to the constraints of this study, this list and scoring does not look into the stringency of the technical requirements, which potentially could be an excellent area for additional research in the future. It is evident that the coverage of technical requirements in

[51] Federation of European Heating, Ventilation and Air Conditioning Associations (REHVA) (2012) Energy performance requirements for buildings in Europe, Marina Economidou, BPIE. Available at: https://www.rehva.eu/publications-and-resources/rehva-journal/2012/032012/energy-performance-requirements-for-buildings-in-europe.html.
[52] Ibid.
[53] Federation of European Heating, Ventilation and Air Conditioning Associations (REHVA) (2012) Energy performance requirements for buildings in Europe, Marina Economidou, BPIE. Available at: https://www.rehva.eu/publications-and-resources/rehva-journal/2012/032012/energy-performance-requirements-for-buildings-in-europe.html.

building energy codes is comprehensive across member States. Out of the max 3 points, sub-region A has an average score of 2.9, followed by sub-region B (2.7) and sub-regions D and E with average scores of 2.6 and 2.5 respectively, and finally sub-region C (2.3).

Whilst there is a small number of countries which are still to implement requirements on heating, cooling, lighting or ventilation, many member States have now these requirements in place. The most advanced building energy codes or standards for energy efficiency in buildings today include all these aspects. It should be the aim to include most of these elements in building energy codes or the calculation of energy performance, especially when requirements are high, since this will increase the saving potentials and will prevent sub-optimization of the demands for some parts of a building.

Best Practices

Spain

Spain's building energy efficiency requirements have both prescriptive and performance-based elements. Their codes cover residential and non-residential buildings and require a performance-based reference building calculation (manual or simulation) to show compliance for most building types. A prescriptive path can be used for buildings in specific locations. This path covers many technical requirements such as the thermal envelope and energy efficiency standards for HVAC, hot-water, lighting, and auxiliary systems. In addition, their code covers design, position, and orientation of building as well as requirements for technical installations.[54]

[54]Rachel Young (2014) Global Approaches: A Comparison of Building Energy Codes in 15 Countries, American Council for an Energy-Efficient Economy. Available at: https://aceee.org/files/proceedings/2014/data/papers/3-606.pdf.

Table 3. Building Energy Code technical requirements

Selected countries	***Thermal insulation***	***Heating and hot water***	***Air conditioning systems***	***Natural and mechanical ventilation***	**Solar gains (G-values)**	**Lighting efficiency**	**Design, position and orientation**	**Air-tightness**	**Thermal bridging**	**Renewables**	**Indoor and outdoor climatic conditions**	**Passive solar systems and solar protection**	**Points (Max 3)**
Sub-region A - European Union (EU15), Norway, and Switzerland													
France	X	X	X	X	X	X	X	X	X	X	X	X	3.0
Germany	X	X	X	X	X	X	X	X	X	X	X	X	3.0
Portugal	X	X	X	X	X	X	X	X	X	X	X	X	3.0
Spain	X	X	X	X	X	X	X	X	X	X	X	X	3.0
Switzerland	X	X	X	X	X	X	X	X	X	X	X	X	3.0
Italy	X	X	X	X	X	X	X	X	X	X	X	X	3.0
United Kingdom	X	X	X	X	-	X	X	X	X	-	X	X	2.5
Sub-region B - European Union enlargement (EU13)													
Bulgaria	X	X	X	X	X	X	X	X	X	X	X	X	3.0
Czech Republic	X	X	X	X	X	X	X	X	X	-	X	X	2.8
Slovakia	X	X	X	X	X	X	X	-	X	X	X	X	2.8
Croatia	X	-	X	X	-	X	X	X	X	-	X	X	2.3
Sub-region C - Eastern Europe, Caucasus, Central Asia and Russian Federation													
Ukraine	X	X	X	X	X	X	X	X	X	X	X	X	3.0
Armenia	X	X	X	X	X	X	X	X	X	-	X	X	2.8
Azerbaijan	X	X	X	X	-	X	X	X	X	X	X	X	2.8
Belarus	X	X	X	X	X	X	X	X	X	-	X	X	2.8
Republic of Moldova	X	X	X	X	-	X	X	X	X	X	X	X	2.8
Uzbekistan	X	X	X	X	X	X	-	X	X	X	X	X	2.8
Russian Federation	X	X	X	X	X	X	X	X	X	-	X	-	2.5
Kazakhstan	X	X	-	X	-	-	X	X	X	-	X	-	1.8
Turkmenistan	X	X	X	X	-	-	X	-	X	-	X	-	1.8
Georgia	-	-	-	-	-	-	-	-	-	-	-	-	0

Selected countries	***Thermal insulation***	***Heating and hot water***	***Air conditioning systems***	***Natural and mechanical ventilation***	**Solar gains (G-values)**	**Lighting efficiency**	**Design, position and orientation**	**Air-tightness**	**Thermal bridging**	**Renewables**	**Indoor and outdoor climatic conditions**	**Passive solar systems and solar protection**	**Points (Max 3)**
Sub-region D - North America													
Canada	X	X	X	X	X	X	X	X	X	-	X	X	2.8
United States	X	X	X	X	X	X	X	X	X	X[55]	-	-	2.5
Sub-region E – South-Eastern Europe													
Albania	X	X	X	X	X	X	X	X	X	X	X	X	3.0
Montenegro	X	X	X	X	-	X	X	X	X	X	X	X	2.8
The former Yugoslav Republic of Macedonia	X	X	X	X	X	-	X	X	X	X	X	X	2.8
Bosnia and Herzegovina	X	-	X	X	X	X	X	X	X	-	X	-	2.3
Serbia	X	X	-	-	X	-	X	X	X	-	X	-	1.8

[55] In 2018, California has become the first US state to mandate solar panels on new homes and apartment buildings built after 1 January, 2020.

2.3 Analysis of the comprehensiveness and stringency of the Energy Performance Certificates (EPC)

Description

EPC is an important instrument to enhance the energy performance of buildings. The main aim of the EPC is to serve as an information tool for building owners; occupiers and real estate actors. Therefore, it can be a powerful market tool to create demand for energy efficiency in buildings by targeting such improvements as a decision-making criterion in real-estate transactions, and by providing recommendations for the cost-effective or cost-optimal upgrading of the energy performance.[56]

In order to measure the effectiveness of the EPC, the same metrics used above for stringency and coverage of building types have been selected. An additional metric has been included to establish the existence of national registry databases for EPC across the region. The centralized EPC registries not only support the independent control system but can be a useful tool to map and monitor the national building stock.

Out of the 6 possible points, countries are awarded 1 point if their EPC are mandatory, 0.5 points for mixed or voluntary, and 0 for no EPC, giving a total possible point allocation of 1 for stringency. Countries can also earn up to 2 points for the EPC coverage. For example, for residential buildings 1 point is allotted for coverage for both single- and multifamily housing. For commercial buildings, the code must include all commercial and public buildings to receive 1 point. If the coverage is partial in either commercial or residential, countries get 0.5 points (e.g. Spain).

The countries which have a national registry database for EPC is awarded 1 point, where no national registry database for EPC exists the country is allocated 0 points against this criterion.

Results

Table 4 shows the stringency of adherence to the EPC and the types of buildings subject to the EPC "coverage" for the residential and commercial sectors. Often EPC only apply to specific types of buildings, such as single- or multifamily buildings in the residential sector.

Table 4. Energy Performance Certification in individual countries

Selected countries	Coverage				Stringency	National registry database for EPC	Points (Max 6)
	New build	Existing	Residential	Commercial			
Sub-region A - European Union (EU15), Norway and Switzerland							
France	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mandatory	Yes	6
Portugal	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mandatory	Yes	6
United Kingdom	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mandatory	Yes	6
Germany	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mixed	Yes	5.5
Switzerland	Residential;	Residential;	Single Family; Apartments	Commercial; Public Buildings	Mixed	Yes	5.5

[56]BPIE (2014) Energy Performance Certificates across the EU, a Mapping of National Approaches. Available at:http://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=7&ved=0ahUKEwiJrqL-x6DaAhUmKsAKHV4yA6EQFghKMAY&url=http%3A%2F%2Fbpie.eu%2Fwp-content%2Fuploads%2F2015%2F10%2FEnergy-Performance-Certificates-EPC-across-the-EU.-A-mapping-of-national-approaches-2014.pdf&usg=AOvVaw2u-BgNNWLGBlFtZ0O3mU5D

Selected countries	Coverage				Stringency	National registry database for EPC	Points (Max 6)
	New build	Existing	Residential	Commercial			
	Non-Residential	Non-Residential					
Italy	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mandatory	No	5.5
Spain	Residential		Single Family; Apartments	Commercial; Public Buildings	Mandatory	No	3.5
Sub-region B - European Union enlargement (EU13)							
Czech Republic	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mandatory	Yes	6
Slovakia	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mandatory	Yes	6
Bulgaria	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mandatory	Yes	6
Croatia			Single Family; Apartments	Commercial; Public Buildings	Mandatory	Yes	4.0
Sub-region C - Eastern Europe, Caucasus, Central Asia and Russian Federation							
Uzbekistan	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mandatory	Yes	6.0
Turkmenistan	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Public Buildings	Mandatory	No	4.5
Russian Federation	Residential		Apartments	Commercial; Public Buildings	Mandatory	Yes	4.0
Republic of Moldova	Non-Residential		Single Family; Apartments	Commercial; Public Buildings	Mixed	No	3.0
Azerbaijan			Apartments	Commercial; Public Buildings	Mandatory	No	2.5
Armenia (Currently not in use)						No	0
Belarus (Currently not in use)						No	0
Georgia (EPC Law to be enforced in 2019)						No	0
Kazakhstan (Currently not in use)						No	0
Ukraine[57]						No	0
Sub-region D - North America							
Canada	Residential	Residential	Single Family; Apartments	Commercial	Mixed	No	3.0
United States	Residential	Residential	Single Family;		Mixed	No	2.5

[57] In Ukraine, new rules on EPC became mandatory in July 2018.

Selected countries	Coverage				Stringency	National registry database for EPC	Points (Max 6)
	New build	Existing	Residential	Commercial			
			Apartments				
Sub-region E – South-Eastern Europe							
Bosnia and Herzegovina	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mandatory	Yes	6.0
Serbia	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mixed	Yes	5.5
Montenegro	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mixed	No	4.5
The former Yugoslav Republic of Macedonia	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mixed	No	4.5
Albania	Non-Residential			Public Buildings	Mandatory	No	2.0

According to the results in **Table 4**, the use of EPC in sub-regions A and B provides greater coverage and stringency with the average score of 5.4 and 5.5 respectively, compared to sub-regions E (4.5), D (2.8) and C (2.0). It is noteworthy, however, that some countries in sub-region C have made some progress in developing EPC. The EPC in Canada are not mandatory although an Energuide rating system developed by the federal government is widely used and supported through incentive programs. In addition, Canada, in its new "Build Smart, Canada's Buildings Strategy 2017", sets the goal for federal, provincial, and territorial governments to work together with the aim of requiring labelling of building energy use by as early as 2019. Most of the countries in sub-regions A and B employ mandatory stringency for EPC while countries in sub-region C currently have a much lower level of EPC implementation. The existence of national registry database for EPC is also more prominent in sub-regions A and B.

Denmark, Estonia, Hungary, Lithuania, the Netherlands, Portugal, Slovakia and Sweden offer access to basic EPC data, such as energy class or energy performance, for any building in an online database searchable by its address (see example below). Greece, Norway and Ireland offer this search functionality only by EPC identification number (that is known only to the building's owner). In addition, in England, Wales and Northern Ireland, there is also a feature to search by EPC identification number, postcode, street name and post town. In Italy, the regions of Marche, Emilia Romagna, Sicily and Valle d'Aosta present some EPC information on their websites. In the region of Lombardy, a complete database is publicly available.[58]

Due to the limited scope of this study, the stringency of EPC in member States was examined only to a certain extent using the criteria used for this particular metric. Thus in order to provide a more in-depth analysis on the stringency of the EPC across the UNECE region, there is an opportunity to conduct a further research into EPC across the UNECE region, particularly for countries in sub-region C, as an additional mapping exercise of national approaches to EPC deployment based on more detailed metrics. The future study should focus on the quality, availability and usability of EPC data and providing examples of good practices.

A number of responses, and the desktop study indicated that the quality of EPC is not satisfactory in some countries. There are inconsistencies across member States on the choice and design of the assessment methodology which hinders the EPC implementation process. The successful implementation of the EPC

[58]BPIE (2014) Energy Performance Certificates across the EU, a Mapping of National Approaches. Available at:http://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=7&ved=0ahUKEwiJrqL-x6DaAhUmKsAKHV4yA6EQFghKMAY&url=http%3A%2F%2Fbpie.eu%2Fwp-content%2Fuploads%2F2015%2F10%2FEnergy-Performance-Certificates-EPC-across-the-EU.-A-mapping-of-national-approaches-2014.pdf&usg=AOvVaw2u-BgNNWLGBlFtZ0O3mU5D

is also hindered by a lack of enforcement and monitoring mechanisms which can be observed from the results previously presented in **Table 4** where national registry database for EPC is not deployed consistently across member States. At present, in some countries, e.g., Belarus, Georgia and Kazakhstan, EPC is not in use.

Best Practices

Slovakia

In Slovakia, the responsibility of the EPC system and the database falls under the jurisdiction of the Ministry of Transport and Construction. Slovakia established a national database in 2010 which is becoming more and more functional with open content.

The data for newly issued certificates must first be uploaded by the qualified expert to the database in order to be approved and validated. Furthermore, Slovakia has implemented an online system which allows the registered assessors to directly access the database. The mandatory upload allows automatic quality controls at a basic level for all entered data and calculations. In addition to qualified experts, any user can view aggregated statistics by using this online tool. It is possible to view statistics for each year since 2009 for the total number of issued certificates in each of the country's provinces. The database also provides information on the year of EPC issuance, the energy class, building type, its exact address, as well as the name of the qualified assessor.

By the second quarter of 2014, the database included about 44,000 certificates, predominately (92 percent) for residential buildings. The whole system seems to be very effectively setup, making use of a very modest annual budget of around 19,200 euros. However, the operation of the database, as well as quality checks of the EPCs, are financed by the government and the actual controls are realized by the Ministry of Transport and Construction of the Slovak Republic and by the Slovak Trade Inspection.[59]

Russian Federation

Russian Federation adopted the decree 399 in August 2016, which sets the rules for energy efficiency classes of apartment buildings. The energy efficiency class is determined based on comparison of the actual energy use (for existing buildings) and estimated energy use (for new buildings), with the base energy use value set depending on the heating degree-days and the building height. The certification includes nine classes (A++ to G) and requires the building class to be presented in the energy passport and on the building façade. The A++ class presumes 60 percent energy savings in comparison to the base level. High energy efficiency classes cannot be given to a building that is not equipped with: an individual heat-supply station with automatic indoor temperature regulation, energy-efficient lighting of common areas and energy meters in each apartment. This certification system is envisioned to be mandatory; however, it is not yet enforced, and measures to stimulate compliance have not been developed yet.[60]

Ireland

The Energy Performance Certificates scheme came into effect in 2009 and became mandatory information for sales and leases. By mid-2014 25 percent of homes had Building Energy Ratings (BERs) and certificates. A one-step increase in BER rating has been valued at a 2.8 percent increase in sale price and 1.4 percent of rent.[61]

[59]BPIE (2014) Energy Performance Certificates across the EU, a Mapping of National Approaches. Available at:http://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=7&ved=0ahUKEwiJrqL-x6DaAhUmKsAKHV4yA6EQFghKMAY&url=http%3A%2F%2Fbpie.eu%2Fwp-content%2Fuploads%2F2015%2F10%2FEnergy-Performance-Certificates-EPC-across-the-EU.-A-mapping-of-national-approaches-2014.pdf&usg=AOvVaw2u-BgNNWLGBlFtZ0O3mU5D

[60]Global Alliance for Buildings and Construction (GABC) (2016) Towards zero-emission efficient and resilient buildings – Global status report 2016. Available at: http://www.buildup.eu/en/practices/publications/towards-zero-emission-efficient-and-resilient-buildings-global-status-repor-0.

[61] IEA (2015) Picture of Capturing the Multiple Benefits of Energy Efficiency. Available at: http://www.iea.org/W/bookshop/475-Capturing_the_Multiple_Benefits_of_Energy_Efficiency.

2.4 Analysis of enforcement mechanisms, including incentive packages and penalties

Since efforts to increase energy efficiency standards in building energy codes differ across countries, it is useful to analyze not only which countries seem to be designing comprehensive building energy codes, but also which are effectively implementing and enforcing those standards.

Building energy codes and regulations could be one effective way to improve energy efficiency but only if their enforcement can be ensured. Enforcing compliance with building codes and standards will be key to countering the perception that energy saving renovation measures come with a price premium.[62]

Implementing an energy standard involves a network of social systems and human interactions that stretches from the officers assigned to administer the standard to the carpenters who apply the weather-stripping.[63] Any person or group involved in a building's development, design, and construction process can affect its final energy use, so there are an almost unlimited number of opportunities for the building to comply with or deviate from the standard's recommendations. The power of the implementing agency, the level of training provided, and the effectiveness of compliance mechanisms are all important indicators of the extent to which the standard is likely to be followed. This report invites to further study these issues by probing the focus of the agency chosen to implement the standard, the type of training provided, and the approach and timing of compliance mechanisms.

Description

This metric is meant to document whether countries' building energy codes have mandatory enforcement and penalties for noncompliance.

In addition, many countries have implemented incentives and disincentives to help push contractors and home builders to comply with the codes. In this report, we attempted to capture these efforts and highlight some of the most robust policy packages. We examine three ways that codes are enforced:

- Financial incentives: Some countries have specific policy packages and incentives that complement or motivate compliance with building codes. Such mechanisms can include green loan programs, financial schemes and incentives, and public incentives including tax credits. For example, there are subsidies, which can only be obtained if certain energy efficiency requirements are fulfilled. These are based on the pure compliance with requirements in the codes or on measures stricter than the energy efficiency requirements in these codes.
- Occupancy and construction permissions: If the building does not comply with the code, then they are refused permission for occupancy or construction; and
- Fines: Enforcement of building codes includes fines and fees for noncompliance.

Regulations that require the detailed monitoring of energy consumption in buildings can drive energy-saving changes in practices and behaviors. Advanced metering and monitoring solutions are vital for enabling data-driven energy efficiency. Landlords and commercial building managers are becoming increasingly aware of power-monitoring solutions as a way of gaining a detailed view of their energy use. This insight in turn supports energy efficiency and cost-reduction efforts. Energy metering can help with identifying cost cutting opportunities by detecting inefficiencies, benchmarking building performance, improving load planning and energy usage and managing demand to ensure there is minimum exposure to volatility.[64]

To reflect the importance of monitoring, two additional metrics have been included in this part of the analysis: the requirements for monitoring and the stringency of monitoring (if these requirements are mandatory mandatory). In total five metrics were examined to investigate the status of the enforcement mechanisms in member States of the UNECE region. Countries were awarded 1 point for each of the five metrics, with the total 5 points max.

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[62] BPIE (2011) Europe's Buildings under the Microscope, A country-by-country review of the energy performance of buildings. Available at: http://bpie.eu/wp-content/uploads/2015/10/HR_EU_B_under_microscope_study.pdf.

[63] Kathryn B. Janda and John F. Busch (1994) Worldwide Status of Energy Standards for Buildings, Energy Vol. IV, No. I, pp. 27-44. 1YY4. Available at: http://www.eci.ox.ac.uk/research/energy/downloads/janda04-wsesb.pdf. Accessed on 2 March 20118.

[64] Modern Building Services (MBS) (2016) How metering and monitoring boost energy efficiency. Available at: http://www.modbs.co.uk/news/fullstory.php/aid/16534/How_metering_and_monitoring_boost_energy_efficiency.html.

Results

Table 5 lays out the enforcement standards by individual country and presents information whether the country has any of the above incentives or disincentives for compliance. A country can have more than one of these incentives in place, and the most robust packages are in countries that have all three elements. We did not take into account the stringency of any enforcement approaches, we simply report whether a country has enforcement standards in place.

The results of the gap analysis suggest that sub-regions A, B, and D have developed a number of specific policy packages and incentives that complement or motivate compliance with building energy codes. Such mechanisms include green loan programs, financial schemes and incentives, and public incentives including tax credits. The results for sub-regions C and E present a different picture where specific incentives and enforcement mechanisms are currently not widely used in building energy codes. Ukraine, for example, currently does not have incentives for owners of buildings to make energy audits and get energy performance certificates. However, the work is currently underway to introduce an Energy Efficiency Fund where the state will provide financial support to partially compensate the costs of modernization and implementation of the energy efficiency measures.

Table 5. Building Energy Codes enforcement standards

Selected countries	Specific incentive	Refusal for occupancy or construction permit	Fines for non-compliance	Requirements for energy performance monitoring	Stringency of monitoring	Points (Max 5)
Sub-region A - European Union (EU15), Norway and Switzerland						
France	X	X	X	X	-	4.0
Portugal	X	X	X	X	-	4.0
Germany	X	X	X	-	-	3.0
Italy	X	X	X	-	-	3.0
Switzerland	X	X	X	-	-	3.0
United Kingdom	X	X	X	X	-	4.0
Spain	-	X	-	X	-	2.0
Sub-region B - European Union enlargement (EU13)						
Czech Republic	X	X	X	X	Mandatory	5.0
Slovakia	X	X	X	X	Mandatory	5.0
Bulgaria	X	X	X	X	Mandatory	5.0
Croatia	-	-	X	X	-	2.0
Sub-region C - Eastern Europe, Caucasus, Central Asia and Russian Federation						
Uzbekistan	X	-	X	X	Mandatory	4.0
Russian Federation	-	X	-	X	Mandatory	2.0
Armenia	X	-	X	-	-	2.0
Azerbaijan	-	-	-	X	-	1.0
Georgia	X	-	-	-	-	1.0
Republic of Moldova	-	-	-	X	-	1.0
Turkmenistan	-	X	-	-	-	1.0
Kazakhstan	-	-	-	-	-	0
Ukraine	-	-	-	-	-	0
Belarus	-	-	-	-	-	0
Sub-region D - North America						
United States	X	X	X	X	-	4.0
Canada	X	X	X	-	-	3.0
Sub-region E – South-Eastern Europe						
Montenegro	X	X	X	X	Mandatory	5.0

Selected countries	Specific incentive	Refusal for occupancy or construction permit	Fines for non-compliance	Requirements for energy performance monitoring	Stringency of monitoring	Points (Max 5)
Serbia	-	X	-	X	Mandatory	3.0
Albania	-	-	X	X	-	2.0
The former Yugoslav Republic of Macedonia	-	X	-	X	Mandatory	2.0
Bosnia and Herzegovina	-	X	-	-	-	1.0

Best Practices

Enforcement

Albania

Albania's National Energy Efficiency Action Plan established a target of 9 percent energy use reduction across sectors by 2018. Energy use reduction in the residential building sector is expected to account for 22 percent of the broader target. Albania has taken important steps toward achieving these reductions by requiring energy efficiency standards for new building construction. Law No. 8937 defined minimal thermal efficiency standards for new construction, and Law No. 10113 mandates compliance with energy efficiency standards. Albania is working towards the development and passage of an updated Law on Energy Efficiency, which will build a framework for enforcement and implementation of national energy efficiency priorities that have previously remained unenforced.[65]

Canada

Canada has all three kinds of enforcement mechanisms in both residential and commercial codes. Canada's most advanced building code, which has not been evenly implemented across the country, contains some comprehensive energy efficiency policies, incentives, and disincentives. Onsite inspections throughout the construction process are required throughout Canada. Specifically, the Ontario Building Code's enforcement includes on-site inspection during and after the completion of a building. They also require certification and inspection of boilers and HVAC systems. Enforcement, as with nearly all building codes, is performed by localities, but the Ontario code also requires a third-party inspection and provides training for inspectors.[66]

Penalties for non-compliance

Belgium

In Flanders, fines are set for the owners (builders, constructors or installers), who fails compliance. These fines are based on the failure in complying on U-values for the surface area. For example, a one family house with non-compliant glazing was fined €2,500.[67]

Declaration of Energy Efficiency before construction

Portugal and Denmark

In Portugal and Denmark the building's energy efficiency must be declared before the building is constructed. This can be done by the architect or the contractor. After construction, a certificate is to be issued by independent consultants including a review of the self-declaration. If the building fails to comply

[65] Source: Clean Energy Solutions Center 2015
[66] Rachel Young (2014) Global Approaches: A Comparison of Building Energy Codes in 15 Countries, American Council for an Energy-Efficient Economy. Available at: https://aceee.org/files/proceedings/2014/data/papers/3-606.pdf.
[67] World Energy Council (2016) Case study on evaluation of energy building codes in emerging countries. Available at: https://wec-policies.enerdata.net/Documents/cases-studies/WEC-case-study-Energy-Building-Codes.pdf.

with the regulations, the occupancy permit needed to use the building can be rejected, until an adequate efficiency level is accomplished.

Furthermore, in Denmark all new buildings are inspected by an independent consultant, who makes calculation based on the self-declaration of the building used for the building permit, and a visual inspection on site which checks the actual insulation, glassing and installed products. Occupancy of the building can only occur once compliance with the building codes is validated.[68]

Incentives

France

France is leading the way in supporting measures. The government incentivizes and rewards initiatives beyond the building energy code. They also have robust labeling and certificate schemes that include grants, subsidies, loans, tax incentives, and trading schemes. France provides a successful example of implementing tax incentives for homeowners: due to a tax credit scheme providing tax credits for homeowners adopting measures which improve the energy performance of their dwellings, a 26 percent reduction in energy consumption of residential buildings by 2020 is expected.[69]

United States

In the US, tax incentives have been given in the last years to increase the level of insulation and to encourage the constructor and building owners to go further than the minimum requirements. These incentives have probably also helped to increase the compliance with the national codes.[70]

2.5 Analysis of energy efficiency materials and products requirements in Building Energy Codes

Description

The analysis of energy efficiency materials and products requirements is the final metric that was investigated in this report and the last step in the gap analysis. To facilitate compliance, it is essential to develop and harmonize testing, ratings and certification of building materials, and to improve the knowledge base.

The quality of building materials is a critical factor in building performance, aside from design and construction practice. In order to assure design performance of buildings, materials must be tested and certified as meeting design specifications.[71] Many low- and middle income countries lack the network of accredited materials testing laboratories necessary to certify the quality of building materials. This testing and certification is particularly important for modern construction materials, such as steel and concrete, and more complex building assemblies. However, materials testing can also be provided for indigenous materials and practices.

Three criteria were selected to be included in this metric:

- Existence of requirements to have building materials certified;
- Harmonization of building materials with CE Marking or ISO; and
- Existence of requirements to test building materials by certified test laboratories

Out of the 3 possible points, countries were awarded 1 point for each of the above criteria.

Results

Table 6 provides a brief overview of how selected countries meet each criterion for the building materials requirements metric. In general, it is safe to conclude that countries of sub-regions A and B perform consistently across all three criteria. Member States of the sub-region C have shown a lower level of

[68] Ibid.
[69] Hilke, A.; Ryan, L. Mobilizing investment in energy efficiency: Economic instruments for low energy buildings. IEA Energy Pap. 2012, 10, 156.
[70] World Energy Council (2016) Case study on evaluation of energy building codes in emerging countries. Available at: https://wec-policies.enerdata.net/Documents/cases-studies/WEC-case-study-Energy-Building-Codes.pdf.
[71] World Bank Group (2010) Building Regulation for Resilience, Managing Risks for Safer Cities. Available at: https://www.gfdrr.org/sites/default/files/publication/BRR%20report.pdf.

consistency in implementing these requirements compared to the sub-regions A and B, with some countries being more stringent than the others when it comes to materials certification and testing. A number of countries from sub-regions C and E, e.g. Albania, Georgia, Turkmenistan, Ukraine and the former Yugoslav Republic of Macedonia, showed relatively low level of implementation for this metric, while other countries, e.g. Armenia, Bosnia and Herzegovina, Kazakhstan, Montenegro, Russian Federation, Serbia and Uzbekistan, exhibited greater level of commitment to implement energy efficiency materials and products in their building energy codes.

Overall, sub-regions A, B, D are leading with an average score of 3 (max score), followed by sub-regions E (2.2) and C (2.0).

Table 6. Building materials and products requirements

Selected countries	Requirements to have building materials certified	Building materials are harmonized with CE Marking or ISO	Requirements to test building materials by certified test laboratories	Points (Max 3)
Sub-region A - European Union (EU15), Norway and Switzerland				
France	X	X	X	3.0
Portugal	X	X	X	3.0
Spain	X	X	X	3.0
Switzerland	X	X	X	3.0
United Kingdom	X	X	X	3.0
Germany	X	X	-	2.0
Sub-region B - European Union enlargement (EU13)				
Slovakia	X	X	X	3.0
Bulgaria	X	X	X	3.0
Croatia	X	X	X	3.0
Czech Republic	X	X	X	3.0
Sub-region C - Eastern Europe, Caucasus, Central Asia and Russian Federation				
Armenia	X	X	X	3.0
Kazakhstan	X	X	X	3.0
Uzbekistan	X	X	X	3.0
Russian Federation	X	X	X	3.0
Azerbaijan	X	-	X	2.0
Belarus	X	-	X	2.0
Republic of Moldova	-	X	X	2.0
Turkmenistan	X	-	-	1.0
Ukraine	X	-	-	1.0
Georgia	-	-	-	0
Sub-region D - North America				
Canada	X	X	X	3.0
United States	X	X	X	3.0
Sub-region E – South-Eastern Europe				
Bosnia and Herzegovina	X	X	X	3.0
Montenegro	X	X	X	3.0
Serbia	X	X	X	3.0
Albania	-	X	-	1.0
The former Yugoslav Republic of Macedonia	-	X	-	1.0

Best Practices

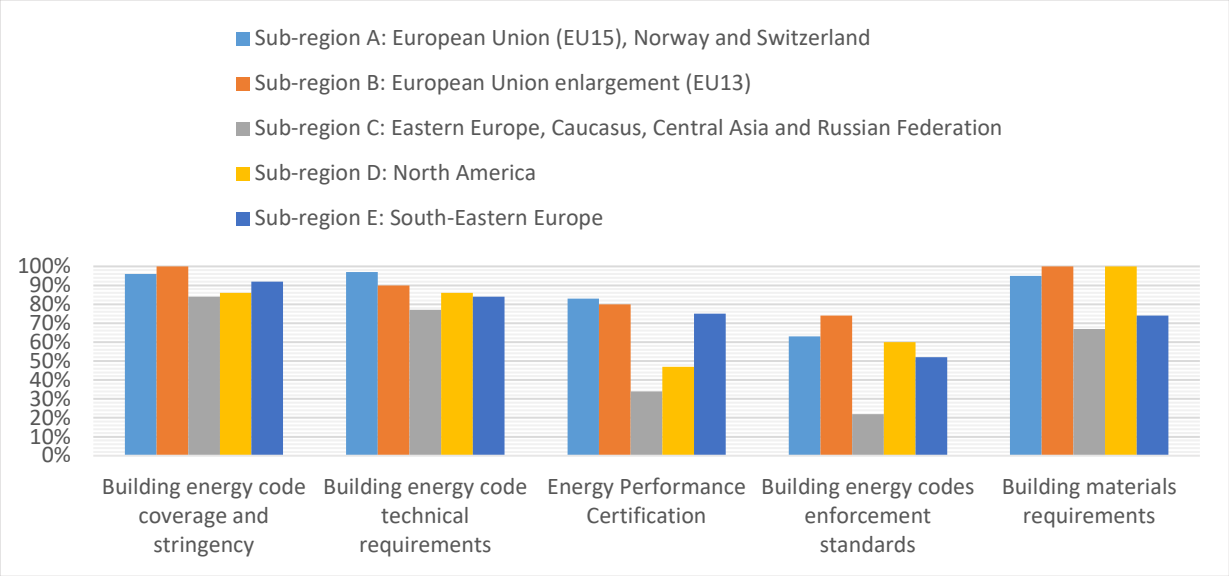
Armenia

In Armenia, technical regulation on "ES and EE in residential multi-apartment buildings under construction as well as in objectives constructed (reconstructed, repaired) at the expense of state means" (12.04.2018) was adopted in April 2018. New building code on "Thermal Protection of Buildings" was developed and adopted in July 2016. 17 EU and ISO standards on energy efficiency were developed/adopted and registered: a database of insulation construction materials and lighting equipment produced locally or imported to Armenia (with technical parameters) was prepared in 2013 and 2016, and an Advisory Handbook on Technical Solutions in Insulation was adopted by the resolution of the Minister of Urban Development in 2013. In addition, a full package of replicable design documents for 5 energy-efficient residential houses (published on the web-site of the State Committee on Urban Development) has been available free of charge for use since 2014. A modern thermal physics laboratory was established for testing and certification of building insulation materials and lighting equipment and more than 13 types of insulation materials were tested and certified since then. An educational energy efficiency laboratory was established for students studying architecture and civil engineering.[72]

Overview of the results of the gap analysis

Fig. 19 below illustrates the overall effectiveness of the building energy codes by sub-region across all five metrics, where previously calculated average scores were converted into percentages (where 100 percent indicates max amount of points per metric).

Figure 19: Effectiveness of building energy codes by sub-region



In Europe, the Energy Performance of Buildings Directive (EPBD, 2002/91/EC) was a step forward through which sub-regions EU15 and EU13 introduced energy efficiency requirements in buildings. This explains a greater level of consistency across the countries that fall under the EPBD in reporting building energy standards stringency, coverage, technical requirements, energy efficient materials and enforcement measures with just a few exceptions noted in some countries. **Fig. 19** presents the results of the gap analysis revealing that, although the first two metrics (codes stringency and coverage and technical requirements) do not indicate a high level of disparity in their application between sub-regions, metrics concerning requirements for the EPC, incentives, enforcement mechanisms and building materials and products suggest an area of focus for further harmonization and an opportunity for improvement in some countries, particularly for countries in sub-region C. In light of these findings, a number of recommendations have been suggested and can be found in **Chapter 4** of this report.

[72]United Nations Development Programme (UNDP) (2016) Armenia -Energy Efficiency in Building Sector, Seventh International Forum on Energy for Sustainable Development, Diana Harutyunyan and VahramJalalyan. Available at: https://www.unece.org/fileadmin/DAM/energy/se/pp/eneff/7th_IFESD_Baku_Oct.2016/3GEEE_UNDP.GEF/2_Vahram.Diana_Armenia.pdf.

CHAPTER 3. INITIAL ASSESSMENT OF ENERGY EFFICIENCY TECHNOLOGIES IN BUILDINGS IN RELATION TO THE EXISTING STANDARDS

3.1 Introduction

In most regions of the world, heating and cooling loads represent the largest building-sector energy end-use. The building envelope can be significantly improved to reduce the energy needed to heat and cool buildings. With energy efficiency (EE) technologies such as high energy efficient windows, high levels of insulation, well-sealed structures, and cool roofs in hot climates, the need for indoor heating and cooling can be avoided or reduced in many parts of the world.

Building envelope improvements are critical to achieve the transition to sustainable buildings, but most countries have still not made them an explicit policy priority. According to the IEA [73], in most of the world, the energy performance of building envelopes has been significantly neglected. While there has been substantial success in improving the energy efficiency of heating and cooling equipment, many buildings are still being constructed leaky, have no insulation or exterior shade control, and have single-glazed clear glass windows.[74]

Increasing the energy efficiency of heating and cooling equipment is an important step towards reducing energy consumption and emissions in the buildings sector. Heating and cooling loads in buildings need to be addressed through best available and advanced technologies that are significantly more efficient, both in terms of energy input and heat output. Effort is also needed on both technical and market maturity. Advanced products that have been commercialized but only serve niche markets need to be improved to become market viable, requiring a combination of efforts related to cost reduction, ease of installation and market conditioning.[75]

Having said that, the aim of this chapter is to provide an initial assessment of energy efficiency technologies in buildings in relation to the existing standards used by the UNECE member States.

This preliminary analysis covers the main building envelope components, photovoltaic systems, selected space and water heating and cooling equipment. However, it does not cover combined heat and power, lighting, cooking, plug loads, appliances, metering and building automation and control systems (BACS) as this chapter provides an overview of the topic which will be further analyzed in other reports.

The preparation of this initial assessment was based on the data collected using the survey responses (see **Annex I**) and the desktop study on the recent trends in deployment of the energy efficiency technologies as well as on the results of the previously published documents.

In particular, part six of the questionnaire focuses on determining the status of the energy efficiency technologies deployment in the countries of the UNECE region. The data collected from of the questionnaire was analyzed and presented in a tabular form at the end of this chapter for selected countries from all sub-regions across individual metrics (energy efficiency technologies) to provide a comparative analysis. This analysis also includes some examples of the recent trends in the selected countries and highlights a few case studies where a successful application of the above-mentioned energy efficiency technologies has been demonstrated. Furthermore, several recommendations have been suggested to address the identified gaps.

3.2 Overview of global trends in energy efficiency technologies

Existing buildings in cold climates with little or no insulation offer the greatest potential for saving energy by installing insulating products and devices. There is also significant potential for energy savings in developing countries, where insulation is often not installed. Advanced insulation materials are also

[73] IEA (2013) Technology Roadmap. Energy Efficient Building Envelopes. Available at: https://www.iea.org/publications/freepublications/publication/TechnologyRoadmapEnergyEfficientBuildingEnvelopes.pdf.
[74] Ibid.
[75] IEA (2013) Transition to Sustainable Buildings. Available at https://www.iea.org/publications/freepublications/publication/Building2013_free.pdf.

beginning to enter the market in various niche applications. Cost is a primary barrier to greater application and in some cases there are also concerns about long-term performance. For example, advanced foam insulation can be difficult to install at lower ambient temperatures.

For the vast majority of buildings that require heating or cooling, tight air sealing with mechanical ventilation will result in large energy savings. While air-sealing methods during new construction are widely available, validation testing can still be expensive, especially in large buildings.[76]

Most cold-climate developed countries are making a significant effort to promote high-performance windows, but triple-glazed windows, which have been available for many decades, have not achieved full market share in any country. Triple glazing with clear glass was more prevalent in Northern European countries but then diminished because manufacturers were able to achieve comparable performance using modern, double-glazed, low-e coated windows. This trend is changing, however, with the promotion of the Passivhaus programme and recent more stringent building codes. Austria, Germany and Switzerland have the highest market share for triple glazing usually with two low-e surfaces, at 54 percent of total window sales. New constructions and the residential sector have the highest market penetration. Overall, the majority of windows sold in the European Union are still double-glazed.[77] More effort is needed globally to research, develop, deploy and expand the market for high performance window technology in all building applications.

Solar energy is promoted in many countries as a substitute for conventional energy currently used to produce hot water. Solar water heaters represent a good economic and environmental solution to save commercial energies, especially in southern countries with a good solar radiation.

In recent years, photovoltaic (PV) cells have become the focus of renewable energy discussions for buildings as they generate electricity and often have greater versatility than solar thermal technologies. However, solar thermal systems are a valuable resource that needs to be expanded in the buildings sector. Solar thermal heat production already has a strong global capacity and could be expanded significantly given the right policy discussions and incentives.[78]

Heat pumps for cooling and space and water heating are mature, highly efficient technologies that take advantage of renewable energy and play an important role in heat decarbonization. Heat pumps have the advantage of providing both heating and cooling with a single unit offering an opportunity to lower initial costs. Sales of heat pumps and renewable heating equipment have continued to increase by around 5 percent per year since 2010, representing 10 percent of overall sales in 2017.[79] Yet despite this progress in Europe and elsewhere, significantly greater attention is needed to increase sales of high-performance heat pumps and solar thermal heating in buildings.[80]

In recent years, in many countries, condensing gas boilers, with efficiencies often higher than 90 percent, have gradually displaced coal, oil and conventional gas boilers, whose efficiencies are frequently less than 80 percent.

3.3 Preliminary analysis of the EE technology deployment

Building envelope components

The analysis of building envelopes is complicated by the extreme global diversity of building materials, climates, and standards and practices of building design and construction,[81] as well as the suitability of energy-efficient technologies depends on the type of economy, climate and whether the materials that are

[76] IEA (2013) Transition to Sustainable Buildings. Available at https://www.iea.org/publications/freepublications/publication/Building2013_free.pdf.
[77] Interconnection (2013), "Euro Crisis Strains the Western European Window Industry, No Recovery Before 2014", May, www.interconnectionconsulting.com.
[78] Ibid.
[79] IEA. [Online]. Heating in buildings. Available at: http://www.iea.org/tcep/buildings/heating/.
[80] Ibid.
[81] IEA (2013) Technology Roadmap. Energy Efficient Building Envelopes. Available at: https://www.iea.org/publications/freepublications/publication/TechnologyRoadmapEnergyEfficientBuildingEnvelopes.

being used for new buildings or retrofits. Thus, policies need to be devised and implemented at the city, regional and country levels.

To achieve the large energy savings that efficient building envelopes can offer, full market saturation (deployment) of high-priority, energy efficient building materials is essential. Data on current market share are difficult or expensive to obtain in developed countries and are often not available in emerging markets.

Table 7 below presents the findings of the status of market saturation for high-priority building envelope components by the UNECE sub-regions. The results were based on the information available from previously published reports from the IEA and the feedback from experts. The IEA has used assessment and inputs from experts worldwide to estimate three levels of market saturation: mature market (greater than 50 percent), established market (approximately 5 percent to 50 percent), and initial market presence (available but less than 5 percent). Policy makers should collect better data and track the progress of energy-efficient building envelope materials and technologies, in order to promote high-performance buildings as part of comprehensive building technology programmes.[82]

There is a scope for further research of the market saturation for high-priority building envelope in the UNECE region in a subsequent energy efficiency technologies study where data could be collected from the relevant national experts and statistical agencies to define market saturation in individual countries.

Table 7: An assessment of market saturation for high-priority building envelope components

Countries	Double-glazed low-e glass	Window films	Window attachments (e.g. shutters, shades, storm panel)	Highly insulating window (e.g. triple-glazed)	Typical insulation	Exterior insulation	Air sealing
Sub-region A - European Union (EU15), Norway and Switzerland	Mature market	Established market	Mature market	Established market	Mature market	Mature market	Mature market
Sub-region B - European Union enlargement (EU13)	Mature market	Established market	Mature market	Established market	Mature market	Mature market	Established market
Sub-region C – Eastern Europe, Caucasus, Central Asia and Russian Federation	Established market	Initial market	Initial market	Initial market	Mature market	Initial market	Initial market
Sub-region D - North America	Mature market	Established market	Established market	Initial market	Mature market	Mature market	Established market
Sub-region E- South-Eastern Europe	Mature market	Established market	Established market	Initial market	Mature market	Established market	Established market

Source: Adapted from the IEA Technology Roadmap Energy Efficient Buildings Envelopes, 2013.[83]

This market assessment shows that sub-regions A, B and D have made the most progress in deploying energy efficient building envelope components. From a technology perspective, the deployment of typical insulation has been successful with full maturity in most sub-regions, followed by low-e glass with some established markets. However, much more work is needed, especially in sub-region C, to promote market

[82] Ibid.
[83] The results of the market assessment of the progress in deploying energy efficient building envelope components may have changed since 2013.

saturation for advanced building materials.[84] For example, air sealing was assessed as being an initial market for sub-region C. Air-sealing is a key way of increasing energy efficiency during new construction and deep renovation. Therefore, it is important to validate the results of air sealing by carrying out standardized tests of its effectiveness in individual markets. According to the responses received from the survey, the majority of countries have air-tightness included in their building energy codes technical requirements, while some countries, e.g. Slovakia and Turkmenistan, currently do not have these requirements included. At the same time, only 64 percent of respondents indicated absence of a mandatory requirement for air-tightness test, majority of whom were countries of sub-region C.

Table 8 below presents data of sales of some building envelope components in selected countries for 2013. Slovakia (6.0 kg per 1000 capita), Denmark (4.4 kg per 1000 capita) and Sweden (3.5 kg per 1000 capita) were the top three countries in Europe with the highest sales of expansible polystyrene while Belgium took a distinctively leading position in sales of polyurethane (67.2 kg per 1000 capita) in 2013. Italy and Denmark were the countries with the highest sales of biomass based (wood wool) building envelope components with sales amounting to 0.96 and 0.80 kg per 1000 capita respectively, while Slovakia, Poland and Belgium had the highest number of annual share of buildings with new multiple-walled insulating units of glass. At the same time, the sales of shading devices were more prominent in Denmark, Spain and Italy with 1.05, 0.80 and 0.72 m^2 per capita respectively in 2013, which can be explained by the mandatory requirements for solar shading in these countries building energy codes.

There is an opportunity to conduct further data collection of more up-to-date information on the sales figures of building envelope components in the countries of the UNECE region in the subsequent studies**.**

Table 8: Building envelope components sales in selected countries, 2013

Annual sales, 2013	Sales of expansible polystyrene in kg per 1000 capita	Sales of polyurethane in kg per 1000 capita	Sales of biomass based (wood wool) in kg per 1000 capita	Annual share of buildings with new multiple-walled insulating units of glass, %	Sales of shading devices area per capita, m^2 per capita
Austria		3.4			
Denmark	4.4		0.80	0.50	1.05
Germany				0.36	
Luxembourg	0.87	2.1	0.10		0.44
Netherlands		3.4	0.26		
Norway					
Poland			0.11	0.83	0.37
Czech Rep.		3.3			
Portugal	0.86	1.3	0.02	0.36	0.66
Belgium		67.2		0.76	0.05
Slovakia	6.0	2.0		0.86	
Spain	0.76	1.5	0.14		0.80
Sweden	3.5	1.2	0.04	0.29	
Italy	2.6	4.8	0.96	0.34	0.72
France	1.4		0.09	0.48	
UK		2.2	0.07	0.48	

Source: Data adapted from Zebra Monitoring, http://www.zebra-monitoring.enerdata.eu/overall-building-activities/annual-installation-of-photovoltaic-systems-per-capita.html#sales-of-biomass-boilers-per-1000-dwellings-wood-chip-and-pellet.html

[84] IEA (2013) Technology Roadmap. Energy Efficient Building Envelopes. Available at: https://www.iea.org/publications/freepublications/publication/TechnologyRoadmapEnergyEfficientBuildingEnvelopes.pdf.

Heating, cooling and other energy efficiency *technologies*

The deployment levels of heating and cooling technologies can be influenced by a range of factors, including awareness of the technology's benefits among consumers, builders and policy makers; the implementation of financing mechanisms to mitigate up-front cost barriers; and the availability of performance standards and certification programmes. Given the well-documented non-market barriers that energy efficient and low/zero-carbon technologies face, active government policy developed in partnership with consumers, building developers, architects, manufacturers, industry associations and local and regional governments will be essential to unlocking the potential these technologies have to reduce energy consumption and CO_2 emissions.[85]

The advanced energy efficiency technologies discussed earlier have significant technical and economic considerations relating to climate (see **Table 9**). The complexity can exist not only in a regional and global context, but also within a specific country. Manufacturers are interested in developing products that have the greatest possible market, so climate is an important consideration for them. Policy makers also have a similar perspective. For example, to address the large global residential heating load, advanced building envelope technologies and heating equipment need to be marketed to the locations with colder weather and greatest populations. Milder weather locations will have lower energy savings and cost effectiveness is diminished because installed costs are the same but usage is much lower.[86]

Table 9: Technology complexities with climate considerations

Technology	Climate		
	Cold	**Mixed**	**Hot**
Gas absorption heat pump for heating	High priority, most cost effective	With cooling capability. Could be cost effective.	Less cost effective
Solar cooling	Not recommended.	Harder to justify.	High priority. Most cost effective.
Solar thermal: water and heat	Freeze protection, less resource.	Freeze protection, good demand.	Low-cost options for water heating.
Heat pump water heater (air source)	Cold ground water, but cold ambient air.	High priority, decent ambient air and cold ground water	Great ambient air temperatures but warmer ground water.

Source: Adapted from IEA, https://www.iea.org/publications/freepublications/publication/Building2013_free.pdf

The results presented in **Table 10** below, provide an analysis of the market saturation of heating, cooling and other energy efficiency technologies, and are based on the responses received from the survey on which energy efficiency technologies are present in the country. The preliminary assessment shows that sub-regions A, B and D have made significant progress in deploying energy efficiency technologies. However, there is a need for improvement in sub-region C to promote market saturation for advanced energy efficiency technologies.

Table 10: An assessment of market saturation of heating, cooling and other energy efficiency technologies

Countries	Condensing boilers	Biomass boilers (wood chip and pellet)	Pellet stoves	Heat pumps	Solar thermal systems	PV systems	Other
Sub-region A - European Union (EU15), Norway and Switzerland							
France	X	X	X	X	X	X	
Germany	X	X	X	X	X	X	

[85] IEA (2011) Technology Roadmap Energy-efficient Buildings: Heating and Cooling Equipment. Available at: http://www.iea.org/publications/freepublications/publication/buildings_roadmap.pdf.
[86] IEA (2013) Transition to Sustainable Buildings. Available at https://www.iea.org/publications/freepublications/publication/Building2013_free.pdf.

Countries	Condensing boilers	Biomass boilers (wood chip and pellet)	Pellet stoves	Heat pumps	Solar thermal systems	PV systems	Other
Italy	X	X	X	X	X	X	
Portugal	X	X	X	X	X	X	Cogeneration, trigeneration, district heating and cooling
Switzerland	X	X	X	X	X	X	
Spain	X	X	X	X	X	X	
United Kingdom	X	X	X	X	X	X	
Sub-region B - European Union enlargement (EU13)							
Bulgaria	X	X	X	X	X	X	
Croatia	X	X	X	X	X	X	
Czech Republic	X	X	X	X	X	X	Forced ventilation with heat recovery, heat recovery
Slovakia	X	X	X	X	X	X	Combined Heat and Power
Sub-region C - Eastern Europe, Caucasus, Central Asia and Russian Federation							
Armenia	X	X	-	X	X	X	
Azerbaijan	X	X	X	X	X	X	
Belarus	X	X	-	X	X	X	
Georgia	X	-	-	X	-	-	
Kazakhstan	-	X	X	X	X	-	
Republic of Moldova	-	X	X	X	X	X	
Russian Federation	-	X	X	X	X	X	
Turkmenistan	-	-	-	-	-	-	
Ukraine	X	X	X	X	X	-	
Uzbekistan	X	X	X	X	X	X	
Sub-region D - North America							
Canada	X	X	X	X	X	X	
United States	X	X	X	X	X	X	
Sub-region E – South-Eastern Europe							
Albania	-	X	X	X	X	X	
Montenegro	X	X	X	X	X	X	
Bosnia and Herzegovina	X	X	X	X	X	X	
Serbia	X	X	X	X	X	X	
The former Yugoslav Republic of Macedonia	X	X	X	X	X	X	

For example, among the countries of the sub-region A, according to the responses received, in Portugal, solar water heaters in new buildings are mandatory and there are specific legal frameworks favoring other renewables and high efficiency cogeneration. EPCs get a higher rating by the existence of renewable energy

installations and high efficient ones. Germany, instead, is witnessing an increase in gas condensing boilers, heat pumps and biomass heating, while solar heat systems slightly decreasing after peak in 2008.

Among the countries of the sub-region B, in Czech Republic there are national financial instruments that support energy efficient technologies that meet stricter requirements, such as highly-efficient boilers, forced ventilation systems with heat recovery and heat pumps. In Bulgaria heat pumps are getting more popular. There are still obstacles in the introduction of individual PV systems. Gas installations for single-family homes is also expected to rise in Bulgaria, while Switzerland has applied strong incentives to encourage distributed (building mounted) PV systems and heat pumps.

Most of the Central Asian countries and Azerbaijan have limited availability of energy efficiency products on the market. Georgia has an evolving market with energy efficiency products of limited variety. In Turkmenistan, there is currently development of an automatic heat control for the heating supply system. The countries located closer to the EU and more harmonized with EU processes (Belarus, Republic of Moldova and Ukraine) have most of the necessary energy efficiency products, and even manufacture some varieties locally. In particular, in the Republic of Moldova all equipment is imported and energy efficiency technologies have a high rate of penetration on the market, while Canada also has indicated a rapidly transforming market, with industry recognizing codes and standards are changing dramatically over the coming years. Armenia has a new law[87] giving strong impetus for the development of the PV plants. Both PV and solar thermal systems are now well represented on the local market with more than 10 companies importing and a few companies even locally producing the PV modules. Furthermore, local financial institutions have developed various loan products for financing the installation of both systems in recent 2-3 years.

Finally, in Montenegro, biomass boilers and stoves become more popular in recent year, mostly thanks to the implementation of ENERGY WOOD project (interest-free credit line for installation of heating systems on modern biomass fuels (pellets, briquettes) for households). Biomass boilers and condensing boilers have been promoted through MEEP and EEPPB projects (refurbishment of educational and health care buildings in Montenegro). Partly, through these projects solar thermal systems and heat pumps have been promoted. Use of photovoltaic systems (decentralized) has been initiated through project SOLARNI KATUNI (installation of photovoltaic solar systems in summer pasture lands).

Table 11 below presents data on the annual installations and sales of heating and cooling energy efficiency technologies in selected countries for 2013. Information for other countries was not available. There is an opportunity to conduct further data collection on more up-to-date information on sales figures of the energy efficiency technologies in countries of the UNECE region in the subsequent studies for further analysis.

Table 11: Energy efficiency equipment sales in selected countries, 2013

Annual installations and sales, 2013	Solar thermal systems per capita, m^2/1000 capita	Photovoltaic systems per capita, kW/1000 capita	Sales of condensing boilers per 1000 dwellings	Sales of biomass boilers per 1000 dwellings (Wood chip and pellet)	Sales of pellet stoves per 1000 dwellings	Sales of heat pumps per 1000 dwellings
Austria	21.3	42.8		3.5	0.67	5.2
Denmark	20.8	0.89	4	1.7		1.8
Germany	12.9			0.48	0.39	
Luxembourg	11.5					2.9
Netherlands			56.6			4.3
Norway						22.5
Poland	7.1	0.04	7.2	0.57	12.7	
Czech Rep.	7		2.4	0.61	0.12	1.7

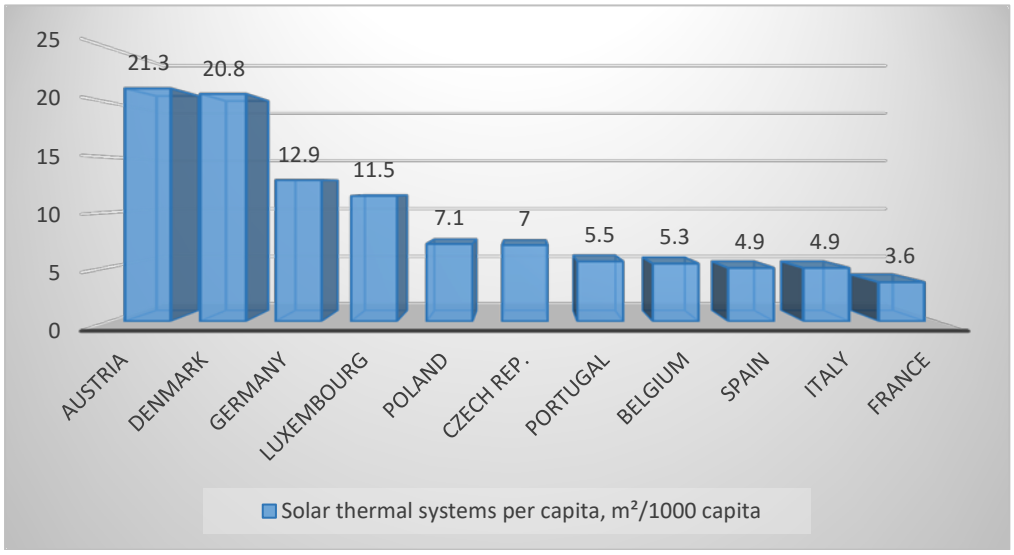
[87] On the 12 May 2016, and 21 December 2017 the Armenian Parliament adopted amendments to the laws “On Energy” and “On Energy Saving and Renewable Energy”.

Annual installations and sales, 2013	Solar thermal systems per capita, m²/1000 capita	Photovoltaic systems per capita, kW/1000 capita	Sales of condensing boilers per 1000 dwellings	Sales of biomass boilers per 1000 dwellings (Wood chip and pellet)	Sales of pellet stoves per 1000 dwellings	Sales of heat pumps per 1000 dwellings
Portugal	5.5					18.2
Belgium	5.3	17.1		0.09	0.64	
Slovakia			3.8			
Spain	4.9	41.4		0.07	0.76	2.8
Sweden		0.07		0.78		8.6
Italy	4.9	12.8	10.2		7.8	34.8
France	3.6	5	12	0.32	3.3	11.1
UK			53.1			

Source: Data adapted from Zebra Monitoring, http://www.zebra-monitoring.enerdata.eu/overall-building-activities/annual-installation-of-photovoltaic-systems-per-capita.html#sales-of-biomass-boilers-per-1000-dwellings-wood-chip-and-pellet.html

As can be seen in **Fig. 20** below, Austria is the benchmark for most countries with medium solar radiation concerning the annual installations of solar thermal systems with 21.3 m² per capita installed in 2013, followed by Denmark (20.8) and Germany (12.9). In most EU countries financial (subsidies or soft loans) and fiscal incentives (tax credit) exist to encourage households to install solar water heaters in their dwellings. Furthermore, regulations have been recently created which makes mandatory the installation of solar heaters in new construction in some countries (e.g. Portugal and Spain).[88]

Figure 20: Annual installation of solar thermal systems per capita, m²/1000 capita, 2013



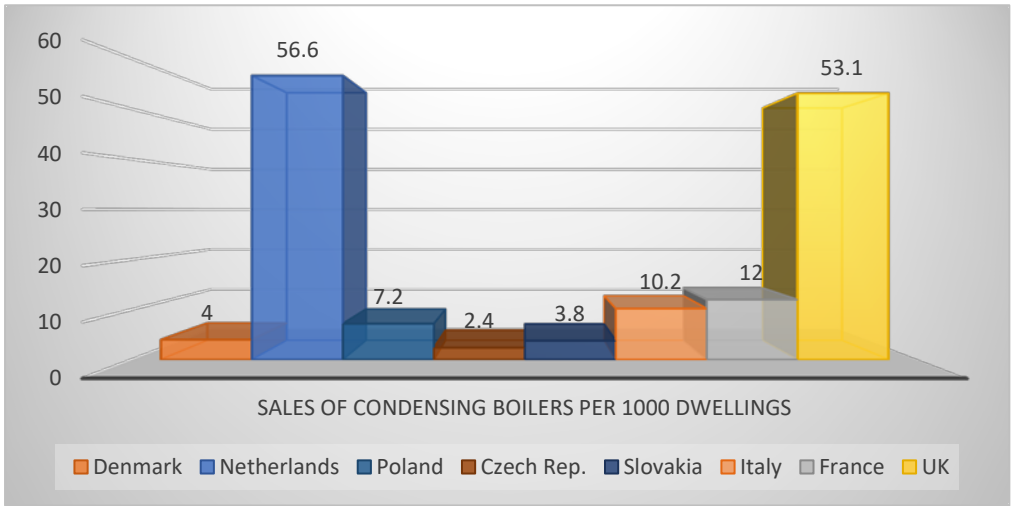
Source: Data compiled from Zebra Monitoring, http://www.zebra-monitoring.enerdata.eu/overall-building-activities/annual-installation-of-photovoltaic-systems-per-capita.html#sales-of-biomass-boilers-per-1000-dwellings-wood-chip-and-pellet.html

Annual sales of condensing boilers for selected countries in 2013 are presented in **Fig. 21** below. As showed in the figure, the biggest number of sales of condensing boilers were in Netherlands (56.6 units per 1000 dwellings) and in the United Kingdom (53.1 units per 1000 dwellings). This could be due to the existence of the stringent requirements in these countries for compulsory condensing boilers that gave right signals for a wider deployment of this energy efficiency technology in the market. However, it is noteworthy that

[88] Enerdata (2012) Energy Efficiency Trends in Buildings in the EU. Available at: https://energiatalgud.ee/img_auth.php/6/68/Enerdata._Energy_Efficiency_Trends_in_Buildings_in_the_EU._2012.pdf.

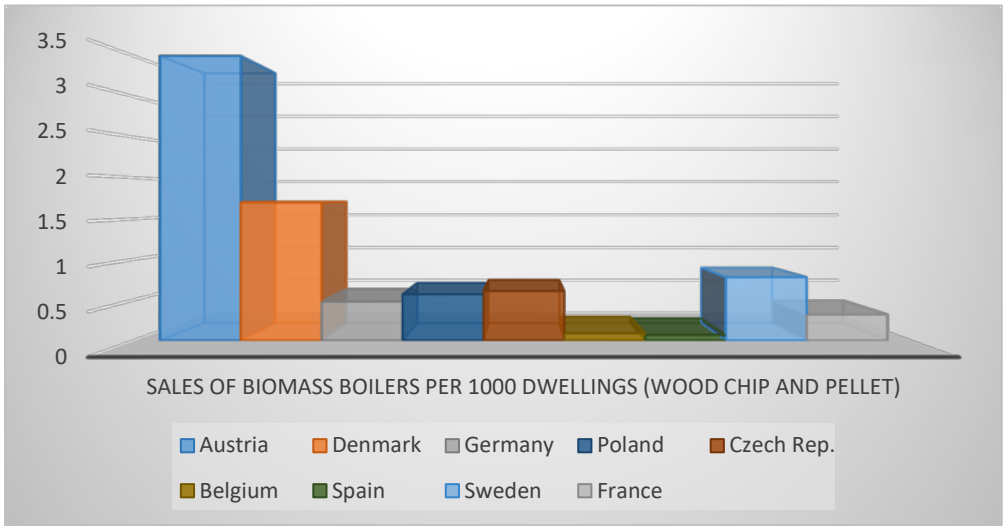
the current policy of Netherlands is to ban the use of natural gas as mayor fuel for heating. This change in policy is the result of the need to bring domestic gas production to zero due to earthquakes; to significantly reduce CO_2 emissions in conformity with the Paris agreement; and to reduce the country's dependency on imported energy. In addition to these factors, the current relation between the price of kWh's electricity and m^3 natural gas have become a game changer for the Dutch market for new and renovated buildings. This has led to a wider deployment of the heat pumps on the market. The heat pumps have become the most used (intermediate) solution and are used in combination with low temperature heat emission systems and high temperature cooling emission systems. These emission systems are possible due to a higher level of thermal insulation and airtightness and the use of ventilation heat recovery in new and renovated buildings.

Figure 21: Annual sales of condensing boilers per 1000 dwellings, 2013



The annual sales of biomass boilers for selected countries in 2013 are presented in **Fig. 22** below. It is evident that in 2013, Austria, Denmark and Sweden had the largest proportion of annual sales of biomass boilers with 3.5, 1.7 and 0.78 units per 1000 dwellings respectively.

Figure 22: Annual sales of biomass boilers per 1000 dwellings, 2013



Austria has 46 percent forest coverage and a significant rural population. The Austrian domestic-scale market for biomass systems is dominated by central heating systems. In the year 2013, 10,281 pellet boilers, 5,754 wood log boilers and 3,477 wood chip boilers were sold on the Austrian market. Furthermore 2,454 pellet stoves, 7,411 cooking stoves and 14,923 wood log stoves were sold on the domestic market. The total turnover of Austrian biomass boiler producers (952 million Euro) as well as of domestic stove manufacturers (131 million Euro) amounted to 1.1 billion Euro in the year 2013. This resulted in a total

number of 5,043 jobs in Austria.[89] As of 2012, there were 1.5 million <50kW domestic biomass boiler systems installed compared to only 26,000 stoves systems.[90] 80 percent of new homes in Austria have a biomass boiler installed with a 25kW typical size.[91]

Austria has had incentives schemes to support biomass heating systems since the 1980s to reduce reliance on heating oil. The Environmental Aid Act (UFG) provides for the general support of schemes to protect the environment. There are special investment incentives for solar thermal installations, heat pumps, geothermal energy and biomass heating plants, especially for businesses. Schemes vary per province but grant of up to 30 percent of the investment cost are available.[92]

The installed base of wood heating systems in Germany is estimated as 9 million units and increasing. One in five German households uses wood heating. The majority of system is currently wood stoves but the use of central wood boiler systems has increased to one fifth of wood-burning households.[93] Annual sales are estimated at 400,000 units for all wood systems.[94]

Germany has a general energy efficiency loan scheme for home improvements with up to €75,000 with loan amount reduced based on achieved improvement and subsided interest rates. Grants for up to 20 percent are also available. This was instigated in 2001 and is managed by Development Bank, KFW.[95]

3.4 Recent trends in energy efficiency technologies deployment in selected countries

United Kingdom

In the United Kingdom, the use of biomass for energy varies from small wood stoves to large-scale co-firing in power stations. Wood burning stoves have experienced a huge upsurge in popularity over the past decade. In 2017, more than one million homes are already using wood burning stoves and fireplaces, and annual sales are currently more than 175,000 units in the United Kingdom.[96]

Emergence of Low Carbon Heating Sales of heating technologies that can help to reduce greenhouse gas (GHG) emissions have steadily increased, supported by subsidies from the Government's domestic and nondomestic Renewable Heat Incentive (RHI) schemes. The latest Building Services Research and Information Association (BSRIA) research indicates that around 22,000 heat pumps were installed in the United Kingdom in 2017, which represents an increase of 18 percent in volume compared to the previous year.

This increase comes after five years of almost continuous market decline that has been caused by the economic slump, the low price of oil, the uncertainty around the Renewable Heat Incentive (RHI) programme, the Brexit outcome and the concerns around the pound to Euro exchange rate.[97] Over the last decade sales have grown and there are now around 120,000 electric heat pumps,[98] with over 19,000 accredited by the domestic RHI in its first year, 2014.[99]
Solar thermal capacity rose by almost four times between 2003 and 2010. Since 2010, the rate of increase has been declining and the introduction of the domestic RHI in 2013 has not altered the trend. PV installations have fallen after government cuts. After analyzing eight years of government data, Energi

[89] Central European Biomass Conference (2017) Bioenergy in Austria. A factor creating added value. Austria, 2017. Available at: www.biomasseverband.at/publikationen/falter/?eID=dam_frontend_push...4532.
[90] Audigane et al (2012). *European Pellet Report 2012.* Report for Pellcert.
[91] Ibid.
[92] Legal sources on renewable energy (2017).[Online]. Available at: http://www.res-legal.eu/search-by-country/austria/single/s/res-hc/t/promotion/aid/subsidy-environmental-assistance-in-austria-ufi/lastp/94/.
[93] ADEME (2013). [Online]. Available at: http://www2.ademe.fr/servlet/getDoc?id=38480&m=3&cid=96.
[94] Ibid.
[95] BSRIA (2014) Development of Systemic Packages for Deep Energy Renovation of Residential and Tertiary Buildings including Envelope and Systems. Available at:http://inspirefp7.eu/wp-content/uploads/2016/08/WP2_D2.1b_20140523_P18_Policies-and-incentives-relevant-to-retrofit.pdf.
[96] Stove Industry Alliance (SIA).[Onlline]. The contribution wood burning stoves can make to carbon reduction and sustainable energy. Available at: http://www.stoveindustryalliance.com/newsarticle/?LatestNews_ID=10000&pPK=618f83d6-c438-4b35-9515-8c3b1aa76bf9.
[97] Open Access Government (2018). [Online]. UK heat pump market is growing again. Available at: https://www.openaccessgovernment.org/uk-heat-pump-market-is-growing-again/44301/.
[98] Committee on Climate Change (CCC) (2015) Meeting Carbon Budgets - Progress in reducing the UK's emissions 2015 Report to Parliament, page 80.
[99] Department of Energy and Climate Change (DECC) (2015) RHI deployment data: May 2015.

Mine found that solar photovoltaics (PV) installations dropped following a shift in government policy away from a rebate incentive scheme called the feed-in tariff (FiT) in 2016.[100]

The firm's research found that in the two years since the government cut the FiT by more than 60 per cent, the number of new solar PV installations plummeted from over 26,000 a month in December 2015 to just 2,422 in January 2018.

Russian Federation

According to PMR reports,[101] most Russian buildings do not have proper insulation. Decades of cheap oil and natural gas have not encouraged construction developers and building managers to reduce their spending on heating. This led to buildings being poorly insulated and using energy extremely inefficiently. The following types of thermal insulation materials are used in Russian Federation (along with some of the major manufacturers that supply the Russian market): mineral wool, glass wool, expanded polystyrene foam and extruded polystyrene.[102] Most insulation materials used are produced locally. Some experts estimate that utilization of insulation materials is still low in Russian Federation and therefore the potential is still large, especially in the northern regions of the country. As the Russian building energy codes have strengthened in the past 15 years, the demand for more efficient windows has also grown. The windows market in the country is very competitive, where Russian producers occupy 70 percent of market share, though mostly use imported technologies.[103] Pressure on market prices is extremely high.

Although heat dominates the Russian HVAC market, the demand for air conditioning and ventilation has also increased. As average incomes have been growing, particularly in large cities, Russians demanded more air conditioning and ventilation.[104]

Currently, there are a large number of heat pumps (HPs) and heat pump systems (HPS's) in the world, but their use in the country is connected with certain difficulties owing to both climatic conditions and the properties of low temperature heat sources.[105] There is much scope for the installation of heat pumps there, but their use is presently at an early stage of development.

France

The French heating equipment market can be divided into 3 markets: fossil fuel (gas, heating oil), renewable energy (wood, geothermal, heating pump, solar thermal) and electricity.[106]According to Uniclima[107], the heating systems with high energy performance such as condensing boilers, heating pump and wood fired boilers, represented in 2011 only 52 percent of the hot water heating boilers; that is far less than the levels showed in Sweden and United Kingdom (99 percent), Holland (98 percent) and 77 percent in Germany according to the association of the European heating industry (EHI).[108]

The renewable energy heaters market is dominated by wood fired heaters, solar thermal and heating pump. The market evolution since 2005 has shown a good increase in 2007 and 2008, the market is slowing down and clearly correlated to the evolution of tax credit rate. In 2013 this market has seen another slowdown reaching 3.7 percent growth versus 2012 (6.9 percent) and 2011 (6.1 percent). The level reached 23,000 units in 2013 mainly as replacement of old heating oil boilers. The wood kWh cost is actually among the lowest possible energy prices, for this reason wood and wood pellets are becoming very popular in residential retrofit.

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[100]CityA.M (2018). [Online]. UK solar panel installations plunge to a seven-year low, "undermined" by government. Accessed on 2 June 2018. Available at: http://www.cityam.com/283373/uk-solar-panel-installations-plunge-seven-year-low.
[101] PMR (2010) The changing structure of the thermal insulation material in Russia. Available at: http://www.pmrpublications.com/downloads/880/the-changing-structure-of-the-thermal-insulation-material-market-in-russia-december-2010.
[102] Ibid.
[103] www.vira.ru.
[104] U.S. Department of Energy (2012) Analysis of the Russian Market for Building Energy Efficiency. Available at: https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22110.pdf.
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[107] Bilan 2013 et perspectives 2014, syndicat des industries thermiques, aérauliques et frigorifiques. Available at : http://www.uniclima.fr/.
[108] Association of European heating industry. http://www.ehi.eu/.

The solar thermal market was dominated by the collective residential equipment with a market share of 51 percent, but the year 2013 has shown a drastic decrease of 24 percent in the overall market.

The eco construction material is still an emerging market in France. As an example, timber frame building in individual housing represented in 2011 about 8 percent of total constructed houses,[109] while it was 90 percent in Canada and the US, 60 percent in Scandinavia and 30 percent in Germany.[110]

Since the enforcement of RT2012,[111] a mandatory air tightness testing is performed usually when the building is finished. Over 800 professional testers are certified by the Qualibat organization in France to perform air tightness tests, either in residential and tertiary buildings, the market is still growing as quality labels requires such a test. An estimated 400,000 air tightness tests are performed every year where about 100,000 are mandatory tests that require a certified Qualibat tester.[112]

[109] CENTRECO et CMA (2011) Eco construction in center region.
[110] Switzerland Global Enterprise (2014) Energy efficiency in France. Available at: https://www.s-ge.com/sites/default/files/cserver/publication/free/market-study-france-energy-efficiency-sep-2014-s-ge.pdf.
[111] The Réglementation Thermique 2012 (RT2012) came into force on 1st January 2013. The RT2012 sets rigorous performance expectations, requiring that residential and non-residential buildings use a maximum of 40-65kWh/m^2/yr depending on locality and altitude of the building.
[112] Switzerland Global Enterprise (2014) Energy efficiency in France. Available at: https://www.s-ge.com/sites/default/files/cserver/publication/free/market-study-france-energy-efficiency-sep-2014-s-ge.pdf.

CHAPTER 4. CONCLUSIONS AND RECOMMENDATIONS

Standards are an effective instrument for addressing energy efficiency in buildings and to support the achievement of the targets set by several international initiatives. However, the constant increase in the number of national and international standards related to energy efficiency in buildings and the existing disagreement among the relevant stakeholders concerning the impact and the relevance of such standards, has convinced the UNECE to develop this study. The study aims to improve the knowledge of the UNECE member States of existing energy efficiency standards in buildings, to collect information on existing standards used in the UNECE region as well as best practices related to existing standards, and to provide a gap analysis with the final goal to develop and implement more effective energy efficiency policies in buildings in the UNECE region.

The gap analysis of the coverage and stringency of building energy codes across member States demonstrated that most countries have mandatory building energy codes in place while some countries still apply building energy codes only to specific types of buildings, such as single- or new multifamily buildings in the residential sector. While many member States of the UNECE have now technical requirements in place in building energy codes, there is a small number of countries which are yet to implement requirements on heating, cooling, lighting or ventilation.

Furthermore, the results of the gap analysis also identified a large disparity between the EPC implementation across member States, with sub-region C lagging behind on the use, stringency and coverage as well as quality and monitoring of EPC. In addition, specific incentives and enforcement mechanisms are also not widely used in countries in sub-region C. A number of responses as well as the desktop research pointed to a lack of satisfactory quality of EPC in some countries. There are inconsistencies across member States on the choice and design of the assessment methodology which hinders the EPC implementation process, success of which is also constrained by the lack of enforcement, training and monitoring mechanisms.

The results of the analysis also suggested a lack of knowledge, inconsistencies in statistics and a lack of appropriate studies in the field of energy performance gap. This could be due to the flaws in the calculation methods or/and a poor enforcement regime in place.

Although most of the countries have now inspection schemes for boilers and/or air conditioning systems, data collection on the number of inspections done by each member State is still at a very low level. A number of countries, e.g. Finland, France, Ireland, the Netherlands, Slovenia, Sweden and the United Kingdom do not include requirements for inspection of boilers in place. Finally, some member States, particularly countries in sub-region C, have demonstrated a low level of implementation of requirements for the use of energy efficient materials and products.

The study has also provided a preliminary analysis of the selection of the energy efficiency technologies deployment in countries of the UNECE region. It has demonstrated that a number of countries have achieved a significant progress in energy efficiency technologies deployment, resulting from a holistic and consistent policy approach to developing and implementing building energy codes with the support of effective financial and enforcement mechanisms. A significant improvement has been noted in increasing energy efficiency of heating and cooling equipment in many countries. However, many new buildings are still leaky, have no insulation or exterior shade control, and have single-glazed clear glass windows. The market maturity for high-priority building envelope components varies significantly between the countries of the UNECE region.

Many countries, particularly countries of sub-region C, still have difficulties in increasing the deployment of the energy efficiency technologies on the market. This may stem from the wrong signals sent by incoherent polices in regards to financial incentives, lack of consumers awareness on the benefits of such technologies, insufficiently developed building energy codes, lack of technical expertise, all of which have negative impacts on the energy efficiency technology cost reduction, ease of installation and market conditioning.

While it is difficult to generalize, our research provides a basis for further inquiry into the development, structure, and implementation of building energy standards throughout the UNECE region. This information may be particularly useful to countries at similar stages of development, countries with common cultural roots, and/or those in comparable climates. This does not establish a complete reference for building energy standards, but it submits a possible framework for further inquiry. It is intended, that this study will draw

attention to the need to further define the field of building energy standards research and support increased communication within it.

Based on the analysis and conclusions of the research, several recommendations can be made in order to make significant progress in the development and implementation of building energy standards throughout the UNECE region. A number of general recommendations have been suggested and are listed below. Furthermore, the countries' specific recommendations according to their climate condition have been developed and can be found in **Table 12.**

Recommendations

Based on the findings of this study, UNECE member States should:

Recommendation 1: Continue the process of harmonization of building energy codes by ensuring comprehensive coverage of all types of buildings in their regulations.

Recommendation 2: Lay down measures to include in the national building energy codes a national energy efficiency target, based either on primary or final energy consumption, or on primary or final energy savings, or on energy intensity.

Recommendation 3: Continue the process of harmonization through further strengthening the requirements for insulation, ventilation and technical installations, in particular they should:

- *Pay more attention to air-tightness of the envelope;*
- *Ensure inclusion of the requirements for air conditioning, lighting, active solar, renewables and natural lighting in the national building codes;*
- *Make mandatory the requirement for the inspection of boilers and air-conditioning systems to improve the quality and precision of Energy Performance Certificates in multi-apartment buildings; and*
- *Follow a holistic approach in building energy codes based on overall building performance, including requirements for technical systems such as HVAC and lighting.*

Recommendation 4: Consider introducing or strengthening quality assurance measures, especially during the early stage of the certification process, in particular:

- *Make sure the requirements for the qualified experts are harmonised across member States;*
- *Make sure the certifier is physically present onsite;*
- *Make sure the procedure of the quality check of the EPC is harmonized among the UNECE countries;*
- *Harmonize the EPC through the integration of ventilation, cooling and lighting into the certificate; and*
- *Develop guidance for the development of the centralised EPCs databases and digitalisation of the EPC process.*

Recommendation 5: Consider challenges of the energy performance gap in existing buildings and data collection on actual energy use to be a priority area for research in the respective country.

Recommendation 6: Establish or strengthen proper (electronic) monitoring systems of compliance, enforcement and quality control processes through the qualified experts to ensure compliance with building energy codes and standards.

Recommendation 7: Establish a regular inspection of boilers and air-conditioning systems in building energy regulations.

Recommendation 8: Continuously monitor, analyze and adjust energy usage in building energy codes.

Recommendation 9: Consider creating incentives for improving energy efficiency through appropriate policies, tax incentives and low-interest loans for energy efficiency projects, particularly in countries with economies in transition.

Recommendation 10: Facilitate the process of harmonization of energy efficient materials and products testing and certification using best practices employed by other countries of the UNECE region. When

developing and harmonizing building energy codes in lower-middle income economies of the UNECE region, attention should be paid to the types of construction that these countries can afford. This will ensure that building energy codes effectively promote manufacture of local traditional materials, research and development for improving local traditional techniques, materials testing, and quality control, and do not create dependency on imported building materials that may stifle local innovation.

Recommendation 11: Ensure that the materials and products used in construction are subject to rigorous quality control processes to meet the requirements for energy efficiency while maintaining robust combustion performance, fire and seismic resistance, ensuring they do not cause threat to the safety of people and property.

Recommendation 12: Consider funding collaborative international research to assist in the establishment of new harmonized building materials test mechanisms and to ensure that independent organizations beyond the manufacturing community can play a key role in developing market-neutral procedures.

Recommendation 13:

a) Consider the opportunity to improve transparency in information access and exchange by making full-featured versions of their building energy codes accessible and available free of charge with the applicable calculation methods on the relevant websites, particularly in countries with economies in transition;

b) Provide methodological or other assistance to countries that need it, especially those countries who have already developed their building energy codes in detail and are at the stage of their practical implementation with real positive effects; and

c) Consider developing common approaches to building energy codes reflecting specifics relevant to energy exporting countries and specifics relevant to the countries importing energy and fuel for primary energy generation, particularly countries with economies in transition.

Recommendation 14: Develop policies based on well-founded identification of the energy efficiency technology options that can best assist national energy aims and carry out an in-depth review of economic and non-economic barriers to progress as a baseline for future policies in their respective countries.

Recommendation 15: Develop policies to increase awareness and understanding within the national and local governments, property developers, local funders, and the international financial community about the feasibility of significant investments in energy efficiency technologies, particularly in countries with economies in transition.

Recommendation 16: Develop policies to educate government officials in ministry offices and targeted municipal offices on the business environment necessary to attract investments in energy efficiency in buildings and how to translate private sector requirements into effective policy measures and/or government initiatives, particularly in countries with economies in transition.

Recommendation 17: Develop policies to facilitate the deployment of energy efficiency technologies in the market place by improving coherence of the energy efficiency technologies programs and other government policies to meet public policy goals.

Opportunities for further studies:

a. Carrying out further studies on mapping of national approaches to EPC deployment based on more detailed metrics and criteria to provide a more in-depth analysis of the stringency of the EPC across the UNECE region, particularly in developing countries and countries with economies in transition. The future study should focus on the quality, availability and usability of EPC data and provide examples for best practice approaches;

b. Carrying out further studies on mapping of national requirements for U-values for wall, roof and floor in new and existing buildings in building energy codes to ensure they are not below the economic optimum and recommend U-values for maximum cost effectiveness, particularly in developing countries and countries with economies in transition; and

c. *Carrying out further studies on the stringency of building energy standards in the UNECE region based on climate conditions, occupant behavior, existing building stock, and construction practices, taking into consideration the turnover of old buildings and rate of new constructions in each member State.*

Table 12: Overview of countries' specific recommendations according to their climate condition

Countries		Building Energy Codes recommendations	EE Technology				Building Envelope	
			Solar thermal	Heat Pumps	Air sealing	Boilers	New Build	Retrofit
Sub-regions A, B and D	Warm Climate	• Facilitate harmonization of the EPC through the integration of ventilation, cooling and lighting into the certificate. • Make mandatory the requirement for the inspection of boilers and air-conditioning systems. • Make mandatory air-tightness test.	Advanced solar thermal technologies are recommended		Implement market-validated air-sealing requirements for new construction and apply to retrofits	Upgrade required standards for condensing boilers to 95% efficiency or higher	• Architectural shading • Very low-SHGC windows (or dynamic shades/windows) • Reflective walls/roofs • Advanced roofs (integrated design/BIPV) • Optimised natural/mechanical ventilation	• Exterior window shading and dynamic glass/shading • Reflective roofing materials and coatings Reflective wall coatings • Window film with lower SHGC • New low-SHGC windows
	Cold Climate	• Facilitate harmonization of the EPC through the integration of ventilation, cooling and lighting into the certificate. • Make mandatory the requirement for the inspection of boilers and air-conditioning systems. • Make mandatory air-tightness test.		Advanced cold climate heat pumps are recommended	Implement market-validated air-sealing requirements for new construction and apply to retrofits	Upgrade required standards for condensing boilers to 95% efficiency or higher	• Highly insulated windows • Passive heating gain (architectural feature /dynamic glass/shades) • Passivhaus-equivalent performance based on LCC limitations	• Highly insulated windows • Low-e storm or interior panels • Insulated shades and other insulating attachments (low-e films) • Exterior insulating wall systems • Interior high-performance insulation
Sub-regions C and E	Warm Climate	• Draw from European and Russian Federation's Energy Passport experience and expand beyond code compliance at the design stage to use Energy Passport to record energy consumption during building operation. • Include lighting, air-conditioning, domestic hot water and ventilation in Energy Passports. • Improve supply off domestic EE products, materials and skills. Improve materials certification capacities. • Promote the prices for energy that reflects its social and environmental costs. Set prices to increase people's motivation. • Improve access to information about consumer's options to improve energy efficiency and broader benefits of energy efficiency measures. • Creating incentives for companies for improving energy efficiency through appropriate policies, tax incentives and low-interest loans for energy efficiency projects.	Implement affordable solar thermal technologies and innovative cooling.		Implement market-validated air-sealing requirements for new construction and apply to retrofits	Promote low-cost, high efficiency fireplaces and stoves with incentives Upgrade required standards for condensing boilers to 95% efficiency or higher	• Exterior shading and architectural features • Low-SHGC windows • Reflective roofs and wall coatings • Optimised natural/mechanical ventilation	• Exterior shading • Reflective coatings (roof and wall) • Low-cost window films • Natural ventilation
	Cold Climate	• Draw from European and Russian Federation's Energy Passport experience and expand beyond code compliance at the design stage to use Energy Passport to record energy consumption during building operation. • Include lighting, air-conditioning, domestic hot water and ventilation in Energy Passports. • Improve supply off domestic EE products, materials and skills. Improve materials certification capacities. • Promote the prices for energy that reflects its social and environmental costs. Set prices to increase people's motivation. • Improve access to information about consumer's options to improve energy efficiency and broader benefits of energy efficiency measures. • Creating incentives for companies for improving energy efficiency through appropriate policies, tax incentives and low-interest loans for energy efficiency projects.	Implement affordable solar thermal technologies	Advanced cold climate heat pumps are recommended	Implement market-validated air-sealing requirements for new construction and apply to retrofits	Promote low-cost, high efficiency fireplaces and stoves with incentives Upgrade required standards for condensing boilers to 95% efficiency or higher	• Highly insulated windows (possibly double-glazed with low-e storm panel) • Passive heating gain (architectural feature) • Optimised low-cost insulation and air sealing • Develop affordable windows with U-value <0.6 (W/M^2K)	• Low-e storm or interior panels • Insulated shades and other insulating attachments (low-e films) • Exterior insulating wall systems • Cavity insulation, lower-cost (e.g. expanded polystyrene) interior insulation

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ANNEX I: MAPPING OF EXISTING ENERGY EFFICIENCY STANDARDS AND TECHNOLOGIES IN BUILDINGS IN THE UNECE REGION QUESTIONNAIRE

Dear Participant in the survey,

This request is addressed to you regarding the decision of the Committee on Housing and Land Management and the Committee on Sustainable Energy to develop a study "Mapping of existing energy efficiency standards and technologies in buildings in the UNECE region".
You are kindly invited to complete the questionnaire below. The questionnaire will provide an input into the work of the Joint Task Force on Energy Efficiency Standards in Buildings, established by the Committee on Housing and Land Management and the Committee on Sustainable Energy of the United Nations Economic Commission for Europe (UNECE). Further information can be found at:
https://www.unece.org/housing/eestandardsinbuildings.html.

Objective: To identify which energy efficiency standards in buildings the UNECE Member States are using.

This information will serve to develop the study on "Mapping of the energy efficiency standards in buildings for the UNECE region". The study aims to improve the knowledge of UNECE Member States of existing energy efficiency standards in buildings, to collect best practices related to existing standards, and to provide a gap analysis and harmonization of data and standards with the final goal to develop and implement more effective energy efficiency policies in buildings in the UNECE region.
Deadline: Tuesday, 31 January 2018

Target audience: Government officials dealing with energy efficiency, buildings and construction, representatives of companies in the building sector, financial institutions, and academia, and energy efficiency and building sector experts.

Please note: All information provided will be treated confidentially and only reproduced in an anonymous and aggregated format.

Part One – General Information

1. First name and last name
2. Male/Female
3. Country (please indicate the country for which you provide responses)
4. Name of organization
5. Position in your organization
6. Contact information
   a. Telephone
   b. Email
   c. Website
7. Type of organization you represent:
   a. National Government
   b. Regional/municipal authority
   c. Business (private company/ state-owned company)
   d. Financial institution
   e. International/intergovernmental organization
   f. Non-profit/non-governmental (NGO)
   g. Educational/research institution
   h. Independent expert
   i. Other (please specify)

Part Two – Building Energy Codes

8. Can you please name and briefly describe the main regulatory documents related to building energy codes (e.g. laws, acts, regulations, notices, etc.) in your country?

9. When was the current set of regulations adopted?

10. Does your country have specific standards for?
    Please select all applicable answers.
    a. climate zones
    b. sub-regions
    c. other, please specify
    d. none of the above

Please briefly provide details (maximum 5 sentences) on how these specific standards compare to relevant national standards.

11a. What type of building(s) do building energy codes cover in your country? Please select all applicable answers:
   a. new non-residential
   b. new residential
   c. existing residential (e.g. after substantial refurbishment)
   d. existing non-residential (e.g. after substantial refurbishment)
   e. none of the above

   Comments:

11b. What type of building(s) do building energy codes cover? Please select all applicable

answers:

a. Single family houses
b. Apartment blocks
c. Commercial
d. Public buildings
e. Other (please specify)

Please specify the national classification of buildings covered by the energy codes

12. What is the policy requirement level of building energy codes in your country?

a. mandatory
b. voluntary
c. mixed (both mandatory and voluntary)

Comments:

Performance-based requirements in building energy codes

13. Are there performance-based requirements in building energy codes? Please select all applicable answers:

a. New buildings
b. Existing buildings (e.g. after substantial refurbishment)
c. Energy efficient development systems

According to your reply in question 13, please provide details/values of the performance-based requirements in building energy codes for:

a. New buildings
b. Existing buildings (e.g. after substantial refurbishment)
c. Energy efficient development systems

14. Which energy levels[113] are considered in building codes when defining the Energy Performance of a Building? Please select all applicable answers:

a. Energy use for heating
b. Energy use for cooling
c. Energy use for hot water
d. Energy use for lighting
e. Energy use for ventilation
f. Total primary energy use
g. Non-renewable primary energy use

15. What are the elements, which must be taken into account for the calculation of the energy performance of a building? Please select all applicable answers:

a. Thermal characteristics and geometry of the building (envelope and internal partitions, etc.)
b. Air-tightness
c. Space heating system and hot water supply units
d. Air-conditioning system(s)
e. Mechanical and natural ventilation

[113] For the definition of these terms according to Standard EN ISO 52000 please refer to Annex I

f. Built-in lighting system (mainly in the non-residential sector)
g. Design position and orientation of buildings
h. Passive solar systems and solar protection
i. Indoor and outdoor climatic conditions
j. Thermal bridge
k. Other (please specify)

16. Does your country intend to use the set of Energy Performance in Buildings (EPB) standards (published in 2017; see: http://epb.center/support/documents)? Please select all applicable answers:
    a. The full set of CEN EPB standards
    b. A selection of the set of CEN EPB standards (please specify)
    c. The subset of ISO EPB standards
    d. Other EPB standards (please specify)
    e. None

Energy performance gap

17. Does your country use the International Performance Measurement & Verification Protocol (IPMVP) as a compliance verification tool to measure the actual performance of the buildings?
    a. Yes
    b. No
    c. Other (please specify)

18. Is there software used for compliance verification?
    a. Yes
    b. No

If yes, please provide the name/title of the software used:

19. What is the average percentage gap between predicted and actual performance levels?

20. Do you consider that the existing standards for determining the energy characteristics of the buildings in operation are sufficiently accurate to compare the energy characteristics with the projected values?
    a. Yes
    b. No
    c. No opinion
21. Is there a mandatory requirement to assess post-construction requirement of the thermal bridge?
    a. Yes
    b. No

22. Is there a mandatory requirement for air tightness testing?
    a. Yes
    b. No

Prescriptive requirements in building energy codes

23. Do prescriptive requirements cover the following? Please select all applicable answers:
    a. Thermal insulation (including U-values for walls, floor, roof and windows)
    b. Specified thermal comfort levels for winter and summer
    c. Solar gains (G-values)
    d. Air-tightness
    e. Ventilation or air quality
    f. External solar protections
    g. Periodic transmittance and time lag of walls and roof
    h. Ventilation for summer comfort
    i. Solar absorbance of external surfaces (e.g. cool paintings for roofs and streets)
    j. Daylighting requirements
    k. Artificial lighting system, lighting density
    l. Boiler/AC system
    m. Renewables
    n. Thermal bridges
    o. Other (please specify)

24. Please provide values for the prescriptive requirements that apply in question 23:
    a. Thermal insulation (including U-values for walls, floor, roof and windows)
    b. Specified thermal comfort levels for winter and summer
    c. Solar gains (G-values)
    d. Air-tightness
    e. Ventilation or air quality
    f. External solar protections
    g. Periodic transmittance and time lag of walls and roof
    h. Ventilation for summer comfort
    i. Solar absorbance of external surfaces (e.g. cool paintings for roofs and streets)
    j. Daylighting requirements
    k. Artificial lighting system, lighting density
    l. Boiler/AC system
    m. Renewables
    n. Thermal bridges
    o. Other (please specify)

25. Do building energy codes contain requirements for regular inspection of heating and AC systems? Please select where applicable:
    a. Yes, for both heating and AC systems
    b. Yes, for heating systems only
    c. Yes, for AC systems only
    d. No

    Please provide further comments on requirements

    If yes, is this a mandatory requirement?
    a. Yes
    b. No

26. With regards to district heating and other external heating systems, are the buildings

equipped with individual energy metering and control units?

a. Yes
b. Partially (approximate share of equipped buildings in the country)
c. No

If yes, is this a mandatory requirement?

a. Yes
b. No

Part Three – Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

27. What are the main legislative documents relating to EPC? Please provide the online reference to the document or a brief description if the online reference is not available and if the references are not in English or Russian.

28a. What type of buildings do EPC cover in your country? Please select all applicable answers:

a. new non-residential
b. new residential
c. existing residential (e.g. after substantial refurbishment)
d. existing non-residential (e.g. after substantial refurbishment)
e. none

Comments:

28b. Which type of building does EPC cover? Please select all applicable answers:

a. Single family houses
b. Apartment blocks
c. Commercial buildings
d. Public buildings
e. None

Comments:

29. What type of energy does the EPC refer to? Please select all applicable answers:

a. total primary energy
b. non-renewable primary energy
c. other, please specify
d. none

Comments:

30. Who is entitled to issue EPC? Please select all applicable answers:

a. qualified experts
b. accredited domestic energy assessors
c. other, please specify

31. What is the policy requirement level for EPC in your country?

a. mandatory

b. voluntary
c. mixed (both mandatory and voluntary)

32. Is there a national registry database for EPC in your country?
a. Yes
b. No
c. Don't know

Part Four – Building Materials and Products

33. Are there requirements to have building materials and products certified/rated?
a. Yes
b. No

If yes, are these requirements harmonised with…? Please select all applicable answers:

a. European Union standards used for CE Marking
b. International technical specifications, such as those prepared by ISO for other countries
c. Other, please specify

Comments:

34. Are there requirements to test building materials and products by certified test laboratories?
a. Yes
b. No

If yes, please provide the name of the agency that certifies laboratories which test building materials:

35. Is there an input control of construction materials and acceptance control of structures on the construction site?
a. Yes
b. No

Comments:

Part Five – Requirements for enforcement and compliance

<u>Penalties, incentives and other mechanisms for improving compliance</u>

36. Does the country have specific incentives that complement or motivate compliance with building energy codes in your country?
a. Yes
b. No

If yes, please briefly describe what specific incentives exist in your country:

37. Penalties for non-compliance with energy provisions in building energy codes include (please select all applicable answers):

a. Fines for non-compliance
b. Refusal for occupancy or construction permit
c. Other, please specify
d. None

Comments:

38. Are there requirements and procedures for energy performance monitoring in building energy codes?

a. Yes
b. No

If yes, is monitoring of energy performance mandatory?

a. Yes
b. No

39. Are the requirements for energy performance monitoring contained in energy building codes complied with? On a scale from 1 (non-compliant) to 5 (fully compliant), please select where applicable:

a. 5 – fully compliant
b. 4 – high level of compliance
c. 3 – medium level of compliance
d. 2 – low level of compliance
e. 1 – non-compliant

If answer is 1 or 2, please provide brief details on the possible causes of poor compliance:

Part Seven – Energy Efficiency Technologies

40. Which energy efficiency technologies listed below are present in your country? Please select all applicable answers:

a. condensing boilers
b. biomass boilers (wood chip and pellet)
c. pellet stoves
d. heat pumps
e. solar thermal systems
f. photovoltaic systems
   - centralized
   - distributed
g. other

Please, provide brief details on the recent trends of the energy efficiency technologies deployment:

ANNEX II: MAIN TERMS AND DEFINITIONS

Air-conditioning system: a combination of all components required to provide a form of air treatment in which temperature is controlled or can be lowered, possibly in combination with the control of ventilation, humidity and air cleanliness [EPBD, 2002/91/EC]

Boiler: the combined boiler body and burner-unit designed to transmit to water the heat released from combustion [EPBD, 2002/91/EC]

Building code: refers to a law or regulation used by state or local governments that establishes specifications for the design and construction of residential or commercial buildings. Building codes help ensure that new and existing residential and commercial structures meet minimum health, safety, and performance standards [https://www.energycodes.gov/resource-center/ace/definitions]

Building envelope: integrated elements of a building which separate its interior from the outdoor environment [IUPAC International Union of Pure and Applied Chemistry - Compendium of Chemical Terminology 2nd Edition (1997)]

Combined heat and power (CHP): the simultaneous conversion of primary fuels into mechanical or electrical and thermal energy, meeting certain quality criteria of energy efficiency [EPBD, 2002/91/EC]

Commercial building: A commercial building is a building that is used for commercial use. Types can include office buildings, warehouses, or retail (i.e. convenience stores, 'big box' stores, shopping malls, etc.)

Cost-optimal level: Cost-optimal level means the energy performance level which leads to the lowest cost during the estimated economic lifecycle [EPBD, recast, 2010/31/EC]

District heating/cooling: means the distribution of thermal energy in the form of steam, hot water or chilled liquids, from a central source of production through a network to multiple buildings or sites, for the use of space or process heating or cooling [EPBD, 2010/31/EC] Energy audit: a systematic procedure to obtain adequate knowledge of the existing energy consumption profile of a building or group of buildings, of an industrial operation and/or installation or of a private or public service, identify and quantify cost-effective energy savings opportunities, and report the findings [ESD, 2006/32/EC]

Energy code: refers to the subset of provisions in a building code that establishes the criteria for the building's thermal envelope; heating, ventilation, and air-conditioning (HVAC) system; service water heating system; lighting system; and other areas related to energy usage and performance. Energy codes are developed as a baseline from which homes and all other buildings will achieve a minimum level of energy efficiency [https://www.energycodes.gov/resource-center/ace/definitions].

Energy consumption: The amount of energy consumed in the form in which it is acquired by the user. The term excludes electrical generation and distribution losses.

Energy need for heating or cooling: Heat to be delivered to or extracted from a thermally conditioned space to maintain the intended space temperature conditions during a given period of time.

Energy need for domestic hot water: Heat to be delivered to the needed amount of domestic hot water to raise its temperature from the cold network temperature to the prefixed delivery temperature at the delivery point without the losses of the domestic hot water system.

Energy performance certificate: a certificate recognized by the member State or a legal person designated by it, which includes the energy performance of a building calculated according to a methodology based on the general framework set out.

Energy performance requirement: minimum level of energy performance that is to be achieved to obtain a right or an advantage: e.g. right to build, lower interest rate, quality label [CEN standard – En 15217 "Energy performance of buildings – "methods for expressing energy performance and for the energy certification of buildings"]

Energy service company (ESCO): a natural or legal person that delivers energy services and/or other energy efficiency improvement measures in a user's facility or premises, and accepts some degree of financial risk in so doing. The payment for the services delivered is based (either wholly or in part) on the achievement of energy efficiency improvements and on the meeting of the other agreed performance criteria [ESD, 2006/32/EC]

Final energy: Energy supplied that is available to the consumer to be converted into useful energy (e.g. electricity at the wall outlet) [Intergovernmental Panel on Climate Change, IPCC]

Gross floor area: The total area of all the floors of a building, including intermediately floored tiers, mezzanine, basements, etc., as measured from the exterior surfaces of the outside walls of the building.

Heat pump: a device or installation that extracts heat at low temperature from air, water or earth and supplies the heat to the building [EPBD, 2002/91/EC].

Internal gross area: A term used in the United Kingdom, defined in the RICS Standard, for the area of a building measured to the internal face of perimeter walls at each floor level.

Internal rate of return (IRR): A rate at which the accounting value of a security is equal to the present value of the future cash flow. [European Central Bank].

Living floor space/area: total area of rooms falling under the concept of rooms [OECD Glossary of statistical terms].

Nearly zero energy building: a building that has very high energy performance, as determined in accordance with Annex I of the EPBD recast. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby [EPBD recast, 2010/31/EC]

Net floor area: A term used in the ISO standard to express the Interior Gross Area less the areas of all interior walls.

Primary energy: Energy from renewable and non-renewable sources which has not undergone any conversion or transformation process.

Public building: building owned or occupied by any public body.

Regulated energy: energy used in the home for heating, cooling, hot water and lighting.

Residential building: A structure used primarily as a dwelling for one or more households. Residential buildings include single-family houses (detached houses, semi-detached houses, terraced houses (or alternatively row houses) and multi-family houses (or apartment blocks) which includes apartments/flats.

Standards: Standards are documents based on voluntary compliance, established by consensus, and approved by a recognized body. They provide, for common and repeated use, rules, guidelines or characteristics for activities or their results. Standards are aimed at the achievement of the optimum degree of order in a given context, and should be based on the consolidated results of science, technology and experience, and aim to promote community benefits [ISO]

U-Value: is the measure of the rate of heat loss through a material. Thus in all aspects of home design one should strive for the lowest U-Values possible because the lower the U-value – the less heat that is needlessly escaping. [Irish Energy Centre - Funded by the Government under the national Development Plan with programmes partly financed by the European Union]

Useful floor space/area: floor space of dwellings measured inside the outer walls, excluding cellars, nonhabitable attics and, in multi-dwelling houses, common areas [OECD Glossary of statistical terms].

White certificates: certificates issued by independent certifying bodies confirming the energy savings claims of market actors as a consequence of energy efficiency improvement measures [ESD, 2006/32/EC]

ANNEX III: COUNTRY PROFILES ON ENERGY EFFICIENCY STANDARDS IN BUILDINGS

Subregion A:
European Union (EU) Member States prior to 2004 (EU15), Norway, and Switzerland

Countries
Austria
Belgium
Denmark
Finland
France
Germany
Greece
Ireland
Italy
Luxembourg
Netherlands
Portugal
Spain
Sweden
United Kingdom

Austria

Austria has had prescriptive energy efficiency requirements for buildings within each of the 9 regions (Lander) since the 1970's. The first nationwide performance-based code was introduced in 2006, to be individually implemented by each of the Lander. The latest 2011 code and supporting policies encompass many dynamic aspects including, air-tightness testing, thermal bridging considerations, well established EPC programs and incentive schemes, voluntary low energy classes and the implementation of Passive House standards by 2015 for residential buildings. National Target date for Zero Energy Buildings (nZEB): 2018 public buildings, 2020 all other buildings [1].

Main regulatory documents related to building energy codes

OIB - Richtlinie 6, National Code

- 2011
- Climate zones
- Performance Codes for Refurbishments
- Performance Codes for New Builds

The OIB is a performance-based code that requires a mandatory energy frame calculation to establish the expected primary energy consumption of residential and non-residential building as well as existing buildings undergoing renovation (25-38% higher than new builds).

Performance-based requirements in building energy codes

- Thermal characteristics and geometry of the building (envelope and internal partitions, etc.)
- Air-tightness
- Space heating system and hot water supply units
- Air-conditioning system(s)
- Mechanical and natural ventilation
- Built-in lighting system
- Design position and orientation of buildings
- Passive solar systems and solar protection
- Indoor and outdoor climatic conditions
- Passive cooling
- Heat recovery
- Thermal bridges

Software: No data

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

Coverage:

- Single family houses
- Apartment blocks
- Commercial buildings
- Public buildings

- new residential
- new non-residential
- existing residential
- existing non-residential

Stringency: Mandatory

EPBD Energy Performance Certificate: Class A, A++, C, E, G

Existence of national registry database for EPC in your country: Yes

Building Materials and Products

Rating/certification of building materials: No data

Harmonization with other technical standards: No data

Requirements to test building materials and products by certified test laboratories: No data

Building Energy Codes Stringency and Coverage

Coverage:

- Residential buildings:
  - One family;
  - Multiple family buildings
- Commercial buildings:
  - Offices; Retail and wholesale; Hotels; Hospitals;
  - Educational buildings
- Public buildings:
  - Offices; Hospitals; Educational buildings
- new residential
- new non-residential
- existing residential
- existing non-residential

Stringency: Mandatory

Energy used for: Space cooling, Space heating, Ventilation

Prescriptive requirements in building energy codes

- Thermal insulation (including U-values for walls, floor, roof and windows)
- Air-tightness
- Ventilation or air quality
- Daylighting requirements
- Boiler/AC system
- Specified thermal comfort levels for summer and winter
- Solar gains (G-values)
- Building parts (lifts, pumps etc.)
- Appliances
- Renewable Energy (solar, PV, others):

Values for New Buildings

Residential Buildings

U-values (W/m^2K): Roof – 0.24; Wall – 0.35; Floor-0.4; Window – 1.4

Energy Performance: 66kwh

Non-Residential Buildings

U-values (W/m^2K): Roof – 0.2; Wall – 0.35; Floor-0.4; Window – 1.4

Energy Performance: 22.75kwh

Other Requirements Set for Thermal Bridge demands

Requirements for enforcement and compliance

Requirements for regular inspection of heating and AC systems: No data

Penalties, incentives and other mechanisms for improving compliance with building energy codes in your country: Refusal of permission to occupy, Refusal of permission to construct

Energy performance monitoring requirements: Yes, during construction, Post completion

Belgium

Belgium is divided into three regions: the Flemish Region that occupies the northern half with Dutch-speaking communities; the Walloon Region, which occupies the southern-half and is made-up largely of French-speaking communities, with a small German-speaking community in the southeast; and Brussels, the administrative capital region, an officially tri-lingual city inside the Flemish region. The most recent numbers by the FPS Economy, SMEs, Self-Employed and Energy indicate a housing stock of 5,318,905 residential units in Belgium in 2015. 58.2% of all residential units are located in Flanders, 31.2% in Wallonia and 10.6% in Brussels. The proportion of apartments in the total Belgian housing stock has increased by 30% in the last 10 years. Each region and community have a separate Law regulating the energy performance of buildings [2].

Main regulatory documents related to building energy codes

Réglementation sur la Performance Energétique des Bâtiments (PEB Wallonia) 2012
Energieprestatie en Binnenklimaat (EPB Flanders) 2012
Performance Energétique des Bâtiments (PEB Brussels) 2011

- 2011-2012

Performance-based requirements in building energy codes

- Thermal characteristics and geometry of the building (envelope and internal partitions, etc.)
- Air-tightness
- Space heating system and hot water supply units
- Air-conditioning system(s)
- Mechanical and natural ventilation
- Built-in lighting system
- Design position and orientation of buildings
- Passive solar systems and solar protection
- Indoor and outdoor climatic conditions
- Thermal bridges

Software: Yes, Flanders EPB Software version 1.6.2

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

PEB Energy Performance Certificate (Brussels) 2011
EPB Energy Performance Certificate (Flanders) 2011
PEB Energy Performance Certificate (Wallonia) 2010
Coverage:

- Single family houses
- Apartment blocks
- Commercial buildings
- Public buildings

- new residential
- new non-residential
- existing residential
- existing non-residential

Stringency: Mandatory
Existence of national registry database for EPC in your country: Yes

Building Materials and Products

Rating/certification of building materials: No data

Harmonization with other technical standards: No data

Requirements to test building materials and products by certified test laboratories: No data

Building Energy Codes Stringency and Coverage

Coverage:

- Single family houses
- Apartment blocks
- Commercial buildings
- Public buildings

- new residential
- new non-residential
- existing residential
- existing non-residential

Stringency: Mandatory

End-uses energy: Auxiliary devices, Space cooling, Space heating, Water heating, Ventilation

Prescriptive requirements in building energy codes

- Thermal insulation (including U-values for walls, floor, roof and windows)
- Air-tightness
- Ventilation or air quality
- Daylighting requirements
- Specified thermal comfort levels for summer and winter
- Artificial lighting system, lighting density
- Boiler/AC system
- Renewable (Cogeneration, biomass and SPV are considered in calculating E-values)

PEB Wallonia, Insulation:

U-Values (W/m²K)	Windows	Walls	Roof	Door	Floor
All climate zones	1.3	0.32	0.27	2.2	0.35

EPB Flanders, Insulation:

U-Values (W/m²K)	Floor	Roof	Door	Windows
All climate zones	0.35	0.27	2.2	2.2

Requirements for enforcement and compliance

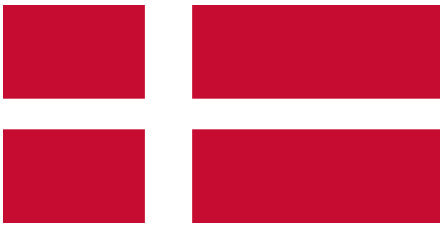
Requirements for regular inspection of heating and AC systems: No data

Penalties, incentives and other mechanisms for improving compliance with building energy codes in your country:

Grants (Belgium Flanders Building Renovation Grant (Flanders) 2007); Tax rebate (Tax reduction according to energy savings - Recipient Types: E60 buildings receive 20% reduction, E40 buildings receive 40% reduction)

Energy performance monitoring requirements: No data

Denmark



The Danish building code plays a key role in ensuring energy efficiency in both new and existing buildings. The code is reviewed and updated at least every five years to reflect developments in technology and prices. It contains minimum energy performance requirements for new buildings and rules for upgrading energy efficiency as part of the renovation of existing buildings. The energy requirements have been strengthened considerably over the last 25 years for new buildings. A norm "lavenergiklasse 2015" (low-energy class 2015) became a legal requirement in 2015, and "bygningsklasse 2020" (building class 2020) is currently voluntary [3,4].

Main regulatory documents related to building energy codes

Building Regulations 2010 (BR10)
Building Regulations 2015 (BR15)

- 2010, 2016
- Climate zones

Performance-based requirements in building energy codes

- Thermal characteristics and geometry of the building (envelope and internal partitions, etc.)
- Air-tightness
- Space heating system and hot water supply units
- Air-conditioning system(s)
- Mechanical and natural ventilation
- Built-in lighting system
- Design position and orientation of buildings
- Passive solar systems and solar protection
- Indoor and outdoor climatic conditions

Software: Yes, SBi-Direction 213

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

Coverage:

- Single family houses
- Apartment blocks
- Commercial buildings
- Public buildings

- new residential
- new non-residential
- existing residential
- existing non-residential

Building Regulations 2010**:** Dwellings: 52.5 kWh/m^2/year+ (1650 kWh/year divided by heated floor area)
Low energy residential buildings (2015): 30 kWh/m^2/year+ (1000 kWh/year divided by heated floor area)
EBPD energy performance certificate. Class: A1, A2, B, C, D, E, F, G
Passive House Class: Maximum cooling demand: 5 kWh/m2.year
Maximum space heating demand: 15 kWh/m^2.year
Maximum total primary energy demand: 120 kWh/m^2.year
Swan: Relative to national regulations - at least 25% below regulated annual energy consumption
Zero Energy Buildings (ZEB):
25% reduction in energy consumption compared to 2008 levels (2010)
50% reduction in energy consumption compared to 2008 levels (2014)
75% reduction in energy consumption compared to 2008 levels (2020)

Building Materials and Products

Rating/certification of building materials: No data

Harmonization with other technical standards: No data

Requirements to test building materials and products by certified test laboratories: No data

Building Energy Codes Stringency and Coverage

Coverage:

- Single family houses
- Apartment blocks
- Commercial buildings
- Public buildings

- new residential
- new non-residential
- existing residential
- existing non-residential

Stringency: Mandatory

Energy used for: Space cooling, Space heating, Water heating, Ventilation, Auxiliary devices, Lighting interior, Humidification

Prescriptive requirements in building energy codes

- Thermal insulation (including U-values for walls, floor, roof and windows)
- Air-tightness
- Ventilation or air quality
- Daylighting requirements
- Boiler/AC system
- Specified thermal comfort levels for summer and winter
- Solar gains (G-values)
- Renewables

Insulation

U-Values (W/m^{2}K)	Walls	Windows	Floor	Roof
All climate zones	0.3	1.8	0.2	0.2

Windows (kWh/m2/year)	Solar energy gains
All climate zones	33

Skylights: Energy gains through rooflights must not be less than - 10kWh/m2/year, in 2015 it should not be less than - 17kWh/m2/year
Air Leakage
Dwellings: 1.5 l/s.m^2 at 50 Pa
Low energy residential buildings (2015): 1.01 l/s.m^2 at 50 Pa
Space Heating System: Ventilation installations must incorporate heat recovery with a dry temperature efficiency of no less than 70% (80% for single dwellings) Heat pumps for heat recovery must have a minimum coefficient of performance of 3.6 in heating mode.
Water Heating System: Domestic water systems supplied by a domestic ventilation heat pump must have a minimum COP (coefficient of performance) at the draw off point of 3.1.
Lighting: No requirement
Renewable Energy: Solar heating systems must be provided when the expected hot water consumption exceeds 2000l per day and able to meet 95% of demand

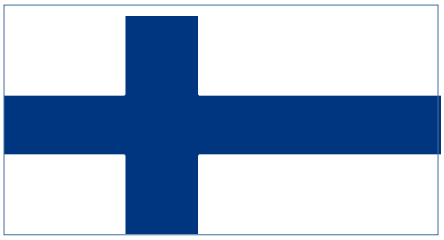
Requirements for enforcement and compliance

Requirements for regular inspection of heating and AC systems: No data

Penalties, incentives and other mechanisms for improving compliance with building energy codes in your country: No data

Energy performance monitoring requirements: No data

Finland



At the end of 2016, there were 2,968,000 dwellings in Finland. Most dwellings have been built in the 1970s- and 1980`s. Residential building construction has centered in urban municipalities. In all, 78 per cent of the dwellings completed in the 1995 to 2016 period are located in urban areas. At the end of 2016, 46 per cent of all dwellings were in blocks of flats, that is 198,000 more dwellings in blocks of flats than in detached houses. The share of district heating (DH) in Finland is quite high, almost half of the population uses the services of the DH. The main technology of low-rise housing in Finland is a wooden frame-panel. Finland has had prescriptive energy efficiency requirements for buildings since the 1990's. The first performance-based code is the latest 2012 code installment [5].

Main regulatory documents related to building energy codes

National Building Code of Finland 2012
Energy performance of buildings undergoing renovation or alteration

- Four Climate zones: 1: Cool, Dry, Marine; 2: Cold, Dry; 3: Very Cold; 4: Subarctic.

Performance-based requirements in building energy codes

- Thermal characteristics and geometry of the building (envelope and internal partitions, etc.)
- Air-tightness
- Space heating system and hot water supply units
- Air-conditioning system(s)
- Mechanical and natural ventilation
- Built-in lighting system
- Design position and orientation of buildings
- Passive solar systems and solar protection
- Indoor and outdoor climatic conditions
- Thermal bridge
- Dehumidification
- Heat recovery
- Passive cooling

Software: No data

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

Coverage:

- Single family houses
- Apartment blocks
- Commercial buildings
- Public buildings
- new residential
- new non-residential
- existing residential
- existing non-residential

Energy Performance Certificate (2008): Buildings are classified into seven categories, and the calculation of energy efficiency is based on a so-called E-number. The E-number is made up of a building's annual calculated consumption of purchased energy weighted with various types of energy coefficients.

Nordic Ecolabel (Swan) (2009): Relative to national regulations - at least 25% below regulated annual energy consumption.

Nearly Zero Energy Buildings: New public buildings have to be nearly zero-energy buildings (2018); all new buildings have to be nearly zero-energy buildings (2020)

Stringency: Mixed (both voluntary and mandatory)

Building Materials and Products

Rating/certification of building materials: No data

Harmonization with other technical standards: No data

Requirements to test building materials and products by certified test laboratories: No data

Building Energy Codes Stringency and Coverage

Coverage:

- Residential buildings: One family, Multiple family buildings
- Commercial buildings: Offices, Retail and wholesale, Hotels, Hospitals
- Educational buildings
- Public buildings: Offices, Hospitals, Educational buildings
- E-value must be calculated.
- new residential
- new non-residential
- existing residential
- existing non-residential

Stringency: Mandatory

Energy used for: Space cooling, Space heating, Water heating, Appliances, Equipment, Lighting interior, Ventilation

Prescriptive requirements in building energy codes

- Thermal insulation (including U-values for walls, floor, roof and windows)
- Air-tightness
- Ventilation or air quality
- Daylighting requirements
- Boiler/AC system
- Specified thermal comfort levels for summer and winter
- Solar gains (G-values)
- Renewables

Insulation

U-Values (W/m²K)	Walls	Floor	Roof
Building elements of warm and cooled cold spaces	0.17	0.09	0.09
Building elements of semi-warm spaces	0.26	0.14	

Windows

U-Values (W/m²K)	Windows
Building elements of warm and cooled cold spaces	1
Building elements of semi-warm spaces	1.4

Total window area should not exceed 50% of total area of external walls
Air Leakage: 4 m3 / h.m² at 50 Pa

Requirements for enforcement and compliance

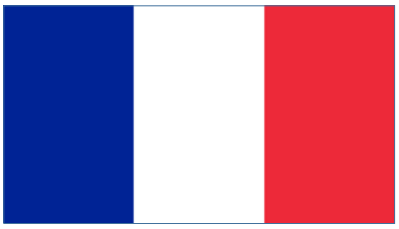
Requirements for regular inspection of heating and AC systems: Yes

Penalties, incentives and other mechanisms for improving compliance with building energy codes in your country: Penalties Non. Grants from the state budget, which cover up to 25 % of approved costs. Tax rebate.

Energy performance monitoring requirements:

Yes, during construction, Post completion

France



Thermal regulations RT 2005 set insulation, envelope, and HVAC standards for energy efficiency for all new and existing buildings in France. France has had prescriptive building energy efficiency requirements since 1955. The first performance-based standard was implemented in 2005 following the release of the Energy Performance of Buildings Directive (EPBD) requirements in 2002. The RT2012 reflect the demands of the EPBD recast, with compliant buildings aiming to be approximately 40% more efficient than buildings built according to the 2005 regulations. The bioclimatic coefficient Bbio is a new indicator introduced along with RT 2012. It measures the building's efficiency in terms of the need for heating, air conditioning and lighting, regardless of the energy systems in place and light [6].

Main regulatory documents related to building energy codes

Decree of 24 may 2006 on the thermal characteristics of new buildings and new parts of buildings

Decree of 26 October 2010 concerning the thermal characteristics and energy performance requirements of new buildings and new parts of buildings

French Thermal Regulation RT 2012

- Climate zones: H1a, H1b, H1c, H2a, H2b, H2c, H2d, H3

Performance-based requirements in building energy codes

- Thermal characteristics and geometry of the building (envelope and internal partitions, etc.)
- Air-tightness
- Space heating system and hot water supply units
- Air-conditioning system(s)
- Mechanical and natural ventilation
- Built-in lighting system
- Design position and orientation of buildings
- Passive solar systems and solar protection
- Indoor and outdoor climatic conditions

Software: Yes, Clima-Win, Cypebat, DesignBuilder, Lesosai, Visual TTH, ArchiWisard, Pleiades & Comfie, U22WinRT 2012

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

Coverage:

- Single family houses (One Family)
- Apartment blocks (Multifamily)
- Commercial buildings
- Public buildings

- new residential
- new non-residential
- existing residential
- existing non-residential

Stringency: Mandatory

Existence of national registry database for EPC in your country: Yes

Building Materials and Products

Rating/certification of building materials: Yes

Harmonization with other technical standards: Yes, HQE, EN 15804 and EN 15977 – in the aim of generating a standardized environmental quality evaluation tool for construction materials and products

Requirements to test building materials and products by certified test laboratories: No data

Building Energy Codes Stringency and Coverage

Coverage:

- Single family houses (One Family)
- Apartment blocks (Multifamily)
- Commercial buildings
- Public buildings

- new residential (No in RT 2006 & 2010)
- new non-residential
- existing residential (No in RT 2006 & 2010)
- existing non-residential

Stringency: Mandatory

The coefficient U-values of mean reference loss through the walls, floors and the door and window openings of the building: Yes

Space cooling, Space heating, Water heating, Lighting interior, Ventilation. The conversion of primary energy

Prescriptive requirements in building energy codes

- Thermal insulation (including U-values for walls, floor, roof and windows)
- Air-tightness
- Ventilation or air quality
- Daylighting requirements
- Artificial lighting system, lighting density
- Boiler/AC system
- Specified thermal comfort levels for summer
- Solar gains (G-values)
- Renewables

Insulation: Average U value <=0.36 W/m^{2}K Ratio of global average linear thermal transmittance <=0.28 W/m^{2}K

Air Leakage: 0.60 m^3/h.m^2 at 4 Pa for single family building

1 m^3/h.m^2 at 4 Pa for multi-family building

Space Heating System: To be connected to urban heating system supplied for more than 50% by renewable energy source Or Boiler (micro-cogeneration) with COP>=90%

Water Heating System: Solar hot water (2 m^2 of solar panels) or Electric hot water (COP=2)

Lighting: Total glazed area >= 1/6 of the total floor area

Requirements for enforcement and compliance

Penalties, incentives and other mechanisms for improving compliance with building energy codes in your country: Yes

Fine Refusal of permission to occupy, Incentives/rewards to go beyond minimum required performance level. The 2012 thermal regulations added recognition for low-energy buildings (LEB), which can receive a special label. A "high energy performance renovation" label has also been introduced.

Energy performance monitoring requirements: Yes

Germany

In Germany, 50 per cent of all existing residential are single-family and double-family houses, 39.5 per cent of the apartments are located in multifamily houses with the number of apartments up to 13 and 10.5 per cent of the apartments are in apartment blocks. Of the total number of houses under construction, 88 per cent are single-family houses, 11 per cent are double-family houses and 1 per cent are multifamily houses. The main technology of low-rise housing is frame-panel technology. In Eastern Germany, 85 per cent of apartment blocks are residential after substantial refurbishment. For such houses, "Energy efficiency modernization" was carried out on the basis the WSVO thermal protection regulation, the law on energy efficiency (EnEV) in accordance with the requirements of modern building standards and energy consumption codes [7].

Main regulatory documents related to building energy codes

The building energy code in Germany (since 2009) is the EnEV, a performance-based code that requires a mandatory (equivalent model building) energy frame calculation to establish the expected primary energy consumption of residential and non-residential buildings.

- EnEV (Energy Saving Ordinance): Adopted 2014; last amendment 2016; EEWärmeG: Adopted 2011
- For all buildings: 1) DIN V 18599 (Energy efficiency)
- Only for residential buildings: 2.1) DIN V 4108-6 (Thermal protection and energy economy); 2.2) DIN V 4701-10 (Energy efficiency of heating and ventilation systems in buildings); 2.3) DIN V 4701-12 (Energetic evaluation of heating and ventilation systems in existing buildings
- Climatic zones are not used, Subregion: only 1 federal state

Performance-based requirements in building energy codes

- Thermal characteristics and geometry of the building (envelope and internal partitions, etc.)
  Air-tightness (there is a mandatory requirement for air tightness testing: Yes)
- Space heating system and hot water supply units
- Air-conditioning system(s)
- Mechanical and natural ventilation
- Built-in lighting system (mainly in the non-residential sector)
- Design position and orientation of buildings
- Passive solar systems and solar protection
- Indoor and outdoor climatic conditions
- Thermal bridge

Software used for compliance verification: Yes
The gap between predicted and actual performance levels: 20%

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

Coverage:

- Single family houses
- Apartment blocks
- Commercial buildings
- Public buildings
- new non-residential

Stringency: Mixed (both mandatory and voluntary)

EPC applies to residential and non-residential buildings, both new and existing

Existence of national registry database for EPC in your country: Yes

Building Materials and Products

Rating/certification of building materials: Yes

Harmonization with other technical standards: European Union standards used for CE Marking

Requirements to test building materials and products by certified test laboratories: No

Building Energy Codes Stringency and Coverage

Coverage:

- Single family houses
- Apartment blocks
- Commercial
- Public buildings
- All buildings that require energy for heating or cooling (irrespective of forms of ownership, size etc. - requirements differ for new/existing and residential/non-residential). Notable exceptions: temporary buildings, commercial buildings for raising animals and plants, religious buildings

- New non-residential
- New residential
- Existing residential (e.g. after substantial refurbishment)
- Existing non-residential (e.g. after substantial refurbishment)

Stringency: Mandatory

Prescriptive requirements in building energy codes

- Thermal insulation (including U-values for walls, floor, roof and windows)
- Air-tightness
- Daylighting requirements
- Artificial lighting system, lighting density
- Boiler/AC system
- Thermal bridges
- External solar protections
- Solar gains (G-values)
- Renewables

The EnEV Standard is not as stringent as the Passive House Standard, which requires as little as 10% of the heating and cooling energy used by typical buildings and only 1.5 liters of heating oil per square meter. Passive House considers only the usable living area and requires the building not to exceed 15kWh annually OR 10W (peak demand) per square meter. Passive House stipulates Primary Energy use of no more than 120 kWh/m^{2}year. There are no fixed absolute values for energy performance of buildings in Germany.

A building may not exceed the primary energy demand (including heating, cooling, hot water and ventilation) and overall transmission heat loss of a so called “reference building” which is identical to the planned building in geometry, area and orientation. Requirements for the reference building (e.g. U-values and building services) are specified in EnEV.

Requirements for enforcement and compliance

Requirements for regular inspection of heating and AC systems: Yes, for both heating and AC systems

Penalties, incentives and other mechanisms for improving compliance with building energy codes in your country: Yes, Financial incentive schemes provide additional motivation for energetic standards higher than the existing minimum standard.

Energy performance monitoring requirements: No

Greece

The buildings constructed before 1980 represent the two thirds of the building stock in Greece and are classified in the first category that represents buildings with no thermal insulation protection. The second category consists of dwellings constructed during the period 1980-2001, which in the majority are partially insulated. Only the buildings that were constructed from 2001 are well insulated with no thermal bridges and with double glazed windows. Residential dwellings represent fourth part of the total energy consumption of the Hellenic building stock and consume more than 30 per cent of the total electricity produced in Greece. Greece has been one of the last countries to adopt the Directive on the Energy Performance of Buildings [8, 9].

Main regulatory documents related to building energy codes

Regulation for Energy Performance of Buildings (KENAK Residential) 2010

Regulation for Energy Performance of Buildings (KENAK Non-residential) 2010

Performance-based requirements in building energy codes

No data

Compliance Software: Yes, KENAK (based on EN 13790), KENAK (based on EN 13790)

End-uses considered Space cooling, Space heating, Water heating, Lighting interior, Humidification, Ventilation

Minimum requirement - Reference Building Class B (or higher)

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

Coverage:

- Single family houses
- Apartment blocks
- Commercial buildings
- Public buildings

- new residential
- new non-residential
- existing residential
- existing non-residential

Stringency: Mandatory

EPBD Energy Performance Certificate (2010), Class:

Scale relative to modelled consumption values. E.A. is total primary energy consumption of existing building. K.A. is the reference building

A=>0.33K.A < E.A. ≤ 0.50K.A; A+ => E.A. ≤ 0.33K.A; B=>0.75K.A < E.A. ≤ 1.00K.A; B+=> 0.50K.A < E.A. ≤ 0.75K.A; E=> 1.82K.A < E.A. ≤ 2.27K.A; H=>2.73K.A< E.A; Γ=> 1.00K.A < E.A. ≤ 1.41K.A; Δ=>1.41K.A < E.A. ≤ 1.82K.A; Z=> 2.27K.A < E.A. ≤ 2.73K.A.

Passive House (1990), Zero Energy Buildings (ZEB) -Voluntary

Existence of national registry database for EPC: No data

Building Materials and Products

Rating/certification of building materials: No data

Harmonization with other technical standards: No data

Requirements to test building materials and products by certified test laboratories: No data

Building Energy Codes Stringency and Coverage

Coverage:

- Single family houses
- Apartment blocks
- Commercial
- Public buildings

- New residential
- New non-residential
- Existing residential
- Existing non-residential

Stringency: Mandatory

Prescriptive requirements in building energy codes

No data

Residential and Non-Residential Buildings

Energy Requirements:

Insulation

Defined per building element in Tables of TGTC No 1

Windows: Thermal characteristics of windows (incl. shading) and walls calculated for Reference Building (see TGTCG 1 & 3)

Skylights: No requirement. Air Leakage: TGTCG No 1 defines ventilation rates per building type / room use and infiltration rates are given per opening type, chimney existence etc.

Residential Buildings

Space Heating System: Min EER of 3.0, with ESEER being introduced to be enforced at later stage (see TGTCG No 1)

Water Heating System: 60% produced by Solar collectors, methodology for the rest and DHW needs defined in TGTCG No 1

Lighting: No requirement for residential buildings

Renewable Energy: 60% of DHW from solar energy

Non-Residential Buildings

Space Heating System: Min EER of 2.8 air-cooled, 3.8 water-cooled, with ESEER being introduced to be enforced at later stage (see TGTCG No 1). Water Heating System: Methodology and DHW needs defined in TGTCG No 1. Lighting: In general, 16 W/m^2 for 500 lux, Table per building use is given in TGTCG No 1

Renewable Energy: Specific study for introduction of RES and CHP is part of the Building permit issue process

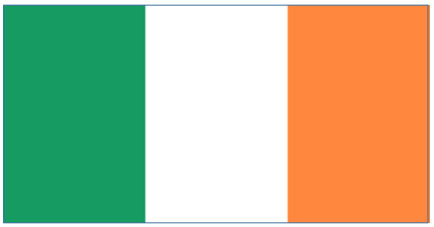
Requirements for enforcement and compliance

Requirements for regular inspection of heating and AC systems:

No data

Penalties, incentives and other mechanisms for improving compliance with building energy codes in your country: No data

Ireland



Ireland has had prescriptive energy efficiency requirements for buildings since 1991. The first performance-based code was introduced following the release of the EPBD in 2002, with the latest code being further strengthened to reflect the requirements of the 2010 EPBD recast. Part L and the surrounding national policies encompass many progressive and dynamic aspects including, mandatory computer modeling for new buildings, low u-value requirements, air-tightness testing requirements for all new dwellings, bioclimatic design considerations, mandatory renewable energy requirements, robust pre-occupancy commissioning and a national target to build nZEB by 2013 [10].

Main regulatory documents related to building energy codes

Conservation of Fuel and Energy: Buildings other than Dwellings -2008

Conservation of Fuel and Energy: Dwellings (2011)

- Ireland's Part L is a performance-based code that requires a mandatory energy frame calculation to establish the Energy Performance Coefficient (EPC) and Carbon Performance Coefficient (CPC) in comparison with a relevant reference building. The code is split into two sections, 'dwellings' (2011) and 'buildings other than dwellings' (2008) with specific requirements outlined for each type of building.

Performance-based requirements in building energy codes

- Thermal characteristics and geometry of the building (envelope and internal partitions, etc.)
- Air-tightness
- Space heating system and hot water supply units
- Air-conditioning system(s)
- Mechanical and natural ventilation
- Built-in lighting system
- Design position and orientation of buildings
- Passive solar systems and solar protection
- Passive cooling
- Heat recovery
- Thermal bridges
- Renewable

Stringency: Mandatory

Software: Yes, SBEM Software

Energy use for: Space cooling and heating, Water heating, Ventilation

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

Coverage:

- Single family houses
- Apartment blocks
- Commercial buildings
- Public buildings

- new residential
- new non-residential
- existing residential
- existing non-residential

Stringency: Mandatory

Energy Performance Certificate support BC; Positive labeling for building beyond the minimum BC level; Energy Offsets/Green Certificates; Number of certified buildings: 295269

Existence of national registry database for EPC in your country: Yes

Building Materials and Products

Rating/certification of building materials: No data

Harmonization with other technical standards: No data

Requirements to test building materials and products by certified test laboratories: No data

Building Energy Codes Stringency and Coverage

Coverage:

- Residential buildings: One family, Multiple family
- Commercial buildings: Offices, Retail and wholesale, Hotels, Hospitals, Educational buildings
- Public buildings: Offices, Hospitals, Educational buildings

- new residential
- new non-residential
- existing non-residential
- existing non-residential

Prescriptive requirements in building energy codes

- Thermal insulation (including U-values for walls, floor, roof and windows)
- Air-tightness
- Ventilation or air quality
- Daylighting requirements
- Specified thermal comfort levels for summer and winter
- Solar gains (G-values)
- Artificial lighting system, lighting density
- Boiler/AC system
- Thermal bridge
- Renewable Energy - 10 kWh/m^2/annum for thermal energy, or 4 kWh/m^2/annum of electrical energy)

Stringency: Mandatory

Dwellings

U-values (W/m^{2}K): Roof – 0.16; Roof2 – 0.2; Wall – 0.2; Floor-0.21; Window – 1.6. Ventilation: Minimum performance levels for mechanical ventilation systems include; Residential - Specific Fan Power (SFP) for continuous supply only and continuous extract only - 0.8 W/liter/sec, SFP for balanced systems - 1.5 W/liter/sec.

Buildings other than Dwellings

U-values (W/m^{2}K): Roof – 0.16; Roof2 – 0.22; Wall – 0.27; Floor-0.25; Window – 2.2. Ventilation: Non-residential, the SFP of ACMV systems should be no greater than 2.0 W/liter/second. For new ACMV systems in refurbished buildings the SFP should be no greater than 3.0 W/liter/second.

Other Requirements Set for (Dwellings and Buildings other than Dwellings): Thermal bridge demands. Domestic Hot Water COP - Heat Pump: Hot water systems should be as efficient in use as reasonably practicable. For fully pumped hot water-based central heating systems utilizing oil or gas, the boiler seasonal efficiency should be not less than 90% as specified in the DEAP manual. Value for airtightness: 7 m^3/h/m^2 at 50 Pa.

Heat Recovery, Technical HVAC systems, Efficient Lighting, Energy Performance: 60.00 kWh (Dwellings); 100.00 kWh

Requirements for enforcement and compliance

Requirements for regular inspection of heating and AC systems: Inspection of boilers, Inspection of HVAC systems

Penalties, incentives and other mechanisms for improving compliance with building energy codes in your country: Yes, Grant, Grants is subject to a SEAI survey, Fine, Refusal of permission to occupy

Energy performance monitoring requirements: Yes, during construction, Post completion

Italy

The Italian government implemented the European Directive on energy efficiency of buildings in 2005 and defined the relevant national guidelines in 2009. In Italy, regions and municipalities have developed in recent years a number of local regulations aimed at promoting building energy regulation. Unlike most European countries, where the criterion characterizing the energy efficiency of buildings, use of primary energy use expressed in kWh/m^2 per year, in Italy is used as a criterion indicator calculated in kWh/m^3 per year. For residential buildings, there are no requirements for air consumption. Italy does not use heat meters and there are no requirements for air consumption. With regard to renewable, to Italy at their expense covered half of the heat energy going into the hot water [11].

Main regulatory documents related to building energy codes

Decreto Inter- Ministeriale 26 giugno 2015. This decree (Law) defines the procedures for applying the methodology for calculating the energy performance of buildings, including the use of renewable sources, as well as the minimum requirements and requirements regarding the energy performance of buildings and building units.

The Standards UNI/TS 11300 1, 2, 3 and 4 are the references of calculation methodologies.

- The current set of regulations adopted 26 June 2015, in the following 2 years the UNI/TS 11300 standards
- The Standards are national, but part of the limit values is different region from region. Based on heating degree-days Italy is divided in 6 climatic zones (A to F). The National Standard UNI 10349 provides the climatic data.

Performance-based requirements in building energy codes

- Thermal characteristics and geometry of the building (envelope and internal partitions, etc.)
- Space heating system and hot water supply units
- Air-conditioning system(s)
- Mechanical and natural ventilation
- Built-in lighting system (mainly in the non-residential sector)
- Design position and orientation of buildings
- Passive solar systems and solar protection
- Indoor and outdoor climatic conditions
- Thermal bridge

Set of Energy Performance in Buildings (EPB) standards: The full set of CEN EPB standards

The International Performance Measurement & Verification Protocol (IPMVP): No

There software used for compliance verification: Yes

The average percentage gap: It depends on the amount of information available to the modeler, the skill and time available to the modeler, the level of predictability of users' behavior

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

Coverage:

- Single family houses
- Apartment blocks
- Commercial buildings
- Public buildings

- new residential
- new non-residential
- existing residential
- existing non-residential

Stringency: Mandatory

Building Materials and Products

Rating/certification of building materials: Yes

Harmonization with other technical standards: No answer

Requirements to test building materials and products by certified test laboratories: Yes

Building Energy Codes Stringency and Coverage

Coverage:

- Single family houses
- Apartment blocks
- Commercial
- Public buildings

- New non-residential
- New residential
- Existing residential (e.g. after substantial refurbishment)
- Existing non-residential (e.g. after substantial refurbishment)

Based on DPR 412/93 buildings are classified in 8 categories Residential; office; hospitals and similar; recreational, associative or religious activities and similar activities; commercial; sport related buildings; educational; industrial and similar

Stringency: Mandatory

Prescriptive requirements in building energy codes

- Thermal insulation (including U-values for walls, floor, roof and windows)
- Ventilation or air quality
- Daylighting requirements
- Artificial lighting system, lighting density
- Boiler/AC system
- Thermal bridges
- Solar gains (G-values)
- Periodic transmittance and time lag of walls and roof
- Renewables
- Solar absorbance of external surfaces (e.g. cool paintings for roofs and streets)

Mandatory requirement: Yes

Comfort levels are not thoroughly specified as a starting point for the energy calculations, and in some regulation, only PMV is considered, despite EN15251 which suggests the use of the adaptive model of comfort for naturally ventilated buildings.

Values for the prescriptive requirements: There is no space allocated for specifying the values. There are different values for the different climatic zones, which are attributed to the reference building, to which each building has to be compared

Individual energy metering and control units: Partially (approximate share of equipped buildings in the country)

DECRETO 26 giugno 2015 defines the procedures for applying the methodology for calculating the energy performance of buildings, including the use of renewable sources

Requirements for enforcement and compliance

Requirements for regular inspection of heating and AC systems: Yes, for both heating and AC systems

Penalties, incentives and other mechanisms for improving compliance with building energy codes in your country:

There are fiscal detractions if you go beyond the minimum requirements (about 60%), but also if you just do retrofit work (50%). The difference is small, so it does not incentives quality work sufficiently. Refusal for occupancy or construction permit

Luxembourg

In 2016, 38.4 percent of the population of Luxembourg lived in detached houses, 27.5 percent occupied semi-detached houses and 30.4 percent - in apartments of Apartment blocks. In conjunction with tighter building codes, the construction of many energy-efficient new homes and the renovation of older buildings helped improving the overall energy efficiency of the completely housing sector. The Ordinance of the Grand Duchy of 21 December 2007 on promoting rational energy use and renewable energy sources, aims at improving cavity wall insulation in existing buildings according to the ordinance on improving the overall energy efficiency of dwellings (Ordinance from 30 November 2007) [12,13].

Main regulatory documents related to building energy codes

Energy Performance of Functional Buildings (2010)

Règlement grand-ducal modifié la performance energétique des bâtiments (2008)

Performance-based requirements in building energy codes

- Thermal characteristics and geometry of the building (envelope and internal partitions, etc.)
- Air-tightness
- Space heating system and hot water supply units
- Air-conditioning system(s)
- Mechanical and natural ventilation
- Built-in lighting system
- Design position and orientation of buildings
- Passive solar systems and solar protection
- Indoor and outdoor climatic conditions
- Passive cooling
- Heat recovery
- Thermal bridges

Software: No data

End-uses energy: Appliances, Auxiliary devices, Space cooling, Space heating, Water heating, Lighting interior, Ventilation

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

Coverage:

- Single family houses
- Apartment blocks
- Commercial buildings
- Public buildings

- new residential
- new non-residential
- existing residential
- existing non-residential

Stringency: Mandatory

EPBD Energy Performance Certificate (2010) - Total primary energy performance:

kWh/m²/year	A	B	C	D	E	F	G	H	I
Multi-family	45	75	85	100	155	225	280	355	355
Single-family	45	95	125	145	210	295	395	530	530

Passive House (1990) - Maximum demand (kWh/m².year): cooling-15; space heating-15; total primary energy-120.

Zero Energy Buildings (ZEB) - Passive House standards in development

Existence of national registry database for EPC in your country: Yes

Building Materials and Products

Rating/certification of building materials: No data

Harmonization with other technical standards: No data

Requirements to test building materials and products by certified test laboratories: No data

Building Energy Codes Stringency and Coverage

Coverage:

- Single family houses
- Apartment blocks
- Commercial buildings
- Public buildings

- new residential
- new non-residential
- existing residential
- existing non-residential

Stringency: Mandatory

Prescriptive requirements in building energy codes

- Thermal insulation (including U-values for walls, floor, roof and windows)
- Air-tightness
- Ventilation or air quality
- Daylighting requirements
- Specified thermal comfort levels for summer and winter
- Solar gains (G-values)
- Artificial lighting system, lighting density
- Boiler/AC system
- Renewable

U-Values (W/m²K)	Walls	Floor	Roof
Building elements exposed to outside air	0.32	0.32	0.25
Building elements adjacent to weakly heated rooms	0.5	2.5	0.35
Building elements adjacent to unheated rooms or soil	0.4	0.4	0.3

U-Values (W/m²K)	Windows	Door
Building elements exposed to outside air	1.5	2
Building elements adjacent to weakly heated rooms	2	0.5
Building elements adjacent to unheated rooms or soil	2	2.5

Buildings without ventilation equipment: 5 m³/h.m² at 50 Pa

Buildings with outlet air ventilation equipment: 3 m³/h.m² at 50 Pa

Buildings with income/outlet air ventilation systems: 2 m³/h.m² 50 Pa

Requirements for primary energy demand are related to the ratio area / volume: Multi-family residential 80.0 - 160.0 kWh/m²/year

Single-family residential 90.0 - 160.0 kWh/m²/year

Requirements for heating energy demand are related to the ratio area / volume: Multi-family residential 40.0 - 95.0 kWh/m²/year

Single-family residential 55.0 - 95.0 kWh/m²/year

Requirements for enforcement and compliance

Penalties, incentives and other mechanisms for improving compliance with building energy codes in your country: Grant, Reduced interest rate on loans: 0.125%

Energy performance monitoring requirements: No data

Netherlands

In the Netherlands with a share of 87.3 per cent, residential property dwellings constitute the bulk of the total building stock. At the end of 2013, non-residential property made up approximately one eighth of the total building stock. Since the 1990s, the Netherlands has had strong taxation mechanisms in place to support energy efficiency efforts. Energy saving measures have also become more beneficial for households due to substantial energy taxes being initiated. The public building targets refer to the objectives of the recast EPBD, which requires nearly-zero energy performance for new government buildings by the end of 2018 and for all other buildings including residential by the end of 2020 [14,15].

Main regulatory documents related to building energy codes

Bouwbesluit 2012 - Chapter 5 (NEN 7120:2011)

The Housing Law refers to the Building Decree: this is the document containing all technical regulations for new and existing buildings. For Energy: there is the Energy performance regulation. This includes a reference to a national standard (Energy Performance Norm) with the calculation method. In 2021 the performance will be on the level of nZEB: 25 kWh/m2

Performance-based requirements in building energy codes

- Thermal characteristics and geometry of the building (envelope and internal partitions, etc.)
- Air-tightness
- Space heating system and hot water supply units
- Air-conditioning system(s)
- Mechanical and natural ventilation
- Built-in lighting system (mainly in the non-residential sector)
- Design position and orientation of buildings
- Passive solar systems and solar protection
- Indoor and outdoor climatic conditions
- Thermal bridge

Stringency: Mandatory

Software: NEN 7210

Energy use for: heating, cooling, hot water, lighting- Only for communal area, ventilation, Total primary energy use, Non-renewable primary energy use

The gap between predicted and actual performance levels: ~ 20%

Airtightness testing required prior to compliance: Yes

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

Coverage:

- Single family houses
- Apartment blocks
- Commercial buildings
- Public buildings

- new residential
- new non-residential
- existing residential
- existing non-residential

Stringency: Mandatory and Voluntary

http://wetten.overheid.nl/BWBR0023734/2016-07-01

Energy Offsets/Green Certificates; EPBD Energy Performance Certificate (2011); Zero Energy Buildings (ZEB) On 31 December 2018 governmental buildings will have to be nearly zero energy buildings (NZEB); Energy neutral buildings (proposal) (2020)

Existence of national registry database for EPC in your country: Yes

Building Materials and Products

Rating/certification of building materials: Yes

Harmonization with other technical standards: European Union standards used for CE Marking, International technical specifications, such as those prepared by ISO for other countries, NEN standards

Requirements to test building materials and products by certified test laboratories: Yes, there are several certification institutes

Building Energy Codes Stringency and Coverage

Coverage:

- Single family houses
- Apartment blocks
- Commercial buildings
- Public buildings

- new residential
- new non-residential
- existing residential (e.g. after substantial refurbishment) => same as new
- existing non-residential (e.g. after substantial refurbishment) => same as new

Prescriptive requirements in building energy codes

- Thermal insulation (including U-values for walls, floor, roof and windows)
- Specified thermal comfort levels for winter and summer
- Solar gains (G-values)
- Air-tightness
- Ventilation or air quality
- External solar protections
- Periodic transmittance and time lag of walls and roof
- Ventilation for summer comfort
- Solar absorbance of external surfaces (e.g. cool paintings for roofs and streets)
- Daylighting requirements
- Artificial lighting system, lighting density
- Boiler/AC system
- Renewables
- Thermal bridges

U-Value (W/m^2K): Roof-0.4; Wall-0.4; Floor-0.4; Window/Window2-1.4/6; Overall U-Value-0.4.

Thermal bridge demands

Overall Thermal bridge max value: 0.5

Ventilation:
Depends on the type and size of system.

Domestic Hot Water COP - Heat Pump:
Depends on the type and size of system.

Value for airtightness:
200 dm^3/s at 10 Pa or 200 dm^3/s per 500 m^3 at 10 Pa For residential buildings, 200 dm^3/s at 10 Pa and for non-residential buildings 200 dm^3/s per 500 m^3 at 10 Pa

Technical HVAC systems

Efficient Lighting

EPN Energy Performance Standard

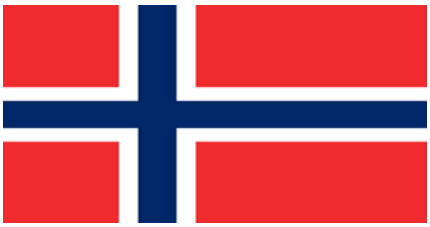
Requirements for enforcement and compliance

Requirements for regular inspection of heating and AC systems: Yes

Penalties, incentives and other mechanisms for improving compliance with building energy codes in your country: Refusal of permission to occupy, Refusal of permission to construct

Energy performance monitoring requirements: Yes

Norway



Insulation to ensure adequate indoor air quality and comfort is always a part of the building code in Norway. Requirements for energy efficiency as a justification was introduced in the technical construction standards in 1969. In 1987, the requirements were tightened. Codes in 1997 placed greater emphasis on energy and the environment. Further tightening of energy requirements in the new 2010 technical code. This code is called TEK10 and is the current code. A new white paper from the Norwegian Parliament regarding future climate and building policy has notified an introduction of passive house level as a minimum requirement in the Building codes from 2015. In the new code from 2015, the passive house level might be defined as supplied energy calculated for a reference building equivalent to a passive house in accordance with NS 3700 and NS 3701 [48].

Main regulatory documents related to building energy codes

The Planning and Building Act of 27 June 2008

The Planning and Building Act (2010-2015)

The Planning and Buildings Act (2016-2017)

Norwegian standard NS 3700:2013 Criteria for passive houses and low energy houses.

- 2008-01.01.2017
- Climate zones: 1, 2, 3

Performance-based requirements in building energy codes

- Thermal characteristics and geometry of the building (envelope and internal partitions, etc.)
- Air-tightness
- Space heating system and hot water supply units
- Air-conditioning system(s)
- Mechanical and natural ventilation
- Built-in lighting system
- Design position and orientation of buildings
- Passive solar systems and solar protection
- Indoor and outdoor climatic conditions

Software: Various software can be used if in line with national calculation methods

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

Coverage:

- Single family houses (Small houses)
- Apartment blocks (Block of flats)
- Commercial buildings
- Public buildings

- new residential
- new non-residential
- existing residential
- existing non-residential

Stringency: Mandatory

Existence of national registry database for EPC in your country: Yes

Building Materials and Products

Rating/certification of building materials: No data

Harmonization with other technical standards: No data

Requirements to test building materials and products by certified test laboratories: No data

Building Energy Codes Stringency and Coverage

Coverage:

- Single family houses (Small houses)
- Apartment blocks (Block of flats)
- Commercial buildings
- Public buildings

- new residential
- new non-residential
- existing residential
- existing non-residential

Stringency: Mandatory

Energy used for: Space heating, Appliances, Water heating, Lighting interior, Ventilation

Prescriptive requirements in building energy codes

- Thermal insulation (including U-values for walls, floor, roof and windows)
- Air-tightness
- Ventilation or air quality
- Daylighting requirements
- Boiler/AC system
- Specified thermal comfort levels for summer and winter
- Solar gains (G-values)
- Renewables

Prescriptive Energy Requirements: Heated usable floor area

Energy Requirements:

Insulation

U-Values (W/m^2.K)	Walls	Floor	Roof
Minimum requirements	≤ 0.22	≤ 0.18	≤ 0.18
Basic/standard requirements	≤ 0.18	≤ 0.10	≤ 0.13
U-Values (W/m^2.K)	Windows		
Minimum requirements	≤ 1.2		
Basic/standard requirements	≤ 0.8		

Proportion of window and door areas ≤ 25% of heated usable floor space.

Air Leakage: The energy budget in the requirements assume an air leakage of max. 0.6 l/s.m^2 at 50 Pa.

Renewable Energy: The installation of fossil fuel heating installations is not permitted.

Small houses and leisure homes with more than 150 m^2 of heated usable floor space: 120 kWh/m^2/year + 1600 kWh/m^2 of heated usable floor area. Block of flats: 115 kWh/m^2/year

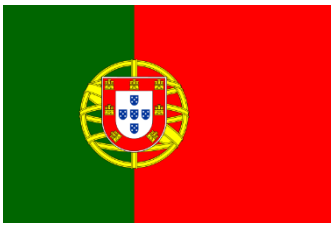
Requirements for enforcement and compliance

Requirements for regular inspection of heating and AC systems: No data

Penalties, incentives and other mechanisms for improving compliance with building energy codes in your country: No data

Energy performance monitoring requirements: No data

Portugal



According to the statistics Institute of Portugal, the housing stock of the country is divided into three parts in the following proportion: 68.2 per cent belongs to the category of permanent housing, 19.3 per cent are houses and apartments of seasonal residence, and 12.5 per cent of housing is not used at all. Almost the entire housing stock of the country belongs to the individual housing stock. Only 0.2 per cent can be attributed to the communal stock, which includes nursing homes, social support institutions, hotels, health resorts, monasteries, educational institutions and dormitories. Portuguese cities are experiencing a building Renaissance thanks to strong economic growth, which contributes to the development of new commercial and office space and an increase in the number of repurchase of old buildings for renovation. Portugal has developed new methods and achieved high efficiency in all sectors of production of building materials [16].

Main regulatory documents related to building energy codes

42 laws, acts, regulations, notices: see the end of the manual responses

- The current set of regulations was adopted during the time of 2009-2017 (see the end of the manual responses)
- Climate zones

Performance-based requirements in building energy codes

Energy use for: heating, cooling, hot water, lighting, ventilation. Total primary energy use, Non-renewable primary energy use.

- Thermal characteristics and geometry of the building (envelope and internal partitions, etc.)
- Air-tightness
- Space heating system and hot water supply units
- Air-conditioning system(s)
- Mechanical and natural ventilation
- Built-in lighting system (mainly in the non-residential sector)
- Design position and orientation of buildings
- Passive solar systems and solar protection
- Indoor and outdoor climatic conditions
- Thermal bridge

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

Coverage:

- Single family houses
- Apartment blocks
- Commercial buildings
- Public buildings

- new non-residential
- new residential
- existing residential (e.g. after substantial refurbishment)
- existing non-residential (e.g. after substantial refurbishment)

Stringency: Mandatory

Existence of national registry database for EPC in your country: Yes

Building Materials and Products

Rating/certification of building materials: Yes,

Harmonization with other technical standards: European Union standards used for CE Marking, International technical specifications, such as those prepared by ISO for other countries

Requirements to test building materials and products by certified test laboratories: Yes, LNEG

Input control of construction materials and acceptance control of structures on the construction site: Yes

Building Energy Codes Stringency and Coverage

Coverage:

- Single family houses
- Apartment blocks
- Commercial
- Public buildings

Energy codes are mandatory for housing buildings and services and commercial buildings being new, sold or rented or under deep renovation.

- New non-residential
- New residential
- Existing residential (e.g. after substantial refurbishment)
- Existing non-residential (e.g. after substantial refurbishment)

Stringency: Mandatory

Prescriptive requirements in building energy codes

- Thermal insulation (including U-values for walls, floor, roof and windows)
- Specified thermal comfort levels for winter and summer
- Solar gains (G-values)
- Air-tightness
- Ventilation or air quality
- External solar protections
- Periodic transmittance and time lag of walls and roof
- Ventilation for summer comfort
- Solar absorbance of external surfaces (e.g. cool paintings for roofs and streets)
- Daylighting requirements
- Artificial lighting system, lighting density
- Boiler/AC system
- Renewables
- Thermal bridges

Individual energy metering and control units: Yes

Mandatory requirement: Yes

Requirements for enforcement and compliance

Requirements for regular inspection of heating and AC systems: Yes, for both heating and AC systems, Yes, for heating systems only

Specific incentives that complement or motivate compliance with building energy codes: Yes, Incentives on buildings renovation and integration of renewables.

Penalties, incentives and other mechanisms for improving compliance with building energy codes in your country: Fines for non-compliance

Energy performance monitoring requirements: Yes, Mandatory

Spain

Spain first implemented prescriptive energy efficiency requirements for buildings in 1979. Recent updates have increased requirements in order to meet the expectations of the EPBD and the subsequent recast in 2010. The 2009 CET and supporting policy encompasses progressive aspects including, mandatory renewable energy requirements (solar hot water and photovoltaic systems), compulsory post occupancy testing of boilers and HVAC systems, bioclimatic design considerations, mandatory performance requirements for existing buildings and low energy classes through Energy Performance Certification levels A, B & C. The Spanish Association for standardization and certification (AENOR) develops technical standards, is also successfully operating in the country [17].

Main regulatory documents related to building energy codes

Plan de Acción de Ahorro y Eficiencia Energética

Escala de calificación energética

- 2006 with the Spanish Building Code
- Climate zones, Sub-regions

Spain has different climatic areas. The areas are precisely defined and the energy code depends on the determined one.

Performance-based requirements in building energy codes

- Thermal characteristics and geometry of the building (envelope and internal partitions, etc.)
- Space heating system and hot water supply units
- Mechanical and natural ventilation
- Design position and orientation of buildings
- Passive solar systems and solar protection
- Indoor and outdoor climatic conditions
- Thermal bridge

The full set of CEN EPB standards

Software used for compliance verification: Llider-Calener y Cerma

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

Coverage:

- Single family houses
- Apartment blocks
- Commercial buildings
- Public buildings

- new residential

Types of buildings that are covered by EPC in your country: It is compulsory for new building and for existing only when the building/property is sold, rented or belong to public institution. Also in a voluntary certification

Stringency: Mandatory

Existence of national registry database for EPC: No

Two regulations reflect the transposition of the EU directives 2002/91/CE into the Royal Decree 47/2007 of January 19 to apply the energy efficiency certification to buildings

Building Materials and Products

Rating/certification of building materials: Yes

Harmonization with other technical standards: European Union standards used for CE Marking

Requirements to test building materials and products by certified test laboratories: Yes

Building Energy Codes Stringency and Coverage

Coverage:

- Single family houses
- Apartment blocks
- Commercial
- Public buildings

- new non-residential
- new residential
- existing residential (e.g. after substantial refurbishment)
- existing non-residential (e.g. after substantial refurbishment)

Stringency: Mixed (both voluntary and mandatory)

The existing stock should obtain the energy code when: (1) they are sold or rented, (2) they have to be refurbished and (3) they are public buildings. New building is submitted to minimum requirements to guarantee a minimum energy efficiency

The national classification of buildings covered by the energy codes: All buildings. Minimum energy consumption saving determined by building code

Refurbishing is submit to an obligation to implement energy efficient installations and works. Only high-energy efficient installations and devices can be installed. Non-renewable primary energy use.

Prescriptive requirements in building energy codes

- Thermal insulation (including U-values for walls, floor, roof and windows)
- Solar gains (G-values)
- Periodic transmittance and time lag of walls and roof
- Solar absorbance of external surfaces (e.g. cool paintings for roofs and streets)
- Artificial lighting system, lighting density
- Boiler/AC system
- Thermal bridges

House building is much regulated and minimum quality in construction is required to obtain building permissions.

District heating and other external heating systems, the buildings equipped with individual energy metering and control units: No

Mandatory requirement: Yes

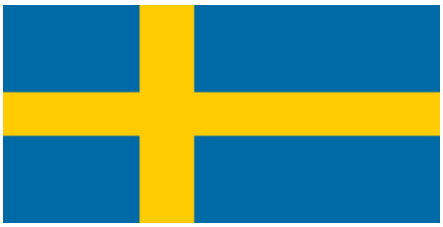
Requirements for enforcement and compliance

Building energy codes contain requirements for regular inspection of heating and AC systems: Yes, for heating systems only

Penalties, incentives and other mechanisms for improving compliance: No, Refusal for occupancy or construction permit

Energy performance monitoring requirements: Yes

Sweden



Sweden has a long history of energy efficiency requirements for buildings, with the first prescriptive requirements being implemented in 1946. The first performance-based code arose following the EPBD in 2002. The latest BBR encompasses many dynamic aspects including low overall u-values requirements, mandatory energy measurement, Specific Fan Power requirements, performance requirements for buildings undergoing renovation and interim (2015) performance targets for most building types in preparation for the nZEB target of 2020. The Swedish Energy Performance Certificates are quite reliable because they are based on energy bills and not on theoretical calculations [18, 19].

Main regulatory documents related to building energy codes

Boverket's Building Regulations, BBR18 - (BFS 2011:26)

Building Regulations BBR10 (2012)

- 2010
- Three climate zones: North - Very Cold/subarctic, Middle - Cold, and South - Cold marine, Cold. All are heating based.

Performance-based requirements in building energy codes

- Thermal characteristics and geometry of the building (envelope and internal partitions, etc.)
- Air-tightness
- Space heating system and hot water supply units
- Air-conditioning system(s)
- Mechanical and natural ventilation
- Built-in lighting system
- Design position and orientation of buildings
- Passive solar systems and solar protection
- Indoor and outdoor climatic conditions
- Thermal bridge
- Dehumidification
- Heat recovery
- Passive cooling

Software: No data

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

Coverage:

- Single family houses (One Family)
- Apartment blocks (Multifamily)
- Commercial buildings
- Public buildings

- new residential
- new non-residential
- existing residential (e.g. after substantial refurbishment)
- existing non-residential (e.g. after substantial refurbishment)

Stringency: Mandatory

Energy Performance Certificate support BC; Positive labeling for building beyond the minimum BC level; Energy Offsets/Green Certificates; Number of certified buildings: 280000; EPBD Energy Performance Certificate (2010); Swan (2009).

Building Materials and Products

Rating/certification of building materials: No data

Harmonization with other technical standards: No data

Requirements to test building materials and products by certified test laboratories: No data

Building Energy Codes Stringency and Coverage

Coverage:

- Residential buildings: One family; Multiple family buildings
- Commercial buildings: Offices; Retail and wholesale; Hotels; Hospitals; Educational buildings
- Public buildings: Offices; Hospitals; Educational buildings

- new residential
- new non-residential
- existing residential
- existing non-residential

Stringency: Mandatory

Space cooling, Space heating, Water heating, Lighting interior, Ventilation. The conversion of primary energy

Prescriptive requirements in building energy codes

- Thermal insulation (including U-values for walls, floor, roof and windows)
- Air-tightness
- Ventilation or air quality
- Daylighting requirements
- Artificial lighting system, lighting density
- Boiler/AC system
- Specified thermal comfort levels for summer
- Solar gains (G-values)
- Renewables

U-values (W/m^{2}K): Roof – 0.4; Wall – 0.4; Window – 0.4

Air Tightness – 0.61 l/s.m^2 at 50 Pa

Climate Zone 3 - Residential, Non-Electrically Heated

U-values (W/m^{2}K): Roof – 0.13; Wall – 0.18; Floor – 0.15; Window – 1.3; Overall U-Value – 0.4. Energy Performance: 90 kWh

Climate Zone 3 - Residential, Electrically Heated

U-values (W/m^{2}K): Roof – 0.08; Wall – 0.1; Floor – 0.1; Window – 1.1; Overall U-Value – 0.4.Energy Performance: 55 kWh

Climate Zone 3 - Non Residential, Non Electrically Heated

Overall U-Value – 0.6. Energy Performance: 80 kWh

Climate Zone 1 - Residential, Electrically Heated

U-values (W/m^{2}K): Roof – 0.13; Wall – 0.18; Floor – 0.15; Window – 1.3. Energy Performance: 95 kWh

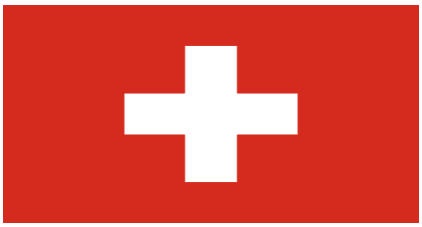
Requirements for enforcement and compliance

Requirements for regular inspection of heating and AC systems: Yes

Penalties, incentives and other mechanisms for improving compliance with building energy codes in your country: Fine, Refusal of permission to occupy, Refusal of permission to construct

Energy performance monitoring requirements: Yes, use by a method of measurement.

Switzerland



Switzerland developed appropriate rules for achieving the targets of the EU 20/20/20. Standards demand for heat and power under development 2014 and 2020: a reassessment of the basic agreement of the cantons on the performance of buildings, changes of various energy laws of the cantons; coordinated building codes of the Swiss cantons shall be strengthened by 2014. The prohibition of electric heating also for existing buildings by 2015. The requirement of near-zero energy buildings for new buildings should be incorporated into the building regulations of Swiss cantons by 2014 to near-zero energy buildings to become mandatory by 2018. Recently launched MINERGIE-a-standard, considered as a way to identify a near-ZERO-energy building [50].

Main regulatory documents related to building energy codes

SIA (Swiss Society of Engineers and Architects) norms: regulations related to every aspect of the construction and operation of the building, especially the SIA 2031:2009: Norm for the Energy certification of buildings, which regulates the energy performance classification. At the same time, each of the 26 cantons of Switzerland sets its own requirements. Local building and insulation codes, vary by canton, sub-regions, varies date.

- EnDK (Conference of Cantonal Energy Directors) prescriptions: the MoPEC 2014: cantonal energy regulations if a model or template for cantonal energy regulations, created with the objective of reducing energy needs in the buildings sector, especially in existing buildings. https://www.endk.ch/fr/politique-energetique/mopec
- CECB: the cantonal label for energy use in buildings https://www.cecb.ch/StartPage.asp
- MINERGIE: the private label for energy use in buildings

Performance-based requirements in building energy codes

- Thermal characteristics and geometry of the building (envelope and internal partitions, etc.)
- Air-tightness
- Space heating system and hot water supply units
- Air-conditioning system(s)
- Mechanical and natural ventilation
- Built-in lighting system (mainly in the non-residential sector)
- Design position and orientation of buildings
- Passive solar systems and solar protection
- Indoor and outdoor climatic conditions
- Thermal bridge

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

Coverage:

- Single family houses
- Apartment blocks
- Commercial buildings
- Public buildings

- new non-residential
- existing residential (e.g. after substantial refurbishment)

Stringency: Mandatory and Mixed (both mandatory and voluntary)

Existence of national registry database for EPC: No and Yes

Building Materials and Products

Rating/certification of building materials: Yes

Harmonization with other technical standards: Swiss codes, European Union standards used for CE Marking, International technical specifications, such as those prepared by ISO

Requirements to test building materials and products by certified test laboratories: Yes

Building Energy Codes Stringency and Coverage

Coverage:

- Single family houses
- Apartment blocks
- Commercial
- Public buildings
- Multifamily house, Hotel, Office, School, Shop, Restaurant, multi-purpose halls, Hospital, Industry, Sport halls, Warehouse

- New non-residential
- New residential
- Existing residential (e.g. after substantial refurbishment)
- Existing non-residential (e.g. after substantial refurbishment)
- Subsidies provided by cantons to upgrade buildings built before 2000

Stringency: Mandatory and Mixed (both voluntary and mandatory)

- Local / canton codes prevalence
- Variable depending on canton

Prescriptive requirements in building energy codes

- Thermal insulation (including U-values for walls, floor, roof and windows)
- Air-tightness
- Ventilation or air quality
- Daylighting requirements
- Artificial lighting system, lighting density
- Boiler/AC system
- Thermal bridges
- Specified thermal comfort levels for winter and summer
- External solar protections
- Solar gains (G-values)
- Periodic transmittance and time lag of walls and roof
- Renewables

District heating and other external heating systems, the buildings equipped with individual energy metering and control units: Yes

Requirements for enforcement and compliance

Requirements for regular inspection of heating and AC systems: Yes, for heating systems only

Penalties, incentives and other mechanisms for improving compliance with building energy codes in your country: Yes,

- subsidies
- refusal for occupancy or construction permit
- Financial incentives are given to improve the thermal efficiency of the envelope and heating systems
- The Swiss Buildings Program supports measures to improve the energy efficiency of real estate assets, such as roof and facade insulation, heat recovery, optimization of technical facilities and the use of renewable energy.

Energy performance monitoring requirements: No

United Kingdom

Each constituent part of the United Kingdom (England, Wales, Scotland and Northern Ireland) sets its own requirements. As a member of the European Union, the United Kingdom must comply with the Energy Performance of Buildings Directive (EPBD). England and Wales, Scotland as well as Northern Ireland are responsible for incorporating European directives at their own national levels. The country's housing stock is old relative to most European countries with many houses dating from the Victorian era. As a result, many houses have poor insulation with properties resulting in additional consumption to maintain a given level of comfort. Houses built prior to 1918 represented 25 per cent of the housing stock in 1970 compared to 17 per cent built prior to 1919 in 2015 [20].

Main regulatory documents related to building energy codes

Each constituent part of the United Kingdom (England Wales, Scotland and Northern Ireland, Scotland, Wales) sets its own requirements. Statutory guidance - Conservation of fuel and power: Approved Document L. Building Regulations 2010 in England setting standards for the energy performance of new and existing buildings.

- Approved Document L1A: conservation of fuel and power in new dwellings, 2013 edition with 2016 amendments;
- Approved Document L1B: conservation of fuel and power in existing dwellings, 2010 edition (incorporating 2010, 2011, 2013 and 2016 amendments);
- Approved Document L2A: conservation of fuel and power in new buildings other than dwellings, 2013 edition with 2016 amendments;
- Approved Document L2B: conservation of fuel and power in existing buildings other than dwellings, 2010 edition (incorporating 2010, 2011, 2013 and 2016 amendments).

Building Energy Codes Stringency and Coverage

Coverage:

- Single family houses
- Apartment blocks
- Commercial
- Public buildings

- new non-residential
- new residential
- existing residential
- existing non-residential

Stringency:

Mixed (both voluntary and mandatory)

Performance-based requirements in building energy codes

- Thermal characteristics and geometry of the building (envelope and internal partitions, etc.)
- Air-tightness
- Space heating system and hot water supply units
- Air-conditioning system(s)
- Mechanical and natural ventilation
- Built-in lighting system (mainly in the non-residential sector)
- Design position and orientation of buildings
- Passive solar systems and solar protection
- Indoor and outdoor climatic conditions
- Thermal bridge

Prescriptive requirements in building energy codes

- Thermal insulation (including U-values for walls, floor, roof and windows)
- Air-tightness
- Ventilation or air quality
- Daylighting requirements
- Artificial lighting system, lighting density
- Boiler/AC system

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

Coverage:

- Single family houses
- Apartment blocks
- Commercial
- Public buildings

- new non-residential
- new residential
- existing residential
- existing non-residential

Stringency: Mandatory

Existence of national registry database for EPC: Yes

Requirements for enforcement and compliance

Requirements for regular inspection of heating and AC systems: Yes, for AC systems only

Penalties, incentives and other mechanisms for improving compliance: Yes, incentives and fines for non-compliance

Energy performance monitoring requirements: No

Building Materials and Products

Rating/certification of building materials: Yes

Harmonization with other technical standards: European Union standards used for CE Marking

Requirements to test building materials and products by certified test laboratories: Yes

Subregion B:
EU enlargement : 13 countries that joined the EU after 2004 (EU13)[114]

Countries
Bulgaria
Croatia
Czech Republic
Estonia
Hungary
Latvia
Lithuania
Poland
Romania
Slovakia
Slovenia

[114] Cyprus and Malta are not included due to lack of available information

Bulgaria

Bulgaria's housing stock is divided into old and new housing stock. In recent years, the Ministry of regional development and public works has set as one of its main objectives the creation of positive regulatory, institutional and financial conditions in order to facilitate the process of modernization and energy-efficient reconstruction of the country's housing stock. Bulgaria plans to implement pilot projects for new public buildings with near zero energy as part of the solution of these tasks, and financing of these projects should be planned for the program period 2014-2020 [21].

Main regulatory documents related to building energy codes

Energy Efficiency Act (EEA), spatial development act, ordinance no. 7 of 2004 on energy efficiency of buildings, order № e-rd-04-1 of 22 January 2016 for energy efficiency, certification and evaluation of energy savings of buildings

- The current set of regulations was adopted: In the amendment of the EEA from 2015
- Year 2004, 2009, 2015
- Climate zones

Performance-based requirements in building energy codes

- Thermal characteristics and geometry of the building (envelope and internal partitions, etc.)
- Air-tightness
- Space heating system and hot water supply units
- Air-conditioning system(s)
- Mechanical and natural ventilation
- Built-in lighting system (mainly in the non-residential sector)
- Design position and orientation of buildings
- Passive solar systems and solar protection
- Indoor and outdoor climatic conditions
- Thermal bridge

Using the set of Energy Performance in Buildings (EPB) standards: A selection of the set of CEN EPB standards; The subset of ISO EPB standards

Using the International Performance Measurement & Verification Protocol (IPMVP): On a voluntary basis

Software for compliance verification: Yes, EAB V 1.0 - Product of the Technical University - Sofia

The average percentage gap: up to 3% while preserving incoming forecast conditions

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

Coverage:

- Single family houses
- Apartment blocks
- Apartment blocks
- Public buildings

- new non-residential

Stringency: mandatory

Existence of national registry database for EPC: Yes

Building Materials and Products

Rating/certification of building materials: Yes

Harmonization with other technical standards: European Union standards used for CE Marking

Requirements to test building materials and products by certified test laboratories: Yes

Building Energy Codes Stringency and Coverage

Coverage:

- Single family houses
- Apartment blocks
- Commercial
- Public buildings

- new non-residential
- new residential
- Existing residential (e.g. after substantial refurbishment)
- Existing non-residential (e.g. after substantial refurbishment)

1. Residential buildings (also used for dormitories)

2. Buildings for public service: 2.1 buildings for administrative service, 2.2 buildings for education and science -schools -universities -kindergartens and nurseries 3. Medical establishments

4. Buildings for public service in the hospitality sector. 5. Buildings in the area of trade. 6. Buildings for sports. 7. Buildings in the field of culture and art

Stringency: Mandatory

Prescriptive requirements in building energy codes

- Thermal insulation (including U-values for walls, floor, roof and windows)
- Specified thermal comfort levels for winter and summer
- Solar gains (G-values)
- Air-tightness
- Ventilation or air quality
- External solar protections
- Periodic transmittance and time lag of walls and roof
- Ventilation for summer comfort
- Solar absorbance of external surfaces (e.g. cool paintings for roofs and streets)
- Daylighting requirements
- Artificial lighting system, lighting density
- Boiler/AC system
- Renewables
- Thermal bridges

Individual energy metering and control units: Yes, Mandatory

The main legislative documents relating to EPC: ORDINANCE No E-RD-04-1 of 22.01.2016.

ORDINANCE No 7 of 15 December 2004 on the energy efficiency of buildings

Through Methodology for the calculation of energy consumption and energy performance indicators of buildings based on EN 13790

Requirements for enforcement and compliance

Requirements for regular inspection of heating and AC systems:

Yes, for both heating and AC systems

Penalties, incentives and other mechanisms for improving compliance: Refusal for occupancy or construction permit, Fines for non-compliance, Exemption from building tax for older buildings that meet certain energy efficiency requirements and are not publicly funded

Energy peformance monitoring requirements: Yes

Croatia

The share of buildings in Croatia accounts for about 40 per cent of the total energy consumption. Although the first regulation on thermal protection of buildings was issued in 1970 (Ordinance on technical measures and conditions for thermal protection of buildings), and the energy efficiency improved through Further Technical Regulations the most significant move in that direction was adopting Building Act (OG 153/2013) which fully transposed Directive 2010/31/EC of the European Parliament and of the Council of 19 may 2010 on energy efficiency of buildings into the legal system of the Republic of Croatia and adopting new Technical regulation on energy economy and heat retention in buildings (OG 128/15) [22].

Main regulatory documents related to building energy codes

Directive 2010/31/EU of the European Parliament and of the Council and Article 6 of Regulation (EU) 244/2012 of 16 January 2012 and Reports according to Article 5(2) of Directive 2010/31/EU. National regulation: Building Act (OG 153/13, 20/17), Technical regulation on energy economy and heat retention in buildings (OG 128/15), Ordinance on energy audits and energy certification of buildings (OG 88/17)

- First transposition activities of the EPBD started in 2005 but official implementation of the EPBD started in 2008 under the Ministry of Construction and Physical Planning (MCPP)
- Climate zones for all localities in the Republic of Croatia with average monthly outdoor temperature of the coldest month θmm is ≤ 3 °C (continental area), and for all localities in the Republic of Croatia with θmm > 3 °C (coastal area). The annual energy demand is calculated on the basis of reference climate data.

Performance-based requirements in building energy codes

- Thermal insulation (including U-values for walls, floor, roof and windows)
- Space heating system and hot water supply units
- Air-tightness
- Air-conditioning system(s)
- Mechanical and natural ventilation
- Built-in lighting system (mainly in the non-residential sector)
- Design position and orientation of buildings
- Passive solar systems and solar protection
- Indoor and outdoor climatic conditions
- Thermal bridge

The subset of ISO EPB standards, The Building Act set the legislative basis for implementation of the EPBD in all parts

The International Performance Measurement & Verification Protocol (IPMVP): Yes

Software used for compliance verification: Yes,

MGIPU Energetski Certifikator

There is mandatory requirement to assess post-construction requirement of the thermal bridge: Yes

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

Coverage:

- Single family houses
- Apartment blocks
- Commercial buildings
- Public buildings

Existence of national registry database for EPC: Yes

Type of energy that the EPC refer to: Total primary energy

Building Materials and Products

Rating/certification of building materials: Yes

Harmonization with other technical standards: European Union standards used for CE Marking

Building Energy Codes Stringency and Coverage

Coverage:

- Single family houses
- Apartment blocks
- Commercial
- Public buildings

- New non-residential
- New residential
- Existing residential (e.g. after substantial refurbishment)
- Existing non-residential (e.g. after substantial refurbishment)

Stringency:

Mandatory

Energy use for: heating, cooling, lighting, ventilation. Total primary energy use, Non-renewable primary energy use.

Prescriptive requirements in building energy codes

- Thermal insulation (including U-values for walls, floor, roof and windows)
- Solar gains (G-values)
- Air-tightness
- External solar protections

The values are specified in the Technical regulation on energy economy and heat retention in buildings (Official Gazette 128/15) Annex B

Requirements for enforcement and compliance

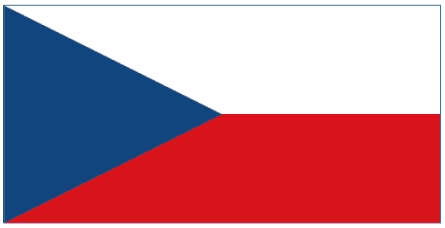
Requirements for regular inspection of heating and AC systems: Yes, for both heating and AC systems

Penalties, incentives and other mechanisms for improving compliance: Yes, Fines for non-compliance

Incentives: For existing buildings, the integral energy renovation of buildings are co-financed (EU funds), for new and existing buildings penalties for non-compliance include fines (Building Act, OG 153/13, 20/17) and refusal for issuing a construction or use permit.

Energy performance monitoring requirements: Yes

Czech Republic



According to the results of the 2011 Population and Housing Census, the dwelling stock of the Czech Republic totaled 4,756,572 dwellings, with 4,104,635 occupied dwellings, of which 43.7 percent were in family houses and 55 percent in multi-dwelling buildings. The average age of occupied multi-dwelling buildings was 52.4 years and of family houses 49.3 years. In the context of implementing the requirements of Directive 2010/31/EU, new buildings must meet the requirement met by nearly zero-energy buildings by 2020. Under the Act No 406/2000 a "nearly zero-energy building" (NZEB) is defined as a 'building that has a very high-energy performance whose energy consumption is covered to a very significant extent by energy from renewable sources [23, 24].

Main regulatory documents related to building energy codes

Energy Management Act No. 406/2000 Coll.

Decree no. 78/2013 Coll. on Energy Performance of Building

ČSN EN 73 0540 Thermal Protection of Buildings (standard)

- Transposition of the EPBD II directive entered into force 1. 1. 2013 on the national level

Performance-based requirements in building energy codes

New buildings – C level or already NZEB level in some cases. Existing buildings – when undergoing major renovation – C level-is the minimum based on the cost-optimum calculation.

- Thermal characteristics and geometry of the building
- Space heating system and hot water supply units
- Air-conditioning system(s)
- Mechanical and natural ventilation
- Built-in lighting system (mainly in the non-residential sector)
- Design position and orientation of buildings
- Passive solar systems and solar protection
- Indoor and outdoor climatic conditions
- Thermal bridge

Stringency: Mandatory

Energy use for: heating, cooling, hot water, lighting, ventilation; total primary energy use; Non-renewable primary energy use

Using the set of EPB standards: None; Using the IPMVP: No

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

Coverage:

- Single family houses
- Apartment blocks
- Commercial buildings
- Public buildings, Buildings occupied by public authorities

- new non-residential
- new residential
- existing residential (e.g. after substantial refurbishment)
- existing non-residential (e.g. after substantial refurbishment)

Type of EPC energy: total primary energy, non-renewable primary energy, total delivered energy. Stringency: Mandatory

Building Materials and Products

Rating/certification of building materials: Yes, European Union standards used for CE Marking

Harmonization with other technical standards: Construction products for which harmonised standards according to point a) do not exist, must follow the Government Decree No. 163/2002 Coll., laying down technical requirements for selected construction products.

Requirements to test building materials and products by certified test laboratories: Czech Office for Standards, Metrology and Testing, Czech Accreditation Institute

Building Energy Codes Stringency and Coverage

Coverage:

- Single family houses
- Apartment blocks
- Commercial buildings
- Public buildings, Buildings occupied by public authorities

- new residential
- new non-residential
- existing residential (e.g. after substantial refurbishment)
- existing non-residential (e.g. after substantial refurbishment)

Stringency: Mandatory

Prescriptive requirements in building energy codes

- Thermal insulation (including U-values for walls, floor, roof and windows)
- Specified thermal comfort levels for winter and summer
- Solar gains (G-values)
- Air-tightness
- Ventilation or air quality
- External solar protections
- Artificial lighting system, lighting density
- Boiler/AC system
- Thermal bridges

Stringency: Mandatory

Individual energy metering and control units: Yes

The values of the prescriptive requirements are given in the Table

"Parameters and values of reference building for the energy performance calculation".

Requirements for enforcement and compliance

Requirements for regular inspection of heating and AC systems: Yes, for both heating and AC systems.

The Energy Management Act implements the whole EPBD II directive, mandatory requirement.

Any new building cannot be built if does not comply with national legislation. CZ also runs several financial instruments such as financing from structural or national funds to reach higher than minimum energy performance requirements in construction. For example: New Green Savings Programme http://www.novazelenausporam.cz/en/.

Penalties, incentives and other mechanisms for improving compliance with building energy codes in your country:

Yes, Fines for non-compliance, construction permit. The EPC must be part of the construction permit to prove compliance with the minimum energy performance requirements. If is not, permit is not issued.

Energy performance monitoring requirements: Yes

Hungary

In the 2010–2013 period, the Government of Hungary prepared the essential documents in which the domestic energy policy, the set of conditions for establishing sustainable energy supply systems, the main tasks for improving energy efficiency and increasing the share of renewable energy as well as energy-related environmental targets are defined for the long term. These documents put the task of improving building energy performance into a wider energy policy, economic and social context. Discussion of these strategic Government documents will be limited in this Chapter to a summary of the main propositions and tasks formulated in them, which have relevance for the energy performance of buildings, without presenting the documents themselves in detail. [25].

Main regulatory documents related to building energy codes

Országos Településrendezési és Építési Követelmények' (OTÉK)

Performance-based requirements in building energy codes

No data

Stringency: Mandatory

Software: No data

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

Coverage:

- Single family houses
- Apartment blocks
- Commercial buildings
- Public buildings

- new residential
- new non-residential
- existing residential
- existing non-residential

Stringency: Mixed (both mandatory and voluntary)

EPBD certification (2012)

Percentage efficiency scale based on primary consumption. 100% = 2006 requirements

Class:

A=>56-76%; A+ => <55%; B=>77-95%; C=> 96-100%; D=>101-120%; E=> 121-150%; F=> 151-190%; G=> 191-250%; H=> 251-340%; I=> >341%

Zero Energy Buildings (ZEB)

New buildings to be zero emission buildings-2020

Building Materials and Products

Rating/certification of building materials: No data

Harmonization with other technical standards: No data

Requirements to test building materials and products by certified test laboratories: No data

Building Energy Codes Stringency and Coverage

Coverage:

- Single family houses
- Apartment blocks
- Commercial buildings
- Public buildings

- new residential
- new non-residential
- existing residential
- existing non-residential

Stringency: Mandatory

Prescriptive requirements in building energy codes

No data

Energy Requirements:

Insulation

U-Values (W/m^2.K)	Roof	Walls	Floor
All climate zones	0.25	0.45	0.45

U-Values (W/m^2.K)	Windows	Door
All climate zones	1.6	1.6

Air Leakage: Not regulated

Requirements for primary energy demand are related to the ratio area / volume: 110.0 - 230.0 kWh/m^2/year

Requirements for enforcement and compliance

Requirements for regular inspection of heating and AC systems: No data

Penalties, incentives and other mechanisms for improving compliance with building energy codes in your country: No data

Energy performance monitoring requirements: No data

Lithuania

The majority of the Lithuanian population (66%), live in multi-apartment buildings constructed in the period from 1960-1990. Currently, 97% of the housing stock is privately owned and only 3 per cent of apartments belong to local municipalities. Institutions responsible for housing are the Ministry of Environment and the Housing and Urban Development Agency, which administrates housing refurbishment programmes. The principal documents for housing sector and refurbishment of the multi-family buildings are Lithuanian Housing Strategy (2004). The Strategy foresees to renovate 70 per cent of the multi-apartment dwelling houses by 2020, and reduce the cost of heat energy up to 30 per cent; "Programme for the Modernisation of Multi-family Buildings", which started in 2005 [26].

Main regulatory documents related to building energy codes

Technical Regulation of Construction STR 2.01.09:2005 Building Technical Regulation STR 2.01.09:2005

- 2005

Performance-based requirements in building energy codes

- Thermal characteristics and geometry of the building (envelope and internal partitions, etc.)
- Air-tightness
- Space heating system and hot water supply units
- Air-conditioning system(s)
- Mechanical and natural ventilation
- Built-in lighting system
- Design position and orientation of buildings
- Passive solar systems and solar protection
- Indoor and outdoor climatic conditions
- Passive cooling
- Heat recovery
- Thermal bridges

Software: No data

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

Coverage:

- Single family houses
- Apartment blocks
- Commercial buildings
- Public buildings

- new residential
- new non-residential
- existing residential
- existing non-residential

Stringency: Mandatory

Existence of national registry database for EPC in your country: Yes

Energy Performance Certificate support BC

Positive labeling for building beyond the minimum BC level

Building Energy Codes Stringency and Coverage

Coverage:

- Residential buildings:
  - One family;
  - Multiple family buildings
- Commercial buildings:
  - Offices; Retail and wholesale; Hotels; Hospitals; Educational buildings
- Public buildings:
  - Offices; Hospitals; Educational buildings
- All urban buildings

- new residential
- new non-residential
- existing residential
- existing non-residential

Stringency: Mandatory

Prescriptive requirements in building energy codes

- Thermal insulation (including U-values for walls, floor, roof and windows)
- Air-tightness
- Ventilation or air quality
- Daylighting requirements
- Boiler/AC system
- Specified thermal comfort levels for summer and winter
- Solar gains (G-values)

Values for New Buildings

Residential Buildings

U-values (W/m^{2}K): Roof – 0.16; Wall – 0.2; Floor-0.25; Window – 1.6

Energy Performance: 80 kWh

Thermal bridge demands

Overall Thermal bridge max value: ΨN 0.18

Ventilation:
Depends on the type and size of system.

Domestic Hot Water COP - Heat Pump:
Depends on the type and size of system.

Value for airtightness:
For naturally ventilated buildings, maximum n50 =3 h-1, for mechanically ventilated buildings, maximum n50 =1.5 h-1.

Heat Recovery

Technical HVAC systems

Efficient Lighting

Building Materials and Products

Rating/certification of building materials: No data

Harmonization with other technical standards: No data

Requirements to test building materials and products by certified test laboratories: No data

Requirements for enforcement and compliance

Requirements for regular inspection of heating and AC systems: Yes, Inspection of boilers, Inspection of HVAC systems

Penalties, incentives and other mechanisms for improving compliance with building energy codes in your country: None

Energy performance monitoring requirements: During construction

Poland

The residential sector in Poland is dominated by individual property (~ 60%), followed by Cooperative property (~20%). In addition to relevant government agencies, energy agencies, such as the National energy efficiency Agency, play an important role in promoting energy efficiency in the country's housing stock. In Poland, as early as 1994, a law was adopted that establishes requirements for buildings in terms of minimum requirements for energy efficiency, thermal insulation and other requirements relating to energy saving. In the development of the use of renewable energy in 2012 adopted a Resolution that prescribes to analyze the possibility of the use of decentralized systems of energy supply based on renewable energy sources [27, 28].

Main regulatory documents related to building energy codes

Technical regulations: Energy Savings and Thermal insulation (2002)

The Act of 7 July 1994. Constructive Law.

The Act of 29 August 2014. The Energy Performance of Buildings Law

Regulation of the Minister of Transport, Construction and Maritime Economy of 25 April 2012 concerning the detailed scope and form of construction

- 2002-2014
- Climate zones

Performance-based requirements in building energy codes

- Thermal characteristics and geometry of the building (envelope and internal partitions, etc.)
- Air-tightness
- Space heating system and hot water supply units
- Air-conditioning system(s)
- Mechanical and natural ventilation
- Built-in lighting system
- Design position and orientation of buildings
- Passive solar systems and solar protection
- Indoor and outdoor climatic conditions
- Passive cooling
- Heat recovery
- Thermal bridges

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

Coverage:

- Single family houses
- Apartment blocks
- Commercial buildings
- Public buildings

- new residential
- new non-residential
- existing residential
- existing non-residential

Stringency: Mandatory

EPBD Energy Performance Certificate (2009)

Passive House (1990), Maximum cooling demand (kWh/m2.year): cooling-15; space heating-15; total primary energy-120. Voluntary

Methodology for calculating the energy performance of buildings

Building Materials and Products

Rating/certification of building materials: No data

Harmonization with other technical standards: No data

Requirements to test building materials and products by certified test laboratories: No data

Building Energy Codes Stringency and Coverage

Coverage:

- Family residential building
  Single-family residential building
  Multi-family residential building
- Collective residential building (Apartment blocks)
- Commercial buildings (Health-care building, Warehouse and production buildings)
- Public buildings (Health-care building, Warehouse and production buildings)

- new residential
- new non-residential
- existing residential
- existing non-residential

Stringency: Mandatory

End-uses energy: Space heating, Ventilation, Lighting interior, Water heating, Appliances, Auxiliary devices, Space cooling, Water heating, Lighting interior, Humidification

Prescriptive requirements in building energy codes

- Thermal insulation (including U-values for walls, floor, roof and windows)
- Air-tightness
- Ventilation or air quality
- Daylighting requirements
- Specified thermal comfort levels for summer and winter
- Solar gains (G-values)
- Artificial lighting system, lighting density
- Boiler/AC system
- Renewable

Insulation (2017): U-values (W/m^2.K): Roof, f(tº C) – 0.18-0,70; External Wall, f(tº C) – 0.23-0.9; Internal Wall-1.0; Floor on the ground, f(tº C) -0.30-1.5; Window, f(tº C) – 1.1-1.6; Door – 1.5; Skylights, f(tº C) – 1.3-1.6;

Space Heating System (2017): EP_{H+W} Values (kWh/m^2*year) for heating, ventilation and hot utility water: Single-family residential building-95; Multi-family residential building-85; Collective residential building-85; Health-care building -290; Public buildings-60; Warehouse and production buildings-90.

Space Cooling System (2017): ΔEP_C Values (kWh/m^{2}year): Single-family residential building and Multi-family residential building-10; Collective residential building, Health-care building and Public buildings-25.

Water Heating System: EP_{H+W} Values, mean partial EP maximum value ratio for heating, ventilation and hot utility water

Lighting (2017): EP_L Values (kWh/m^{2}year): Single-family residential building and Multi-family residential building-0; Collective residential building, Health-care building, Public buildings and Warehouse and production buildings - for $t_0 < 2500$ $EP_L = 50$; for $t_0 \geq 2500$ $EP_L = 100$.

Requirements for enforcement and compliance

Penalties, incentives and other mechanisms for improving compliance with building energy codes in your country: bonuses, grants

Energy performance monitoring requirements: No data

Slovakia

The housing sector of Slovakia took third place in the overall balance of energy consumption of the country. The need to develop a strategy for the reconstruction of residential and non-residential buildings in Slovakia follows from Directive 2012/27/EC of the European Parliament and of the Council of 25 October 2012 on energy efficiency. A systematic approach to the reconstruction of buildings was made in the late 1990s, when it was found that many facilities built between 1960 and 1992 had insufficient thermal protection of structures and technical facilities of buildings had a high degree of wear and tear. For such buildings, there was a need to replace structures with quality components to create the necessary security and well-being in these buildings [29].

Main regulatory documents related to building energy codes

MTC SR: 555/2005 Coll. Act on the Energy Performance of Buildings and on Amendments to Certain Acts - 300/2012 Coll.

Act amending Act no 555/2005 Coll. on the Energy Performance of Buildings and on Amendments to some Acts as amended and amending.

ISO, European and Slovak Technical norms, Plan for the restoration of relevant (public) buildings, Update of the Energy Performance of Building Concept f 2010 with a view to 2020.

- The first law act to energy performance of buildings was adopted by 2005

Performance-based requirements in building energy codes

- Thermal characteristics and geometry of the building (envelope and internal partitions, etc.)
- Space heating system and hot water supply units
- Air-conditioning system(s)
- Mechanical and natural ventilation
- Built-in lighting system (mainly in the non-residential sector)
- Design position and orientation of buildings
- Passive solar systems and solar protection
- Indoor and outdoor climatic conditions
- Thermal bridge, mandatory requirement to assess post-construction requirement of the thermal bridge: Yes

Non-renewable primary energy use

The existing standards for determining the energy characteristics of the buildings in operation are sufficiently accurate: Yes

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

Coverage:

- Single family houses
- Apartment blocks
- Commercial buildings
- Public buildings

- new non-residential
- new residential

Stringency: Mandatory

Existence of national registry database for EPC: Yes

Type of energy that the EPC refer to: Total primary energy, Non-renewable primary energy.

Existence of national registry database for EPC: Yes

Building Materials and Products

Rating/certification of building materials: Yes

Harmonization with other technical standards: European Union standards used for CE Marking

Requirements to test building materials and products by certified test laboratories: Yes

Building Energy Codes Stringency and Coverage

Coverage:

- Single family houses
- Apartment blocks
- Commercial
- Public buildings

- new non-residential
- new residential
- Existing residential (e.g. after substantial refurbishment)
- Existing non-residential (e.g. after substantial refurbishment)

The buildings covered by the energy codes: They are separated by residential and nonresidential for the means of certification. For the needs of energy audits, there is more detailed breakdown.

Stringency: Mandatory

Prescriptive requirements in building energy codes

- Thermal insulation (including U-values for walls, floor, roof and windows)
- Specified thermal comfort levels for winter and summer
- Solar gains (G-values)
- External solar protections
- Ventilation or air quality
- Periodic transmittance and time lag of walls and roof
- Ventilation for summer comfort
- Solar absorbance of external surfaces (e.g. cool paintings for roofs and streets)
- Daylighting requirements
- Artificial lighting system, lighting density
- Boiler/AC system
- Renewables
- Thermal bridges

Requirements for enforcement and compliance

Requirements for regular inspection of heating and AC systems: Yes, for both heating and AC systems

Penalties, incentives and other mechanisms for improving compliance with building energy codes in your country: Yes, Financial support,

Fines for non-compliance,

Also possible: Refusal for occupancy or construction permit

Energy performance monitoring requirements: Yes

Subregion C:
Eastern Europe, Caucasus, Central Asia, and Russian Federation

Countries

Armenia
Azerbaijan
Belarus
Georgia
Kazakhstan
Republic of Moldova
Russian Federation
Tajikistan
Turkmenistan
Ukraine
Uzbekistan

Armenia

Armenia introduced in 2016 a mandatory building energy code with the adoption of a new regulation "Thermal Protection of Buildings", which was developed based on Russian Building Energy Code from 2003 (updated in 2012) with application of some methodologies and approaches of European codes and standards. It links building envelope elements/components and heat losses with established energy limits, taking into account differences in climatic conditions. It also includes a requirement for issuing a building energy passport and an energy efficiency label with energy efficiency classes [30].

Main regulatory documents related to building energy codes

Law on Standardization, AL-21-N (08.02.2012)
Law on Technical Regulation, AL-19-N (08.02.2012)
Energy Law, Al-148 (07.03.2001) (Amendments 2016, 2017)
Law on Energy Saving and Renewable Energy, AL-122 (2004) (Amendments 2016, 2017)
Energy Security Concept of the RA, 2013
Second National Energy Efficiency Action Plan (02.02.2017)
Technical regulation on ES and EE in residential multi-apartment buildings under construction as well as in objects being constructed (reconstructed, repaired) at the expense of state means (12.04.2018)

Performance-based requirements in building energy codes

- Thermal characteristics and geometry of the building (envelope and internal partitions, etc.)
- Air-tightness ["Ventilation for buildings - Calculation methods for the determination of air flow rates in buildings including infiltration" - AST EN 15242-2014]
- Air-conditioning system(s)
- Space heating system and hot water supply units
- Mechanical and natural ventilation
- Built-in lighting system (mainly in the non-residential sector)
- Design position and orientation of buildings
- Passive solar systems and solar protection
- Indoor and outdoor climatic conditions
- Thermal bridge

Software used for compliance verification: No

There is mandatory requirement to assess post-construction requirement of the thermal bridge: No

There is mandatory requirement for air tightness testing: No

Building Energy Codes Stringency and Coverage

Coverage:

- Single family houses
- Apartment blocks
- Commercial
- Public buildings

- new non-residential
- new residential
- Existing residential (e.g. after substantial refurbishment)
- Existing non-residential (e.g. after substantial refurbishment)

Stringency: Mixed (both voluntary and mandatory)

The building stock in the Republic of Armenia is divided into five categories depending on their volume, significance, importance and complexity, as well as the safety of citizens and the environment. 1) low-risk objects: Category I; 2) objects of medium risk category II; 3) objects of medium risk category III category; 4) high-risk objects - category IV; 5) objects with the highest degree of risk - category V (RA Gov. Decree N596 dated 19.03.2015).

Mandatory measures to ensure the energy efficiency of buildings (at the expense of public funds) are established by the Decree of the Government (25.12.2014, 1504-N Decree) of the Republic of Armenia. Indicators for assessing energy efficiency and energy consumption in building codes have not yet established.

(Residential and public buildings: walls – 0,29-0,56 W/m^{2}K, floors -– 0.22-0,37 W/m^{2}K, roofs -0,23-0,42 W/m^{2}K, windows - 2.04-3.33 W/m^{2}K)

Energy use for: heating, cooling, hot water, lighting, ventilation

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

Coverage:

- Single family houses
- Apartment blocks
- Commercial
- Public buildings

- new non-residential
- new residential
- existing residential
- existing non-residential

Type of energy that the EPC refer to: Total primary energy,
Stringency: Mixed (both voluntary and mandatory)

Prescriptive requirements in building energy codes

- Thermal insulation (including U-values for walls, floor, roof and windows)
- Air-tightness
- Solar gains (G-values)
- Ventilation or air quality
- Ventilation for summer comfort
- Daylighting requirements
- Periodic transmittance and time lag of walls and roof
- Artificial lighting system, lighting density
- Boiler/AC system

Building Materials and Products

Rating/certification of building materials: Yes (not mandatory)

Harmonization with other technical standards: European Union standards used for CE Marking

Requirements to test building materials and products by certified test laboratories: Yes (laboratories are available)

Requirements for enforcement and compliance

Requirements for regular inspection of heating and AC systems: Yes, for heating systems only

Penalties, incentives and other mechanisms for improving compliance: AL-204-N (24.10.2005) Law on State regulation of technical security protection. For equipment >0.07MPa, <115˚C, < 60 kW and >115˚C

Energy performance monitoring requirements: No

Azerbaijan

The existing housing stock in Azerbaijan consists of houses built before the 1920s and located mainly in the historical part of the cities, and, as a rule, these houses need reconstruction and repair, and in rural areas, the houses built during the 1920-1940 period prevail. The basis of the old housing stock (more than 80%) consists of houses built before 1990. The quality level of these mainly large-panel houses is below modern standards. The construction of the new residential sector is mainly carried out in the form of private cottage settlements and multi-apartment complexes in major cities of the country. The country is provided with oil and natural gas, and problems of energy saving in housing sector first of all are planned to be solved at the expense of development of alternative energy sources and strengthening of control of consumption of energy [31].

Main regulatory documents related to building energy codes

It is processed the draft law "Efficient Use of Energy Resources and Energy Efficiency" with the support of Energy Charter and it is planned to draft a law "Energy Efficiency in Buildings" afterwards. There is currently applied regulative document named as "Urban Planning and Building codes"

Decree of the Cabinet of Ministries "The rules of increasing energy efficiency of construction facilities and economized use of energy resources" has been remaining in force since 2014.

- climate zones and sub-regions

Performance-based requirements in building energy codes

- New buildings
- Existing buildings

- Thermal characteristics and geometry of the building (envelope and internal partitions, etc.)
- Air-tightness
- Space heating system and hot water supply units
- Air-conditioning system(s)
- Mechanical and natural ventilation
- Built-in lighting system (mainly in the non-residential sector)
- Design position and orientation of buildings
- Passive solar systems and solar protection
- Indoor and outdoor climatic conditions
- Thermal bridge

There is not an officially confirmed document to: Energy levels are considered in building codes; the subset of ISO EPB standards; The International Performance Measurement & Verification Protocol.

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

Coverage:

- Apartment blocks
- Commercial
- Public buildings

- new non-residential
- new residential
- existing residential
- existing non-residential

Stringency: Mandatory

Building Materials and Products

Rating/certification of building materials: The compliance of construction materials to requirements of the legal acts is checking

Harmonization with other technical standards: No answer

Requirements to test building materials and products by certified test laboratories: It is checked in the accredited laboratories

Building Energy Codes Stringency and Coverage

Coverage:

- Apartment blocks
- Commercial
- Public buildings

- new non-residential
- new residential
- existing residential
- existing non-residential

Stringency: Voluntary

Prescriptive requirements in building energy codes

- Thermal insulation (including U-values for walls, floor, roof and windows)
- Air-tightness
- Ventilation or air quality
- Daylighting requirements
- Artificial lighting system, lighting density
- Boiler/AC system
- Renewables

These all are included in the technical normative documents

Values for the prescriptive requirements: No answer

Individual energy metering and control units: It is not applied in existing buildings, but it is planned to be implemented in new buildings

Mandatory requirement: No

Requirements for enforcement and compliance

Specific policy packages and incentives that complement or motivate compliance with building codes: There are not specific policy packages and incentives.

Requirements for regular inspection of heating and AC systems: No

Penalties, incentives and other mechanisms for improving compliance: Fines and fees for non-compliance, Refusal for occupancy or construction permit

There is no any penalty for non-compliance, but it will be considered in the further planned project named as "Energy efficiency in buildings"

Energy performance monitoring requirements: Yes, there is.

The government according to the law of the utilizing of energy resources controls it.

Belarus

In Belarus, the urban population is three-quarters of the total population. Despite the high level of home ownership and the dominant position of home ownership in new housing construction, the housing Finance structure in Belarus remains largely public sector-oriented and the role of private investment and market-based housing Finance remains insignificant. Housing Finance, maintenance, modernization and management systems are dominated by state-owned enterprises, that is, state-owned companies and banks. The housing sector, including housing construction, maintenance, financing and infrastructure development, is covered by the State Housing Policy, by the National Housing Program, the Housing Code of Belarus and a number of other normative acts. [32].

Main regulatory documents related to building energy codes

The draft technical regulation of the Republic of Belarus "Energy efficiency of buildings", harmonized with the Directive 2010/31 / EU, is expected to be approved in mid-2018

- 2000 - 2017

Performance-based requirements in building energy codes

- Thermal characteristics and geometry of the building (envelope and internal partitions, etc.)
- Air-tightness
- Space heating system and hot water supply units
- Design position and orientation of buildings
- Passive solar systems and solar protection
- Indoor and outdoor climatic conditions
- Thermal bridge
- Mechanical and natural ventilation
- Air-conditioning system(s)
- Built-in lighting system (mainly in the non-residential sector)

Partial set of CEN EPB standards, a subset of ISO standards EPB

Software for compliance checking: No

The existence of a mandatory requirement for post-construction requirement for thermal bridge: Yes, the regulatory requirements for the resistance to heat transfer of buildings require the consideration of thermal bridges

Mandatory requirement for air-tightness: Yes, the draft Technical Regulations provide for the mandatory measurement. Voluntary level of requirements and corresponding methods are available in the current standards.

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

Main regulatory documents for the EPC:

In the country, there is no system of power certification of buildings. There is a system of classification of buildings by an indicator of specific consumption of thermal energy on heating and ventilation.

Coverage: No answer

Building Materials and Products

Rating/certification of building materials: Yes

Harmonization with other technical standards: Requirements of national standards

Requirements to test building materials and products by certified test laboratories: Yes

Building Energy Codes Stringency and Coverage

Coverage:

- Single family houses
- Apartment blocks
- Commercial buildings
- Public buildings

- new non-residential
- new residential
- existing residential (e.g. after substantial refurbishment)
- existing non-residential (e.g. after substantial refurbishment)

Stringency: Mandatory

There is a power classification of buildings by consumption of thermal energy on heating and ventilation, classes G - A+. An indicator for reference to a certain class - specific annual consumption of thermal energy on heating and ventilation

It is not allowed to design new buildings if the requirements for buildings do not correspond to classes A +, A or B.

Types of energy considered in building codes and regulations: Use of energy for heating

Prescriptive requirements in building energy codes

- Thermal insulation (including U-values for walls, floor, roof and windows)
- Specified thermal comfort levels for winter and summer
- Air-tightness
- Ventilation or air quality
- The requirements for daylight
- Artificial lighting system, lighting density
- Thermal bridges
- Solar gains (G-values)

Buildings equipped with individual energy metering and control units – Yes,

Stringency: Mandatory

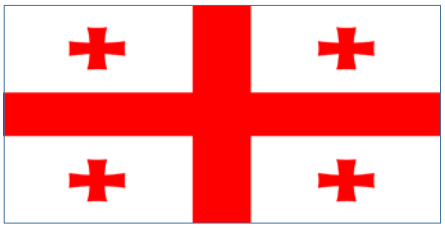
Requirements for enforcement and compliance

Requirements for regular inspection of heating and AC systems: Yes, for heating systems only, Mandatory

Penalties, incentives and other mechanisms for improving compliance with building energy codes in your country: No

Energy performance monitoring requirements: No

Georgia



Almost 93 per cent of the rural population lives in separate homes. At the same, more than half of Georgia's population live in urban areas, with 67% of households living in Apartment blocks apartments in urban areas. Typically, for a large part of the housing stock in Georgia-regardless of its ownership-will require reconstruction as part of the old housing stock to be demolished due to natural wear and tear of structures and lack of timely maintenance. Since 2017, unified building design standards have been introduced in Georgia [33].

Main regulatory documents related to building energy codes

"Law of the Energy Performance of Buildings" was elaborated, but not entered into force yet.

Performance-based requirements in building energy codes

- Elements, which must be taken into account for the calculation of the energy performance of a building: Not set yet

The subset of ISO EPB standards: Directive 2010/31/EU on Energy Performance of Buildings (EPBD).

The International Performance Measurement & Verification Protocol (IPMVP): No

Software used for compliance verification: No

The existing standards for determining the energy characteristics of the buildings in operation are sufficiently accurate: No

There is mandatory requirement to assess post-construction requirement of the thermal bridge: No

There is mandatory requirement for air tightness testing: No

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

Coverage: Not yet defined

Stringency: Mandatory

Who is entitled to issue EPC: Accredited body

Existence of national registry database for EPC: No

Type of the EPC energy:

Total primary energy, Non-renewable primary energy

Building Materials and Products

Rating/certification of building materials: No

Harmonization with other technical standards: No answer

Requirements to test building materials and products by certified test laboratories: No answer

Building Energy Codes Stringency and Coverage

Coverage:

- new residential

This law shall apply to new and existing buildings, except for the following buildings:

Buildings which have a status of cultural heritage monuments, buildings used as places of worship and for religious activities, temporary buildings with a time of use of two (2) years or less, industrial sites, workshops and non-residential agricultural buildings with low energy demand, stand-alone buildings with a total useful floor area of less than 50 m2.

Stringency: Mandatory

Performance-based requirements in building energy codes: New buildings

Energy levels are considered in building codes:

Energy use for: heating, cooling, hot water, lighting, ventilation.

Non-renewable primary energy use

Prescriptive requirements in building energy codes

Prescriptive requirements coverage: When the law enters into force, the relevant regulations will be adopted and detailed information will be available

Requirements for regular inspection of heating and AC systems: After the law will enter into fore establishment of rules on regular, inspection of heating and air-conditioning systems will be mandatory

Individual energy metering and control units:

Yes, this a mandatory requirement

Requirements for enforcement and compliance

Requirements for regular inspection of heating and AC systems: Please provide further comments on requirements

Penalties, incentives and other mechanisms for improving compliance: Yes, But this article (on penalties) is under processing

There is separate article on penalties in EPB Law

Energy performance monitoring requirements: Yes

Kazakhstan

The residential sector is the third largest consumer of heat and electricity in the country after the energy and manufacturing sectors. In recent years, improving the energy efficiency of the economy has become a national strategic priority of Kazakhstan. The political will of the country's leadership in strengthening energy efficiency is expressed through the adoption of a number of strategic documents, namely the strategy of transition of the Republic of Kazakhstan to a "green" economy, strategy-2050," Nurly Zhol "program, 100 steps of the nation, energy Saving2020 and others. The main document on energy efficiency is the Law of the Republic of Kazakhstan № 541-IV "On energy saving and energy efficiency" dated January 13, 2012 [34].

Main regulatory documents related to building energy codes

The Law of the Republic of Kazakhstan № 541-IV "On energy saving and energy efficiency", January 13, 2012

SN 2.04-21-2004 " Thermal protection and energy consumption of civil buildings"

SN RK-2.04-04-2011 " Thermal protection of buildings"

Performance-based requirements in building energy codes

- Thermal characteristics and geometry of the building (envelope and internal partitions, etc.)
- Air-tightness
- Space heating system and hot water supply units
- Design position and orientation of buildings
- Indoor and outdoor climatic conditions
- Thermal bridge

Software: No

The average energy performance gap between the projected and actual levels of energy efficiency and energy consumption: 20-30% in new buildings

Mandatory requirement to assess post-construction requirement of the thermal bridge: No

Mandatory requirement for air tightness testing: No

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

Main regulatory documents for the EPC: No

EPC Coverage: currently EPC is not used

Policy requirement level for EPC: mandatory

Existence of national registry database: No

Building Materials and Products

Rating/certification of building materials: Yes

Harmonization with other technical standards: International technical standards (ISO)

Requirements to test building materials and products by certified test laboratories: Yes, Committee for Technical Regulation and Metrology

Building Energy Codes Stringency and Coverage

Coverage:

- Apartment blocks
- Commercial buildings
- Public buildings

- new non-residential
- new residential
- existing residential (e.g. after substantial refurbishment)
- existing non-residential (e.g. after substantial refurbishment)

Stringency: Mandatory

National classification of buildings in the building code of 2012:

A++; A+; A; B+; B; C+; C; C-; D; E.

Requirements for the assessment of energy efficiency and energy consumption:

Existing buildings (for example, after major repairs)
There are requirements, but they are not really implemented.

Energy use for: heating, ventilation.

Prescriptive requirements in building energy codes

- Thermal insulation (including U-values for walls, floor, roof and windows)
- Specified thermal comfort levels for winter and summer
- Air-tightness
- Ventilation or air quality
- The requirements for daylight
- Thermal bridges

District heating and other external heating system, buildings are equipped with individual energy metering and control units: Yes

Requirements for enforcement and compliance

Requirements for regular inspection of heating and AC systems: No

Penalties, incentives and other mechanisms for improving compliance with building energy codes in your country: No

Energy performance monitoring requirements: No

Kyrgyzstan

In Kyrgyzstan, the population has grown faster than the housing stock in recent years. About 85% of the existing housing stock was built before 1990. Since then, a large part of the housing stock is in multi-apartment buildings, but as a rule, technical systems in multi-apartment houses need repair. Some new expensive residential complexes meet modern energy efficiency standards, including thermal insulation and triple glazing. Technical maintenance of housing is identified as one of the key priorities of the national housing programme in Kyrgyzstan. The Ministry of energy and industry of the Republic has prepared a draft program of energy saving and energy efficiency planning until 2017 and in the future until 2025 [35].

Main regulatory documents related to building energy codes

Law of the Kyrgyz Republic (KR) "On Energy Efficiency of Buildings" of 26.07.2011, No. 137, as amended by Law No. 194 of 18 October 2013

- 2011

Performance-based requirements in building energy codes

- Space heating system and hot water supply units
- Air-conditioning system(s)
- Mechanical and natural ventilation
- Built-in lighting system
- Passive solar systems and solar protection
- Passive cooling

Software: None

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

Coverage:

- Single family houses
- Apartment blocks
- Commercial buildings
- Public buildings

- new residential
- new non-residential
- existing residential
- existing non-residential

Stringency: Mandatory

EPC: Yes

Existence of national registry database for EPC in your country: None

Building Materials and Products

Rating/certification of building materials: No data

Harmonization with other technical standards: No data

Requirements to test building materials and products by certified test laboratories: No data

Building Energy Codes Stringency and Coverage

Coverage:

Buildings: residential, public, administrative and multifunctional

- new residential
- new non-residential
- existing residential
- existing non-residential

Stringency: Mandatory

The minimum energy efficiency requirements for buildings do not apply to:

• Individual residential buildings, the total area of which does not exceed 150 square meters;

• Buildings designed for religious rites, rituals and ceremonies;

• Buildings that, in accordance with legislation, are assigned to cultural heritage sites

• Temporary objects of non-capital construction;

• Holiday homes;

• Buildings and structures of auxiliary use.

Prescriptive requirements in building energy codes

- Thermal insulation
- Ventilation or air quality
- Daylighting requirements
- Boiler/AC system
- Specified thermal comfort levels for summer and winter
- Solar gains (G-values)
- Artificial lighting system, lighting density

Requirements for enforcement and compliance

Requirements for regular inspection of heating and AC systems: periodic monitoring of energy efficiency of boilers, heating systems and hot water supply

Penalties, incentives and other mechanisms for improving compliance with building energy codes in your country: No data

Energy performance monitoring requirements: carried out at least once a year

Republic of Moldova

The energy sector of the Republic of Moldova is highly dependent on foreign energy, importing 65% of its energy demand. The housing sector is the highest consumer of about 60 per cent of total energy consumption. Therefore, improving energy efficiency is crucial. This will contribute to energy security, economic competitiveness and will have a positive impact on the environment. Improving energy efficiency will improve housing conditions and reduce energy costs in the future, thus reducing energy costs for households. The Government's goal is to reduce energy consumption in buildings by 10% by 2020. The government may consider actively participating in the work of the UNECE task force on energy efficiency standards [36].

Main regulatory documents related to building energy codes

Law on Energy Performance of Buildings (2014),

Law on energy efficiency nr 140 from 2012; transpose Directive 32/2010 on energy performance of the buildings.

- In year 2012
- Moldova is on the way to transpose EU standards. Some current standards are old GOST and SNIP norms and need revision.

Performance-based requirements in building energy codes

- Thermal characteristics and geometry of the building (envelope and internal partitions, etc.)
- Air-tightness
- Space heating system and hot water supply units
- Air-conditioning system(s)
- Mechanical and natural ventilation
- Built-in lighting system (mainly in the non-residential sector)
- Design position and orientation of buildings
- Passive solar systems and solar protection
- Indoor and outdoor climatic conditions

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

Coverage:

- Single family houses
- Apartment blocks
- Commercial
- Public buildings

- new non-residential

Type of energy that the EPC refer to: Total primary energy,

Entitled to issue EPC: Qualified experts

Stringency: Mixed (both mandatory and voluntary)

Building Energy Codes Stringency and Coverage

Coverage:

- Single family houses
- Apartment blocks
- Public buildings

- new non-residential
- Existing residential (e.g. after substantial refurbishment)
- Existing non-residential (e.g. after substantial refurbishment)

LAW OF THE REPUBLIC OF MOLDOVA of July 11, 2014 No. 128 on energy performance of buildings transposes the Directive 2010/31/EC . Energy class – system of measurement from "A" to "G" for specifying of energy efficiency of the building. In case of classification of buildings with very outstanding energy performance, the class "A" can be subdivided into sub-classes.

Stringency: Mixed (both voluntary and mandatory)

Performance-based requirements in building energy codes: Energy efficient development systems

Details/values of the performance-based requirements: After year 2021, all new buildings must be NZEB

Class A = 50 kWh/m^2/year; B=99 kWh/m^2/year

Energy use for: heating, cooling, hot water, lighting, ventilation.

Prescriptive requirements in building energy codes

- Thermal insulation (including U-values for walls, floor, roof and windows)
- Specified thermal comfort levels for winter and summer
- Ventilation or air quality
- Boiler/AC system
- Renewables

Individual energy metering and control units: Partially (approximate share of equipped buildings in the country)

Building Materials and Products

Rating/certification of building materials: No

Harmonization with other technical standards: European Union standards used for CE Marking

Requirements to test building materials and products by certified test laboratories: Yes

Requirements for enforcement and compliance

Requirements for regular inspection of heating and AC systems: Yes, for both heating and AC systems

Penalties, incentives and other mechanisms for improving compliance: No

Energy performance monitoring requirements: Yes

Russian Federation

In Russia, about 80% of apartment buildings were built before 1999 according to outdated building codes. New legislation in the field of energy efficiency sets standards for energy consumption regulation to stimulate energy saving and amends the current legislation to ensure compliance with energy saving regulations. The government program recognizes that Russia's energy intensity is 2.5 times higher than the world average and up to 3.5 times higher than in developed countries, and it is expected that 44 percent of the projected energy savings will be in buildings and district heating. These changes imply that regional and municipal authorities should develop programmes at the local level to increase the use of energy-efficient technologies and the use of renewable energy to achieve energy saving goals [37].

Main regulatory documents related to building energy codes

Federal law No. 261-FZ "On energy saving and energy efficiency improvement" – 23.11.2009

GOST R 56828.18-2017 GOST R 51388-99 Energy Saving

Government resolution No. 18 of 25 January 2011

Performance-based requirements in building energy codes

- Thermal characteristics and geometry of the building (envelope and internal partitions, etc.)
- Air-tightness
- Space heating system and hot water supply units
- Air-conditioning system(s)
- Mechanical and natural ventilation
- Built-in lighting system
- Design position and orientation of buildings
- Indoor and outdoor climatic conditions
- Thermal bridge

Use of the International Performance Measurement & Verification Protocol (IPMVP): Yes

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

Main regulatory documents for the EPC: The EPC contract can be concluded between the customer and the contractor to perform a full cycle of work and responsibility for the risks.

Coverage:

- Apartment blocks
- Commercial buildings
- Public buildings

- new residential

Stringency: Mandatory

Energy EPC refer to: total primary energy

Building Materials and Products

Rating/certification of building materials: Yes

Harmonization with other technical standards: European Union standards used for CE Marking and International technical specifications, such as those prepared by ISO for other countries

Requirements to test building materials and products by certified test laboratories: Yes

Building Energy Codes Stringency and Coverage

Coverage:

- Single family
- Apartment blocks
- Commercial buildings
- Public buildings

- new non-residential
- new residential
- existing residential (e.g. after substantial refurbishment)
- existing non-residential (e.g. after substantial refurbishment)

National classification of buildings covered in building energy code:

A++, A+, A, B+, B, C+, C, C-, D, E.

Stringency: Mixed (both voluntary and mandatory)

Energy use for: heating, cooling, hot water, lighting, ventilation. Total primary energy use

Prescriptive requirements in building energy codes

- Thermal insulation (including U-values for walls, floor, roof and windows)
- Air-tightness
- Ventilation or air quality
- Daylighting requirements
- Artificial lighting system, lighting density
- Boiler/AC system
- Specified thermal comfort levels for summer
- Solar gains (G-values)
- Thermal bridge

Individual energy metering and control units: Yes

Stringency: Mandatory

Requirements for enforcement and compliance

Requirements for regular inspection of heating and AC systems: Yes, for heating only, Mandatory

Penalties, incentives and other mechanisms for improving compliance with building energy codes in your country: Yes,

Refusal for occupancy or construction permit

Energy performance monitoring requirements: Yes, Mandatory

Tajikistan

Reserves of energy efficiency in residential buildings. About 90% of the housing stock in Tajikistan is built according to old standards, and the main consumption of energy resources (3.6 billion kWh) is carried out by these houses. Therefore, it is important for the Republic not only to build energy-efficient houses, but also to bring the old housing stock to the characteristics of modern buildings by warming and thermal modernization of the Complex of measures to minimize heat and electricity losses in buildings. The Government should develop building codes for newly constructed buildings as well as ensure its proper enforcement - In rural areas The Government should stimulate the systematic use of efficient techniques based on local expertise [38].

Main regulatory documents related to building energy codes

Law of the Republic of Tajikistan No. 1018 of September 19, 2013 "On Energy Saving and Energy Efficiency"

- 2013

Performance-based requirements in building energy codes

No data

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

Coverage:

No data

Building Energy Codes Stringency and Coverage

Coverage:

No data

Prescriptive requirements in building energy codes

No data

Building Materials and Products

Rating/certification of building materials: No data

Harmonization with other technical standards: No data

Requirements to test building materials and products by certified test laboratories: No data

Requirements for enforcement and compliance

Penalties, incentives and other mechanisms for improving compliance with building energy codes in your country: No data

Energy performance monitoring requirements: No data

Turkmenistan

In Turkmenistan, the existing apartment buildings were built in 1960-1991. Thermal insulation of roofs and external walls in such buildings is practically not used. The government is promoting a number of strategies to stimulate housing growth and could easily organize a gradual change in energy efficiency by creating incentives for energy inclusion efficiency technologies in construction. It is encouraging that the government of Turkmenistan is currently working with the United Nations Development Programme (UNDP) and the Global Environment Facility (GEF) on a project that seeks to introduce efficient designs and technologies in the residential sector of Turkmenistan [39].

Main regulatory documents related to building energy codes

SNT 2.08.01-15 "Residential buildings"

SNT 2.01.03-17 "Thermal building engineering"

SNT 2.03.10-01* “Roofs and roofing”

A Guidance on the Design of Energy-Efficient Residential Buildings for SNT 2.08.01-15 "Residential Buildings"

Performance-based requirements in building energy codes

- Thermal characteristics and geometry of the building (envelope and internal partitions, etc.)
- Space heating system
- Air-conditioning system(s)
- Mechanical and natural ventilation
- Design position and orientation of buildings
- Indoor and outdoor climatic conditions
- Thermal bridge

Energy use for: heating, cooling, hot water, ventilation. Total primary energy use.

Note: The primary indicator for estimating the energy consumption of buildings is the primary energy consumption for heating, cooling and ventilation.

Software used for compliance verification: No

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

The main document related to certification (EPC) is the Regulation on the rules and procedure for conducting energy audits in residential buildings in Turkmenistan. The document is under review and not adopted yet.

Coverage:

- Single family houses
- Apartment blocks

- new non-residential
- new residential
- existing residential (e.g. after substantial refurbishment)
- existing non-residential (e.g. after substantial refurbishment)

Type of energy that the EPC refer to: total primary energy

Stringency: Mandatory

Building Materials and Products

Rating/certification of building materials: Yes

Harmonization with other technical standards: No information

Requirements to test building materials and products by certified test laboratories: The State Standardization Agency "Turkmenstandartlary" and the Institute of Seismology of Turkmenistan

Building Energy Codes Stringency and Coverage

Coverage:

- Single family houses
- Apartment blocks
- Commercial
- Public buildings

- new residential
- existing residential (e.g. after substantial refurbishment)
- existing non-residential (e.g. after substantial refurbishment)

Stringency: Mandatory

Energy saving is a requirement of the new SNT 2.01.03- "Building heat engineering" and can be considered mandatory

Prescriptive requirements in building energy codes

- Specified thermal comfort levels for winter and summer
  Ventilation
- Thermal bridges

Certain levels of thermal comfort for winter and summer for the cold period t = 20 ° C, for the warm period of the year t = 25 ° C. Relative humidity ϕB,% for the cold period of the year 55 and for the warm period of the year 50.

Ventilation - the amount of air delivered from the premises of 3 m3 / h per 1 m2 of residential premises

Thermal bridges - there is a special calculation and calculated for a specific node.

Building energy codes contain requirements for regular inspection of heating and AC systems: Yes, both for heating and AC systems

Mandatory requirement: Yes

Individual energy metering and control units: No

Requirements for enforcement and compliance

Requirements for regular inspection of heating and AC systems: Yes, for both heating and AC systems:

Penalties, incentives and other mechanisms for improving compliance with building energy codes in your country: Refusal for occupancy or construction permit

Ukraine

The number of households in Ukraine is about 17 million. A sample survey of household living conditions in 2013 showed that 69.3% of Ukrainian households live in urban areas and 30.7% in rural areas. The number of flats in Ukraine, per 1,000 inhabitants (425 apartments) close to the EU level. Although the data show some improvement in living conditions in Ukraine, many problems remain, such as limited space and deteriorating living conditions, deteriorating living conditions and growing inequalities in access to better housing. There is an uneven distribution of housing consumption, which means that some households have more than one housing unit, but there is no official data on housing needs. Modern housing and construction is estimated as energy efficient, with the use of modern technical solutions and technological materials [40].

Main regulatory documents related to building energy codes

DBN.2.6-31 (state building codes) - the document concerns buildings;

DSTU B A.2.2-8 (state standards of Ukraine) - the document concerns engineering systems

• DBN B.2.6-31 - 2006

Performance-based requirements in building energy codes

- Thermal characteristics and geometry of the building (envelope and internal partitions, etc.)
- Space heating system and hot water supply units
- Air-conditioning system(s)
- Mechanical and natural ventilation
- Built-in lighting system (mainly in the non-residential sector)
- Design position and orientation of buildings
- Passive solar systems and solar protection
- Indoor and outdoor climatic conditions
- Thermal bridge

Use of Energy Performance in Buildings (EPB) standards (2017): Yes

Software used for compliance verification: No

Mandatory requirement to assess post-construction requirement of the thermal bridge: Yes

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

Coverage: http://zakon3.rada.gov.ua/laws/show/2118-19

EPC Coverage: currently under development

Type of energy EPC refers to: currently under development

Stringency: Mixed (both mandatory and voluntary)

Existence of national registry database for the EPC: No

Building Materials and Products

Rating/certification of building materials: Yes

Harmonization with other technical standards: No

Requirements to test building materials and products by certified test laboratories: No

Building Energy Codes Stringency and Coverage

Coverage:

- Single family houses
- Apartment blocks
- Public buildings: hotels, trade enterprises, buildings and facilities of educational institutions, pre-school institutions, health care institutions

- new non-residential
- new residential
- existing residential (e.g. after substantial refurbishment)
- existing non-residential (e.g. after substantial refurbishment)

Stringency: Mixed (both voluntary and mandatory)

National classification of buildings covered in building energy codes: A, B, C, D, E, F and G.

Energy use for: heating, cooling, hot water, ventilation. Total primary energy use.

Prescriptive requirements in building energy codes

Thermal insulation (including U-values for walls, floor, roof and windows)

- Specified thermal comfort levels for winter and summer
- Solar gains (G-values)
- Air-tightness
- Ventilation or air quality
- External solar protections
- Solar absorbance of external surfaces
- Artificial lighting system, lighting density
- Boiler/AC system
- Renewables
- Thermal bridges

Individual energy metering and control units: Partially,
This is a mandatory requirement

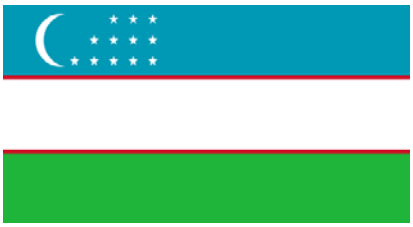
Requirements for enforcement and compliance

Requirements for regular inspection of heating and AC systems: No

Penalties, incentives and other mechanisms for improving compliance with building energy codes in your country: No

Energy performance monitoring requirements: No

Uzbekistan



The main share of housing construction (87%) falls on individual housing 97% of households in the Republic have their own home or apartment, including 99.5 % in rural areas. The main type of housing is a separate house (77.1%). In the housing stock, the share of multi-apartment houses built before 1991 is 83.2%. The housing stock has a relatively high level of centralized water supply (82.7%), gas supply (83.5%) and heat supply (45%). Introduction of new energy-efficient building codes create conditions for practical implementation of energy-saving technologies in Uzbekistan [41].

Main regulatory documents related to building energy codes

The Uniform Building Regulations of the Republic of Uzbekistan (Part 1) (Annex No. 3 to the Decision of the Cabinet of Ministers of the Republic of Uzbekistan on August 20, 2013, No. 229)

Rules of organization of works on the improvement of settlements taking into account modern architectural and town-planning requirements (Annex to the Decision of the Cabinet of Ministers of the Republic of Uzbekistan of 09.03.2009 N 59)

KMK 2.01.12-2000 Norms of energy consumption for heating ventilation and air conditioning of buildings and structures

Performance-based requirements in building energy codes

- Thermal characteristics and geometry of the building (envelope and internal partitions, etc.)
- Air-tightness
- Space heating system and hot water supply units
- Air-conditioning system(s)
- Mechanical and natural ventilation
- Built-in lighting system (mainly in the non-residential sector)
- Passive solar systems and solar protection
- Indoor and outdoor climatic conditions
- Thermal bridge

Use of Energy Performance in Buildings (EPB) standards (2017): Yes

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

The main legislative documents related to the EPC: Decision on measures to ensure the rational use of energy resources. November 8, 2017, No. PP-3379

Coverage:

- Single family houses
- Apartment blocks
- Commercial buildings
- Public buildings

- new non-residential
- new residential
- existing residential (e.g. after substantial refurbishment)
- existing non-residential (e.g. after substantial refurbishment)

Type of energy EPC refers to: total primary energy, electricity, heat and hot water

Policy requirement for the EPC: Mandatory

Building Materials and Products

Rating/certification of building materials: Yes

Harmonization with other technical standards: ISO

Requirements to test building materials and products by certified test laboratories: Yes

Building Energy Codes Stringency and Coverage

Coverage:

- Single family houses
- Apartment blocks
- Commercial buildings
- Public buildings

- new non-residential
- new residential
- existing residential (e.g. after substantial refurbishment)
- existing non-residential (e.g. after substantial refurbishment)

Stringency: Mandatory

Energy use for: heating, cooling, hot water, lighting, ventilation. Total primary energy use.

Prescriptive requirements in building energy codes

- Thermal insulation (including U-values for walls, floor, roof and windows)
- Specified thermal comfort levels for winter and summer
- Solar gains (G-values)
- Air-tightness
- Ventilation or air quality
- External solar protections
- Ventilation for summer comfort
- Solar absorbance of external surfaces
- The requirements for daylight
- Artificial lighting system, lighting density
- Boiler/AC system
- Renewables

Stringency: Mandatory

Individual energy metering and control units: yes

This is a mandatory requirement

Requirements for enforcement and compliance

Requirements for regular inspection of heating and AC systems: Yes, for both heating and AC systems

Penalties, incentives and other mechanisms for improving compliance with building energy codes in your country: Yes, differentiated tariffs for energy resources. Penalties and charges for non-compliance.

Energy performance monitoring requirements: Yes, mandatory

Subregion D:
North America

Countries

Canada
United States

Canada

In Canada, as a rule, those who can afford to do so, buy a home. This is done partly to ensure security of tenure and partly as investments. Across the country, 70% of Canadians own and 30% rent housing. Canadian housing takes many forms. More than half of Canadian homes are single-family detached houses; 17% are other land-based forms, such as row houses, duplexes, semi-detached or mobile; 18% are low - rise and 10% are high-rise apartments. About 80 per cent of the houses are made of wood, the rest of the houses are built of stone, brick and reinforced concrete structures. As a rule, more than 90% of internal communications (water supply, sewer, wiring, heating systems) are hidden in the walls. In Canada there are 100,000 units of cooperative housing [42].

Main regulatory documents related to building energy codes

Canada has a model national code system for buildings, but implementation and enforcements of building codes is within Provincial jurisdiction. The federal model national code development process includes participation from the Provinces & Territories plus industry groups & NGOs. In general, the model national code is adopted as law by provinces although they may modify it. The list of documents is too extensive to include in this survey. Once a province adopts a building code, enforcement of its provisions rests with local municipalities, who issue building permits and have building inspectors to verify compliance.

Performance-based requirements in building energy codes

- Thermal characteristics and geometry of the building (envelope and internal partitions, etc.)
- Air-tightness
- Space heating system and hot water supply units
- Air-conditioning system(s)
- Mechanical and natural ventilation
- Built-in lighting system (mainly in the non-residential sector)
- Design position and orientation of buildings
- Indoor and outdoor climatic conditions
- Thermal bridge

All factors must be considered to determine the efficiency of a building where energy provisions apply. Existing codes are not effective in doing in achieving high levels of efficiency, but anticipated changes in our codes seek to do so. Specific standards and references for future codes are being developed.

Software used for compliance verification: The use of energy models is widespread, but the use of a specific model is not prescribed by law. The federal government developed a simple model for homes and small buildings decades ago that became the common model to use for those buildings.

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

Coverage:

- Single family houses
- Apartment blocks
- Commercial
- Existing residential
- New residential

Stringency: Mixed, and such programs are voluntary in most locations. New regulations are introducing energy performance requirements, and work is underway to develop a national system.

Building Materials and Products

Rating/certification of building materials: Yes

Harmonization with other technical standards: Yes

Requirements to test building materials and products by certified test laboratories: Yes

Building Energy Codes Stringency and Coverage

Coverage:

- Single family houses
- Apartment blocks
- Commercial
- Public buildings

- new non-residential
- new residential

Stringency: Mixed (both voluntary and mandatory)

Energy codes are relatively recent and, until recently have been modest in their level of ambition. The new national building strategy is designed to dramatically improve building efficiency and have code requirements apply to all buildings, both new and existing.

Canada has two classes of buildings in its codes. Large buildings are dealt with by Part 3 of the code and are therefore called Part 3 buildings. Houses and small buildings are dealt with by Part 9 of the code and are called Part 9 buildings.

Energy use for heating, cooling, hot water, lighting, ventilation is considered under some existing regulations, and new federal regulations are anticipated to make it the norm in the future.

Prescriptive requirements in building energy codes

- Thermal insulation (including U-values for walls, floor, roof and windows)
- Ventilation or air quality
- Boiler/AC system

The responses above reflect current codes. The work now underway is intended to address most or all of the gaps in current practices.

Values for the prescriptive requirements: The values vary with building type, climate zone, etc.

Requirements for enforcement and compliance

Requirements for regular inspection of heating and AC systems: No

Penalties, incentives and other mechanisms for improving compliance: Yes

Energy performance monitoring requirements: None required by law.

United States

Almost all cities or territorial entities have their own rules and laws on construction, but in recent years, the requirements for thermal insulation and sound insulation of buildings under construction have become tougher. The 1990 American Standard for Heating, Refrigeration and air conditioning engineers (ASHRAE) was the first building energy code to include prescriptive requirements on solar reflection (how much light roofs should reflect) and minimal thermal emissions (how efficiently roofs shed heat) of roofs for air-conditioned buildings. Today, most warm staffs in the United States include prescriptive requirements on the use of steep roofs. The use of cold roofs can reduce the requirement for air conditioning by up to 20%. In warm climates with high requirements for cooling energy cool roofs to reduce peak electricity demand and transmit less heat to the outside environment thereby slowing the formation of urban smog due to energy production and improved human health and comfort in the open air [43]

Main regulatory documents related to building energy codes

These vary by region and are adopted and amended by each state. Most states base their energy code on the IECC code developed by the International Code Council.

- The US is currently utilizing the 2015 version of the ICC codes
- Climate zones
- Many states, such as California, require additional energy calculation compliance based on localized climate requirements.

Performance-based requirements in building energy codes

- Thermal characteristics and geometry of the building (envelope and internal partitions, etc.)
- Space heating system and hot water supply units
- Air-conditioning system(s)
- Built-in lighting system (mainly in the non-residential sector)

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

Coverage

- Single family houses
- Apartment blocks
- New residential
- Existing residential (e.g. after substantial refurbishment)

Stringency: Mixed

Requirements for enforcement and compliance

Penalties, incentives and other mechanisms for improving compliance:

- Refusal of permission to construct
- Refusal of permission to occupy
- Fines

Incentive programs are sometimes run by utilities and offer financial support in exchange for energy improvements to buildings.

Building Energy Codes Stringency and Coverage

Coverage:

- Single family houses
- Apartment blocks
- Commercial
- Public buildings

- new non-residential
- new residential
- Existing residential (e.g. after substantial refurbishment)
- Existing non-residential (e.g. after substantial refurbishment)

Stringency: Mandatory

Performance-based requirements in building energy codes: This is an optional/alternate path of compliance in some states.

Details/values of the performance-based requirements in building: Varies considerably and only applicable in some states.

Energy levels are considered in building codes when defining the Energy Performance of a Building: Energy use for lighting

Prescriptive requirements in building energy codes

No information

Building Materials and Products

Rating/certification of building materials: Yes

Harmonization with other technical standards: Yes

Requirements to test building materials and products by certified test laboratories: yes

Subregion E:
South-Eastern Europe

Countries

Albania,

Bosnia and Herzegovina

Montenegro

Serbia

The former Yugoslav Republic of Macedonia

Albania

Albania's National Energy Efficiency Action Plan established a target of 9% energy use reduction across sectors by 2018. Energy use reduction in the residential building sector is expected to account for 22% of the broader target. Albania has taken important steps toward achieving these reductions by requiring energy efficiency standards for new building construction. Law No. 8937 defined minimal thermal efficiency standards for new construction, and Law No. 10113 mandates compliance with energy efficiency standards. Albania is working towards the development and passage of an updated Law on Energy Efficiency, which will build a framework for enforcement and implementation of national energy efficiency priorities that have previously remained unenforced [44].

Main regulatory documents related to building energy codes

Law was adopted in November 2015, which transposes many of the requirements of Directive 2012/27/EU (the "Energy Efficiency Directive"). Approval is expected of the draft Law on the Energy Performance of Buildings (EPB), which transposes Directive 2010/31/EU (the "Energy Performance of Buildings Directive")

Energy performance on building law 116/2016.

- On 11th of November 2016 the Energy Performance Law. Until have new sublaws on EPB law, we have in force the regulation of DCM no 38 dt. 16.01.2003
- Climate zones: three different climate zones A B C. The C zone is the coldest with 2370 Heating Degree Days (HDD), the 2nd zone B

Performance-based requirements in building energy codes

- Thermal characteristics and geometry of the building (envelope and internal partitions, etc.)
- Air-tightness
- Space heating system and hot water supply units
- Air-conditioning system(s)
- Mechanical and natural ventilation
- Built-in lighting system (mainly in the non-residential sector)
- Design position and orientation of buildings
- Passive solar systems and solar protection
- Indoor and outdoor climatic conditions
- Thermal bridge

The International Performance Measurement & Verification Protocol (IPMVP): No

Software used for compliance verification: No

The gap between predicted and actual performance levels: 30-40%

There is mandatory requirement to assess post-construction requirement of the thermal bridge: No

There is mandatory requirement for air tightness testing: No

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

Coverage:

- Public buildings
- new non-residential

Stringency: Mandatory

Type of energy that the EPC refer to: Total primary energy,

Existence of national registry database for EPC: No

Building Materials and Products

Rating/certification of building materials: No

Harmonization with other technical standards: International technical specifications, such as those prepared by ISO

Requirements to test building materials and products by certified test laboratories: No

Building Energy Codes Stringency and Coverage

Coverage:

- Single family houses
- Apartment blocks
- Commercial
- Public buildings

- new non-residential
- new residential
- existing residential (e.g. after substantial refurbishment)

Stones Building Brick Building Prefabricated Building

Stringency: Mixed (both voluntary and mandatory) and Voluntary

Performance-based requirements: Energy efficient development systems

Values of the performance-based requirements: New buildings: 55 kwh/m^2/yr, Existing buildings (e.g. after substantial refurbishment): 80 kwh/m^2/yr

Energy levels are considered in building codes:

Energy use for: heating, cooling, hot water, lighting, ventilation.

Prescriptive requirements in building energy codes

- Thermal insulation (including U-values for walls, floor, roof and windows)
- Specified thermal comfort levels for winter and summer
- Solar gains (G-values)
- Air-tightness
- Ventilation or air quality
- Ventilation for summer comfort
- Daylighting requirements
- Artificial lighting system, lighting density
- Boiler/AC system
- Renewables

Requirements for enforcement and compliance

Requirements for regular inspection of heating and AC systems: No

Penalties, incentives and other mechanisms for improving compliance: Fines for non-compliance

Energy performance monitoring requirements: Yes

Bosnia and Herzegovina

Nearly two thirds of the housing sector has been rehabilitated with the support of various international and local donors, and another third, mostly less damaged buildings, has been renovated with private funds from homeowners. The number of completed dwellings in Bosnia and Herzegovina increased to 989 in the fourth quarter of 2017 from 640 in the third quarter of 2017. District heating systems are available in urban areas, particularly Sarajevo, Banja Luka, Zenica and Tuzla. The district heating system in Tuzla receives heat from the Tuzla power plant, which is the only example of a co-production plant for domestic heating in Bosnia and Herzegovina [45].

Main regulatory documents related to building energy codes

The law on energy efficiency in the Federation of B&H (Federal official Gazette, 22/17)
The law on construction in Republika Srpska
Regulation of the minimum energy efficiency of buildings in the Federation of B&H and Republika Srpska.

- The Regulation of minimum of energy performance of buildings in Republika Srpska (2015).
- The Regulation of minimum of energy performance of buildings in Federation of B&H currently is in adoption procedure.
- Two Climate zones

Performance-based requirements in building energy codes

- Thermal characteristics and geometry of the building (envelope and internal partitions, etc.)
- Air-tightness Space heating system and hot water supply units
- Air-conditioning system(s)
- Mechanical and natural ventilation
- Built-in lighting system (mainly in the non-residential sector)
- Design position and orientation of buildings
- Indoor and outdoor climatic conditions
- Thermal bridge

Energy use for: heating, cooling, hot water, ventilation

A subset of ISO EPB standards: currently we use EN ISO or EN standards as soon as other technical requirements are met, we will adopt EU standards such as EPB from 2017 (EN ISO 52000)

International performance measurement and verification Protocol (IPMVP): Yes, we are currently in the process of creating the same

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

Coverage:

- Single family houses
- Apartment blocks
- Commercial
- Public buildings

- new non-residential
- new residential
- existing residential (e.g. after substantial refurbishment)
- existing non-residential (e.g. after substantial refurbishment)

Stringency: Mandatory

Type of energy that the EPC refer to: Energy for heating space and water

Entitled to issue EPC: accredited domestic energy assessors

Existence of national registry database for EPC: Yes

Building Materials and Products

Rating/certification of building materials: Yes

Harmonization with other technical standards: European Union standards used for CE Marking

Requirements to test building materials and products by certified test laboratories: Yes, Institute for accreditation of B&H

Building Energy Codes Stringency and Coverage

Coverage:

- Single family houses
- Apartment blocks
- Commercial
- Public buildings

- New non-residential
- New residential
- Existing residential (e.g. after substantial refurbishment)
- Existing non-residential (e.g. after substantial refurbishment)

Stringency: Mandatory

National classification of buildings covered by energy codes: Residential building: Apartment building and individual family house

Nonresidential building: Administrative building: for education, social and health,

Commercial building for sports and recreation, tourism and catering (restaurant-hotel).

The values are the same as for new buildings and major renovations.

This is reflected in:

Maximum permissible values of annual heat energy required per m^2 of useful surface of the building (kWh / m^2year), depending on the shape factor (geometry of the building), climatic zone and the purpose of the building.

The maximum transmittance for buildings on the climate zone, use of the building and the shape factor of the building (geometry of buildings)

Prescriptive requirements in building energy codes

- Thermal insulation (including U-values for walls, floor, roof and windows)
- Solar gains (G-values)
- Air-tightness
- Ventilation or air quality
- External solar protections
- Thermal bridge

The U values for external walls, floor, roof and windows depends of designed temperature of buildings and climatic zone.

Individual energy metering and control units: Partially

Requirements for enforcement and compliance

Requirements for regular inspection of heating and AC systems: No

Penalties, incentives and other mechanisms for improving compliance: Refusal for occupancy or construction permit

Energy performance monitoring requirements: No

Montenegro

The state - building sector is an obvious priority for solving energy-saving problems in Montenegro, as it accounts for about 30% of the energy-saving potential in the public buildings sector and up to 10% in the residential buildings sector from the total energy-saving potential in the country. The government is taking measures to modernize the housing stock in order to improve its energy efficiency. Montenegro adopted the energy policy until 2030, which defines three main priorities: sustainable energy development, security of supply and development of the energy market. In order to achieve these priorities, the main objectives are defined, where the use of energy-saving and renewable energy potential and the achievement of the goals are concepts that emphasize many of the defined goals [47].

Main regulatory documents related to building energy codes

Law on efficient use of energy (official Gazette of Montenegro, 57/14)
Set of rules on minimum requirements for energy efficiency of buildings (official Gazette of Montenegro 75/15)
Guidelines for energy efficiency certification of buildings (official Gazette of Montenegro 75/15)
Guidelines for energy audits of buildings (official Gazette of Montenegro 75/15)

- 2014-2015
- Climate zones: Zone I, Zone II and Zone III

Performance-based requirements in building energy codes

Performance-based requirements for buildings do not exist at this moment. Energy classes will be defined within the EEPPB II project

- Thermal characteristics and geometry of the building (envelope and internal partitions, etc.)
- Air-tightness
- Space heating system and hot water supply units
- Air-conditioning system(s)
- Mechanical and natural ventilation
- Design position and orientation of buildings
- Thermal bridges
- Electricity for the pumps and fans and Electricity for appliances and equipment
- Passive solar systems and solar protection
- Indoor and outdoor climatic conditions

Energy use for: heating, cooling, hot water, lighting, ventilation.

Total primary energy use

The subset of ISO EPB standards: This will be decided within the EEPPB II project

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

Coverage:

- Single family houses
- Apartment blocks
- Commercial
- Public buildings

- new non-residential
- new residential
- Existing residential (e.g. after substantial refurbishment)
- Existing non-residential (e.g. after substantial refurbishment)

Stringency: Mandatory
EPC is not carried out in practice due to the lack of national software for calculating. This will be done in the project EEPPB II.
Existence of national registry database for EPC: No

Building Materials and Products

Rating/certification of building materials: Yes

Harmonization with other technical standards: Yes

Requirements to test building materials and products by certified test laboratories: Yes, Laboratory for testing building materials and constructions (part of Civil Engineering Faculty in Podgorica)

Building Energy Codes Stringency and Coverage

Coverage:

- Single family houses
- Apartment blocks
- Commercial: hotels, recreational facilities, cultural facilities, warehouses, light industry,
- Public buildings: schools, kindergartens, universities, hospitals, dormitories,
- Other buildings that are heated on temperature above 12° C, has area more than 50 m2 and are not under cultural heritage.

This typology is represented in current Rulebook on minimal energy efficiency requirements in buildings. New building typology will be defined within the EEPPB II project.

- new non-residential
- new residential
- Existing residential (e.g. after substantial refurbishment)
- Existing non-residential (e.g. after substantial refurbishment)

Prescriptive requirements in building energy codes

- Thermal insulation (including U-values for walls, floor, roof and windows)
- Air-tightness
- Ventilation or air quality
- External solar protections
- Artificial lighting system, lighting density
- Boiler/AC system
- Renewables
- Thermal bridges

Tightness: at a pressure difference of 50 PA: n50 = 3.0 h - 1 in buildings without mechanical ventilation, and n50 = 1.5 h-1 in buildings with mechanical ventilation.

Ventilation or air quality: N = 0.5 h-1. In the case when people are not in the part of the building is n = 0.3 h-1.

Heat recovery: change of air is greater than 0.7 h-1; the total air flow is greater than 2500 m^3 / h. If the criteria are met, the recovery efficiency should be above 50 %.

External solar protection: condition: fall-winter <0.4: requirements: g_{tot}.firmware < 0.20 (zone I), g_{tot}.firmware < 0.25 (zones II and III); condition: fall-winter >0.4: requirements: $g_{tot} \leq 0.50$ (zone I), $g_{tot} \leq 0.60$ (zones II and III).

Artificial lighting system, lighting density: more than 42 lm/W.

Boiler / AC system: (boiler efficiency), 3.2 (efficiency / AIR up to 12 kW) and 3.3 (efficiency / AIR over 12 kW)

Renewable energy: a commitment for new buildings in climate zone I to cover 30% of their annual energy needs for domestic hot water with renewable sources (solar thermal systems).

Requirements for enforcement and compliance

Requirements for regular inspection of heating and AC systems: Yes, for both heating and AC systems

Penalties, incentives and other mechanisms for improving compliance: Fines for non-compliance, specific incentive, refusal for occupancy or construction permit

Energy performance monitoring requirements: Yes, Mandatory

Serbia

Studies have shown that Serbia has great potential for improving energy efficiency in the construction sector, primarily because of the fact that most of the Serbian construction Fund-a building built in the 70s and 80s, with brick walls and without thermal insulation. In addition, individual boilers for heating systems are often in poor condition. Because of the low efficiency of heating systems combined with poor performance of building dimensions leads to a significant loss of valuable energy. Serbia has adopted a number of rules aimed at improving energy efficiency, including the national energy efficiency action plan (2010), as well as the decree on energy efficiency of buildings and the decree on conditions for issuing and maintaining energy efficiency certificates for buildings (2012) [49].

Main regulatory documents related to building energy codes

The law on planning and construction ("Official Gazette of the Republic of Serbia", No. 72/2009, 81/2009, 145/2014)
Rulebook on energy performance of buildings ("Official Gazette of the Republic of Serbia", No. 61/2011)
Rulebook on conditions, contents and manner of issuing certificates on energy performance of buildings ("Official Gazette of the Republic of Serbia" No. 69/2012).

- Energy certification of buildings (2012), mandatory.
- Climate zones

Performance-based requirements in building energy codes

- Thermal characteristics and geometry of the building (envelope and internal partitions, etc.)
- Air-tightness
- Space heating system and hot water supply units
- Air-conditioning system(s)
- Mechanical and natural ventilation
- Design position and orientation of buildings
- Thermal bridges

- New building
- Existing building (e.g. after substantial refurbishment)

The energy class of the new building shall not be lower than class "C" or higher. The class of energy consumption of existing buildings should be upgraded to at least one class after reconstruction.

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

Coverage:

- Single family houses
- Apartment blocks
- Commercial
- Public buildings

- New non-residential
- New residential
- Existing residential (e.g. after substantial refurbishment)
- Existing non-residential (e.g. after substantial refurbishment)

Energy type to which EPC refers: total primary energy

Stringency: Mixed (both mandatory and voluntary)

Building Materials and Products

Rating/certification of building materials: Yes

Harmonization with other technical standards: The Draft Law on Construction Products is currently under way.

Requirements to test building materials and products by certified test laboratories: Yes, Accreditation Board of Serbia (ABS)

Building Energy Codes Stringency and Coverage

Coverage:

- Single family houses
- Apartment blocks
- Commercial
- Public buildings

- new non-residential
- new residential
- Existing residential (e.g. after substantial refurbishment)
- Existing non-residential (e.g. after substantial refurbishment)

National classification of buildings covered by the energy codes: A+, A, B, C, D, E, F, G.

According to the Rulebook on energy efficiency in buildings, the energy performance and manners of calculating thermal properties are established for the following types of buildings:

Residential single apartment buildings; Residential buildings with two or more apartments; Administrative and commercial buildings;

Education and culture buildings; Health and social care buildings;

Tourism and hospitality buildings; Sports and recreation buildings;

Buildings in trade and service industries; Mixed purpose buildings;

10) Buildings for other purposes that use energy.

Prescriptive requirements in building energy codes

- Thermal insulation (including U-values for walls, floor, roof and windows)
- Specified thermal comfort levels for winter and summer
- Solar gains (G-values)
- Air-tightness
- Ventilation or air quality
- External solar protections
- Periodic transmittance and time lag of walls and roof
- Solar absorbance of external surfaces (e.g. cool paintings for roofs and streets)
- Daylighting requirements
- Thermal bridges

Main legislative documents relating to the EPC: the law on efficient use of energy; the law on environmental protection;

Position on the assessment of the limit values of the annual energy consumption; Rulebook on conditions, contents and procedure of issuing certificates on the energy performance of buildings

Individual energy metering and control units: No

Requirements for enforcement and compliance

Requirements for regular inspection of heating and AC systems: Yes, for both heating and AC systems, but it is defined in separate regulation, this is a mandatory requirement

Penalties, incentives and other mechanisms for improving compliance: Refusal for occupancy or construction permit. Construction and use permits.

The former Yugoslav Republic of Macedonia

Major problematic areas in the former Yugoslav Republic of Macedonia, as far as energy efficiency is concerned, are the wide use of electricity for domestic heating and the inefficient energy consumption in buildings. The Government has started addressing these problems, but they have not been given enough priority. The introduction of the building certificate system is planned. The Energy Law allocates the responsibilities for energy efficiency policy development and implementation in Macedonia to the Ministry of Economy, supported by the Energy Agency. Responsibility within the Ministry is with the Energy Department and its Unit [46].

Main regulatory documents related to building energy codes

Law on Energy (Energy Law (EL)) 2011

Law on Construction (Construction Law (CL)).

Law on spatial and urban planning, Rulebook on energy audits 2013. Rulebook for energy characteristics of buildings 2013, Rulebook for Information System for monitoring and management of energy consumption at legal entities in public sector 2015.

Energy efficiency strategy for 2010-2020.

- The current set of regulations was adopted in 2015, but the legislation is going through changes at the moment
- Climate zones, Sub-regions. Now ion rulebook for energy characteristics of buildings only 4.

Performance-based requirements in building energy codes

- Thermal characteristics and geometry of the building (envelope and internal partitions, etc.)
- Air-tightness
- Space heating system and hot water supply units
- Air-conditioning system(s)
- Mechanical and natural ventilation
- Design position and orientation of buildings
- Passive solar systems and solar protection
- Indoor and outdoor climatic conditions
- Thermal bridge

Energy use for: heating, cooling, hot water

The subset of ISO EPB standards

Software used for compliance verification: No

Energy Performance Certification (EPC)/Energy Labelling/Energy Passport of the building

Coverage:

- Single family houses
- Apartment blocks
- Commercial buildings
- Public buildings

- new non-residential
- new residential
- existing residential (e.g. after substantial refurbishment)
- existing non-residential (e.g. after substantial refurbishment)

Stringency: Mixed (both voluntary and mandatory)

Existence of national registry database for EPC: No, EPC is not currently functioning.

Building Materials and Products

Rating/certification of building materials: No

Harmonization with other technical standards: European Union standards used for CE Marking

Requirements to test building materials and products by certified test laboratories: No

Building Energy Codes Stringency and Coverage

Coverage:

- Single family houses
- Apartment blocks
- Commercial
- Public buildings

- new non-residential
- new residential
- existing residential (e.g. after substantial refurbishment)
- existing non-residential (e.g. after substantial refurbishment)

Stringency: Mixed (both voluntary and mandatory)

The national classification of buildings covered by the energy codes: they are separated by residential and non-residential for the means of certification. For the needs of energy audits, there is more detailed breakdown.

Residential sector min "C class"100 kWh/m^2 annual consumption, public sector min "C class" 150 kWh/m^2 annual consumption

Mandatory for public sector min "D class" after substantial refurbishment

Prescriptive requirements in building energy codes

- Thermal insulation (including U-values for walls, floor, roof and windows)
- Air-tightness
- Solar gains (G-values)
- Ventilation or air quality
- External solar protections
- Daylighting requirements
- Boiler/AC system
- Renewables
- Thermal bridge

Requirements for enforcement and compliance

Requirements for regular inspection of heating and AC systems: Yes, for both heating and AC systems

Penalties, incentives and other mechanisms for improving compliance: Yes, losing the license

Energy performance monitoring requirements: Yes

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