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

First Draft

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NOTE

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Acronyms and Abbreviations

CHLM	Committee on Housing and Land Management
CSE	Committee on Sustainable Energy
CE Marking	Conformité Européene or European Conformity marking
EPBD	Energy Performance of Buildings Directive
EPC	Energy Performance Certification
EU	European Union
GEEE	Group of Experts on Energy Efficiency
GBPN	Global Buildings Performance Network GBPN
HVAC	Heating, ventilation, and air conditioning
IPMVP	International Performance Measurement & Verification Protocol
ISO	International Organization for Standardization
NGOs	Non-governmental organizations
SE4ALL	Sustainable Energy for All
SDGs	Sustainable Development Goals
UNECE	United Nations Economic Commission for Europe

Sings and Measures

kWh	kilowatt hour (10^3 watt-hour)
m2	square metre
Pa	Pascal
µm	micrometre (10-6 metre)
W/mK	watts per metre Kelvin
W/m2K	watts per square metre Kelvin
W.s/m^3	watt second per cubic metre
W/(m^2.lx)	watts per square metre lux
kW/(m^3/s)	kilowatt per cubic metre second
m^3/h	cubic metre per hour
l/(s.m2)	liter per second square metre
m3/h.m2	cubic metre per hour per square metre
kWh/m2yr =	kilowatt hour per square metre per year
W/litre/sec	watt per litre per second
lumen/watt	lumen per watt

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 any combination of participants. 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 this challenge and to strengthen understanding about the status of deployment and implementation of energy efficiency standards in buildings in the UNECE region, Committee on Housing and Land Management (CHLM) and Committee on Sustainable Energy (CSE) 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. The objective of this study is also to evaluate the most effective policies and highlight the best practices to help nations learn from one another and achieve greater savings. This report presents the results of this study and takes a look at the building energy standards in the UNECE region to determine which countries are embracing energy efficiency through highly effective building energy codes.

This report provides a snapshot of the legal status and coverage of building energy standards in 56 Member States, 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 and 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 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 standards and technology in buildings in the UNECE region using a questionnaire survey, complemented by the desktop study 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.

UNECE developed a survey questionnaire to gather a detailed information about the activities undertaken by the UNECE Member States to develop and implement energy efficiency standards in buildings. A questionnaire was developed in consultation with the members of the Joint Task Force on Energy Efficiency Standards in Buildings. The questionnaire was comprised of 40 questions and was divided into six parts.

The full version of the questionnaire can be found in **Annex I.** The first draft 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 members of the Joint Task Force were collected and taken into account to finalize the final set of questions to be disseminated to the focal points of all 56 Member States of the UNECE. 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. In total, around 300 questionnaires were sent out to the CHLM and CSE focal points in 56 Member States, members of the UNECE Group of Experts on Energy Efficiency (GEEE) and members of the first Meeting of the Joint Task Force on Energy Efficiency in Buildings, international experts, representing international intergovernmental and non-governmental organizations, the private sector and academia.

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);
B. EU enlargement - the 13 countries that joined the EU after 2004 10 (EU12);
C. Russian Federation, South-Eastern Europe, the Caucasus and Central Asia;
D. United States and Canada; and
E. Other

A total of 63 responses were received from 28 countries, of which 26 fully completed the questionnaire. 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).

The respondents has indicated 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 share equally 96 percent coverage, with commercial buildings having a slight lower share of 91 percent in the UNECE region. Public buildings and apartment blocks in sub-region C represent an equal (94 percent) coverage which is slightly lower compared to UNECE region, with commercial buildings representing 81 percent.

According to respondents, 52 percent of building energy codes are mandatory, followed by mixed (38 percent) and voluntary (10 percent). In regard to elements that must be taken into account for the calculation of the energy performance of a building, thermal characteristics of the building represent 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).

50 percent of responses confirmed the existence of software used for compliance verification. 68 percent responses have pointed out to an absence of a mandatory requirement to assess post-construction requirement of the thermal bridge and 74 percent have indicated that there is no mandatory requirement for air tightness testing.

According to respondents, there is 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.

With regards to the prescriptive requirements in building energy codes, the large majority of 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 of responses.

44 percent of respondents have confirmed the existence of the requirement for a regular inspection of heating and A/C systems, while 28 percent have stated that such requirement does not exist in their country's building energy code. 66 percent of responses also have indicated that a regular inspection of heating and A/C systems is a mandatory requirement in country building energy code.

The next set of questions was focused on gaining information about the status of the Energy Performance Certification (EPC). The responses received suggest that the majority of buildings covered by EPC are new non-residential (41 percent), 24 percent of responses have indicated that none of the building types are covered by EPC, followed by new residential buildings (18 percent). According to respondents, the 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. The majority of the EPC requirements are mandatory (56 percent), followed by mixed (33 percent) and voluntary requirements (11 percent).

With regards to building materials and products, respondents were asked whether there were requirements to have building materials certified. The vast majority of responses (72 percent) have confirmed the existence of such requirements in the country's building energy code. In addition, 75 percent of responses have indicated that these requirements are harmonized with the European Union standards used for CE Marking, while 31 percent of respondents use international technical specifications, such as those prepared by International Organization for Standardization (ISO).

65 percent of respondents confirmed the existence of specific incentives for compliance in country's building energy code, while requirements for energy performance monitoring 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. 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 monitoring requirements set in country's building energy code.

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 the best practices in countries from different sub-regions. Furthermore, a number of recommendations have been suggested to address gaps identified.

The analysis of the coverage and stringency of building energy codes across the UNECE Member States has 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. Azerbaijan and Kazakhstan do not currently have provisions to cover single family buildings types while in Turkmenistan building energy code does not cover new non-residential buildings. Building energy code in Georgia covers only new residential buildings while, in Moldova, it covers only 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 which 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 EPC implementation across the 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. A number of responses and some published studies have indicated that the quality of the EPC is not satisfactory in some countries. There are also some inconsistencies across the 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 Canada, Macedonia, Armenia, Kazakhstan, Georgia, Albania and Belarus the EPC is not currently used.

The results of the survey also have indicated a lack of knowledge, inconsistencies in statistics and a lack of appropriate studies in the field of energy performance gap. This suggests one or more of the following issues: 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 are to deliver the climate and environmental targets related to buildings. In Switzerland, for example, this is currently being researched, with initial findings suggesting 30-300 percent gap measured compared to predicted energy performance in residential buildings. Other countries, e.g. Albania stated 30-40 percent energy performance gap, Armenia - 60 percent and 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 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, Turkmenistan, Montenegro, Ukraine, Kazakhstan, Croatia, Moldova, Azerbaijan, Belarus, Albania, Russia and Serbia 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 at a very low level. 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 UK do not include 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-region C, e.g. Turkmenistan, Georgia, Ukraine, Moldova, Albania and Macedonia, showed a relatively low level of implementation for this metric, while other countries, e.g. Uzbekistan, Kazakhstan, Russia, Armenia, Serbia, Bosnia and Herzegovina and Montenegro include requirements for the use of 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 initial assessment of energy efficiency technologies in buildings is currently being prepared and will formulate the next stage of this study. The results of this assessment will be reported in the next draft report and it is intended for this study to be completed by the end of June 2018.

Conclusions and recommendations

The information gathered in this report is another step toward fostering cooperation among countries with building energy standards and those contemplating standards or other policies for increasing energy-efficiency in buildings. While it is difficult to generalize, this 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 for the increased communication within it.

Recommendations

Recommendation 1: *Member States of the UNECE should continue the process of harmonization of building energy codes by ensuring comprehensive coverage of all types of buildings in their regulations.*

Recommendation 2: *Member States of the UNECE shall lay down the necessary measures to include 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: *Member States of the UNECE to continue the process of harmonization through further strengthening the requirements for insulation, ventilation and technical installations:*

- *Give more attention to air-tightness of the envelope;*
- *Ensure inclusion of the requirements for air conditioning, lighting, active solar, renewables and natural lighting;*
- *Make mandatory the requirement for the inspection of boilers and air-conditioning systems to improve the quality and precision of Energy Performance Certificates in collective dwellings;*
- *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: *Member States of the UNECE should consider to continue introducing quality assurance measures, especially during the early state of the certification process:*

- *The requirements for the qualified experts should be harmonised across Member States of the UNECE region;*
- *The certifier needs to be physically present onsite;*
- *There is a need to further harmonize the quality check of the EPC;*
- *Facilitate harmonization of the EPC through integration of ventilation, cooling and lighting into the certificate;*
- *Need for guidance in development of the centralised EPCs databases and digitalisation of the EPC process; and*
- *UNECE to consider to providing further technical assistance and capacity building activities to the countries where the EPC scheme is not yet in use or not fully developed based on the recognized best practice approaches.*

Recommendation 5: *Member States of the UNECE should consider making the challenges of the energy performance gap to be a priority area for research.*

Recommendation 6: *Member States of the UNECE should continue establishing proper (electronic) monitoring systems of compliance, enforcement and quality control processes through a qualified workforce to ensure compliance with building energy codes and standards.*

Recommendation 7: *Member States of the UNECE shall lay down the necessary measures to establish a regular inspection of boilers and air-conditioning systems in building energy codes.*

Recommendation 8: *Member States of the UNECE shall lay down the necessary measures to continuously monitor, analyze and adjust energy usage in building energy codes.*

Recommendation 9: *Member States of the UNECE, particularly countries with economies in transition, should consider creating incentives for companies for improving energy efficiency through appropriate policies, tax incentives and low-interest loans for energy efficiency projects.*

Recommendation 10: *Member States of the UNECE shall lay down the necessary measures in building energy codes to 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 income countries of the UNECE region, regard should be given to the types of construction that these countries can afford to ensure that building energy codes effectively promote research and development for improving local traditional techniques, materials testing and quality control, and do not create dependency on imported building materials that may stiff local innovation.*

Recommendation 11: *Member States of the UNECE shall lay down the necessary measures in building energy codes to 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 resistance test and seismic resistance, ensuring they do not cause threat to the safety of life and property.*

<u>Recommendation 12:</u> Member States of the UNECE should 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.

<u>Recommendation 13:</u>

a) *UNECE should consider the matter in relevant UN committees on the feasibility of creating and publishing a printed set of national building energy codes for all 56 countries of the UNECE, followed by the release of the Yearbook. All such printed publications are to be distributed in all countries of the UNECE region and beyond;*

b) *Member States of the UNECE, particularly countries with economies in transition, should consider to post free of charge accessible full-featured versions of their building energy codes with the applicable calculation methods on the relevant websites;*

c) *UNECE (GEEE) to consider to set up a new webpage containing free of charge online information with links to the full versions of building energy codes of all Member States of the UNECE, including information on countries' best practices;*

d) *Member States of the UNECE, especially neighbouring countries who have already developed their building energy codes in detail and are at the stage of their practical implementation with real positive effects, to provide methodological assistance and other types of assistance to countries in need of such development; and*

e) *Member States of the UNECE, particularly countries with economies in transition, to 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.*

<u>Recommendation 14:</u>

a) *UNECE to consider carrying out further studies on mapping of national approaches 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; and*

b) *UNECE to consider 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.*

Introduction

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. 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[1]. 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[2].

Building energy codes[3] and standards[4] are regulatory instruments that set minimum requirements for energy efficiency and use of resources in buildings. Building energy codes commonly mandate certain energy efficiency characteristics for building technologies. As another approach, outcome-based building energy codes are aligned with technology performance and provide target energy use levels for a building as a whole. They 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.[5]

Building energy codes 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 (SE4ALL) initiative of the United Nations Secretary General, and the Geneva UN Charter on Sustainable Housing. However, effective enforcement of building energy standards which can be ensured through compliance checks, incentives and other supporting instruments, is critical and remains an issues in a number of countries.

UNECE is executing the extra budgetary project "Energy Efficiency Standards in Buildings" under the Divisions of Forests, Land and Housing and Sustainable Energy working jointly. The project is aimed to improve energy efficiency in buildings by developing and implementing energy efficiency standards in buildings in the UNECE region. Member States established the Joint Task Force on Energy Efficiency Standards in Buildings under the Committee on Housing and Land Management (CHLM) and Committee on Sustainable Energy (CSE) in 2015.

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[1] 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, accessed on 17 March 2018.

[2] https://www.unece.org/fileadmin/DAM/hlm/documents/Publications/good.practices.ee.housing.pdf

[3] Energy Building codes, 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.

[4] We use the word "standard" to refer 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.

[5] https://www.nrel.gov/docs/fy16osti/65542.pdf

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 any combination of participants from a range of institutions, including government, academia, utilities, industry groups, and professional associations. 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 CHLM and CSE 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.

Need to undertake this 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. Building energy standards are anticipated to be in a dynamic phase in the next decade. Understanding building energy standards however requires specific technical expertise which makes monitoring and evaluating the progress of what is happening from the political level difficult.

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 such standards published by different entities, and they may be self-contained or subsumed within another document (such as a general building code)[6]. 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 CHLM and the CSE conducted the survey, outcomes of which indicated that one of the main activities that UNECE could support its Member States with was to undertake "Mapping of existing energy efficiency standards in buildings".

[6] http://www.eci.ox.ac.uk/research/energy/downloads/janda04-wsesb.pdf

In response, the CHLM and CSE made a decision to develop a study "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.

This study does not seek to identify one best practice amongst the building energy codes and standards. Instead, this 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. This study also provides findings of an initial assessment of energy efficiency technologies in buildings in relation to the existing standards (currently this is under preparation and is not included in this first draft report).

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.

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

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 was comprised of 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;

- 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;
- 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.

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 on the UNECE website from 26 January to 12 February 2018 in English and Russian, with deadline further being extended to 28 February 2018. In total, around 300 questionnaires were sent out to CHLM and CSE focal points in 56 Member States, members of the UNECE Group of Experts on Energy Efficiency (GEEE) and members of the first Meeting of the Joint Task Force on Energy Efficiency in Buildings, international experts, representing international intergovernmental and non-governmental organizations, the private sector and academia.

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 31 October 2017 in Geneva and on 15 May 2018 in Yerevan with the participation of representatives from government agencies, the private sector, NGOs, professional associations, education and research institutes and regional/donor agencies. At these workshops, the preliminary approach and methodology for this study were discussed, initial findings of the assessment results presented, data gaps identified and validated among the participants.

d. Countries Information Sheets.

Countries information sheets were prepared for individual countries where the level of information gathered through the desktop study and the survey responses were 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 country information sheet contains a number of metrics for energy efficiency in buildings presented below, and a detailed information for each country can be found in **Annex III** of this report:

- 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 the best practices in countries from different sub-regions. Furthermore, a number of recommendations have been suggested to address gaps identified.

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

A. European Union (EU) Member States prior to 2004 (EU15)[7];

B. EU enlargement - the 13 countries that joined the EU after 2004 10 (EU12)[8];

C. Russian Federation, South-Eastern Europe, the Caucasus and Central Asia;

D. United States and Canada; and

E. Other

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 Russian Federation, South-Eastern Europe, the Caucasus and Central Asia (sub-region C). 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, Switzerland and Norway 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.

[7] It alphabetically includes Austria, Belgium, Denmark, Finland, France, Germany, Greece Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom.
[8] It alphabetically includes Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia.

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

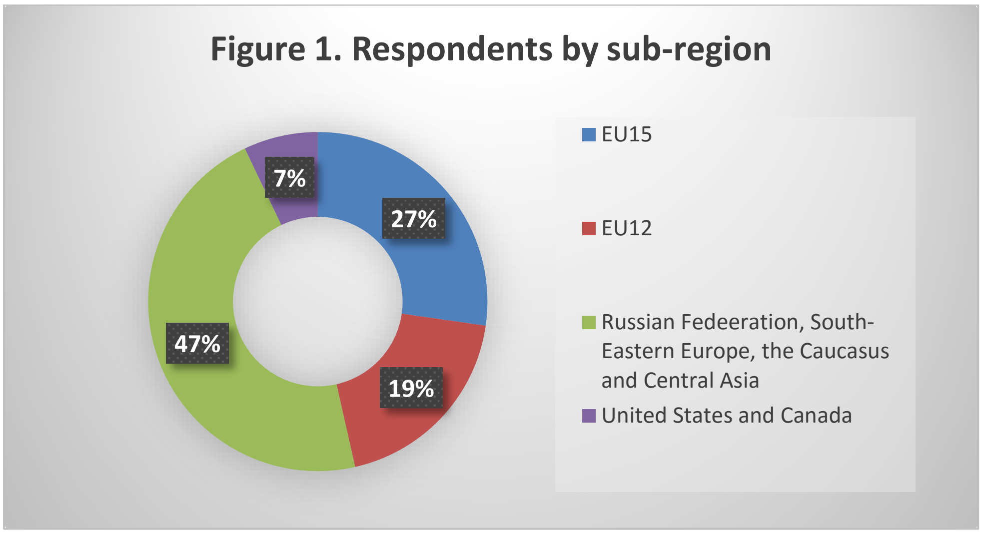
The preparation of an initial assessment of energy efficiency technologies in buildings was based on the data collected using the survey responses and the desktop study on trends in deployment of energy efficiency technologies. Best practices in countries from different sub-regions were also identified.

Chapter 1: Analysis of the survey results

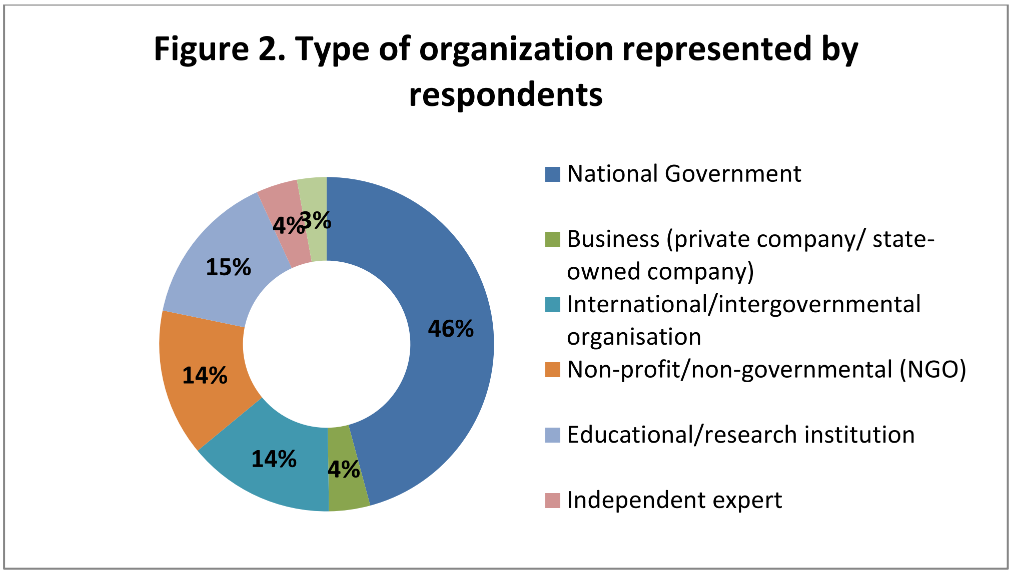
1.1 Part One – General Information

This section includes questions related to the personal details of the respondents, such as name, address, contact details, country, etc.

A total of **63** responses were given from **28** countries, of which **26** fully completed the questionnaire. Approximately one-quarter of the respondents were female. As shown in **Fig.1**, most of the respondents (47 percent) belong to the countries of sub-region C[9], followed by Member States that joined the EU before 2004 (27 percent) and countries that joined the EU after 2004 (19 percent).



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).



[9] Russian Federation, South-Eastern Europe, the Caucasus and Central Asia.

1.2 Part Two – Building Energy Codes

The next part of the questionnaire had the purpose to access 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 a national level. In countries with large climatic differences the 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. In this case, a model building code is often developed to cover the whole country, either on a public or as a private initiative[10]. 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[11].

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.

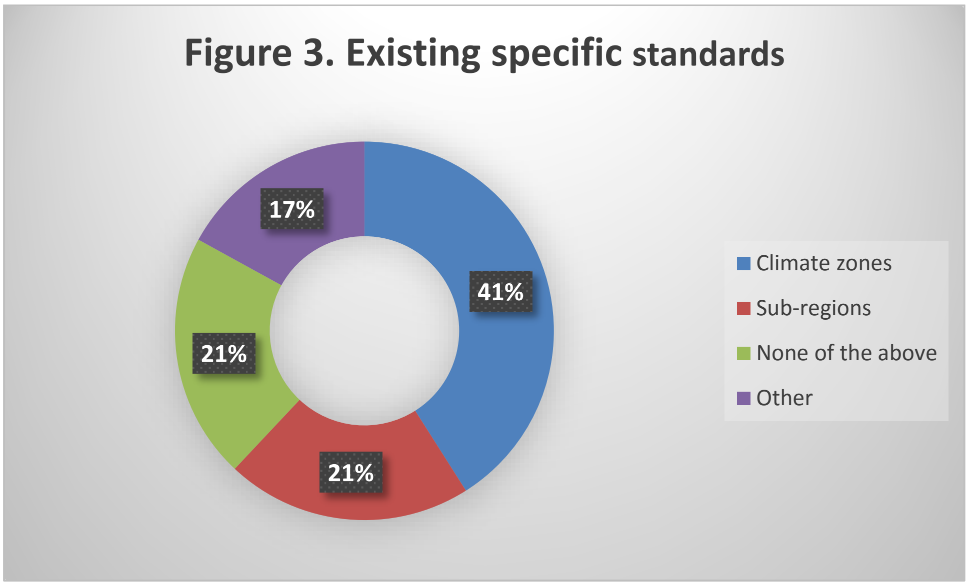


Fig. 3 above shows the presence of specific standards for climate zones, sub-regions, etc. The rate of responses to this question was 56 percent, and the responses received confirmed the existence of specific standards for climate zones (41 percent), followed by sub-regions (21 percent). Montenegro indicated that climate data is used for calculation of total primary energy consumption in buildings by three climatic zones, Bosnia and Herzegovina reported two climate zones. Spain also has different climatic areas. The areas are precisely defined and the building energy code depends on the determined one. Based on heating degree days Italy is divided into six climatic zones (A to F). The

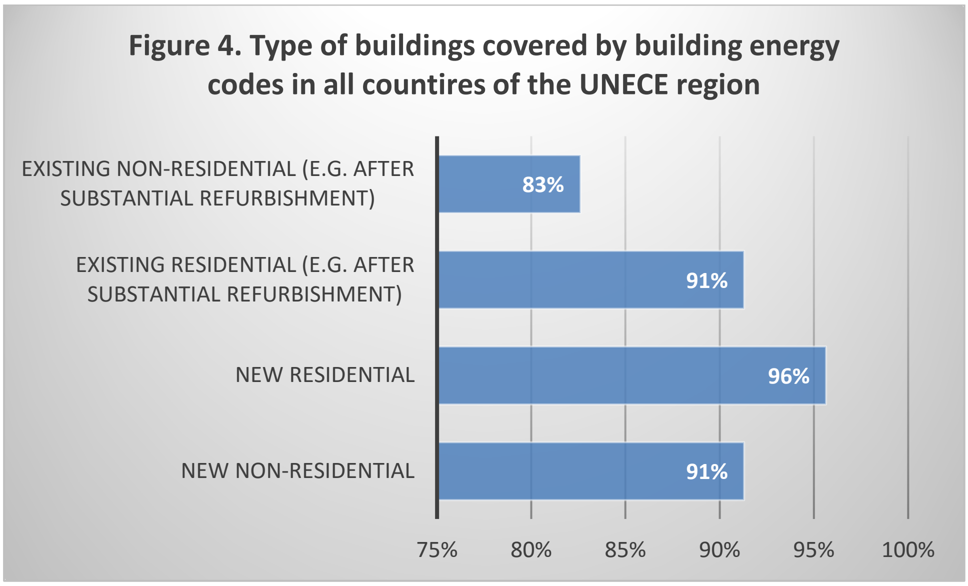
[10] https://www.iea.org/publications/freepublications/publication/Building_Codes.pdf
[11] https://www.iea.org/publications/freepublications/publication/energy-efficiency-requirements-in-building-codes---policies-for-new-buildings.html

territory of Republic 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. [12]

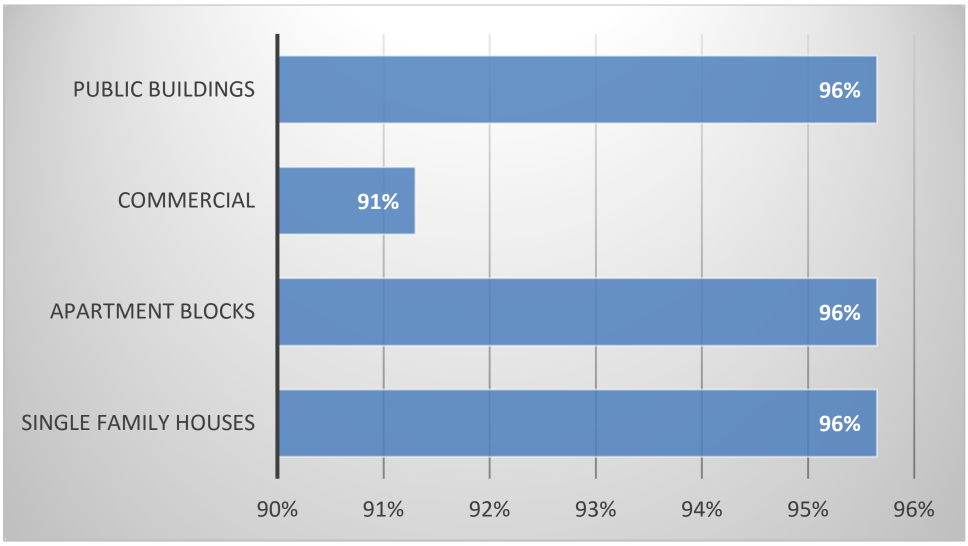
In the United States, many states, such as California, require additional energy calculation compliance based on localized climate requirements. Canada also has specific standards for climate zones and sub-regions, and although buildings in colder climates require higher levels of thermal performance, provinces and territories do not always adopt the federal model code, or adopt it with some modification, creating some differences between provinces or sub-regions.

The next series of 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[13].

Fig. 4 below 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.



[12] http://journals.euser.org/files/articles/ejms_may_aug_17/Gjergji.pdf
[13] http://www.eci.ox.ac.uk/research/energy/downloads/janda04-wsesb.pdf



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 UNECE region. Building energy code in Republic of Moldova does not contain provisions to cover new residential buildings, while building energy codes in both Georgia and Albania 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. Azerbaijan and Kazakhstan do not currently have provisions to cover single family buildings types while in Turkmenistan building energy code does not cover new non-residential buildings. Building energy code in Georgia covers only new residential buildings while, in Moldova, the code does not cover new residential and commercial buildings.

The responses received from countries of the EU 15 and 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 code. In Canada, 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.

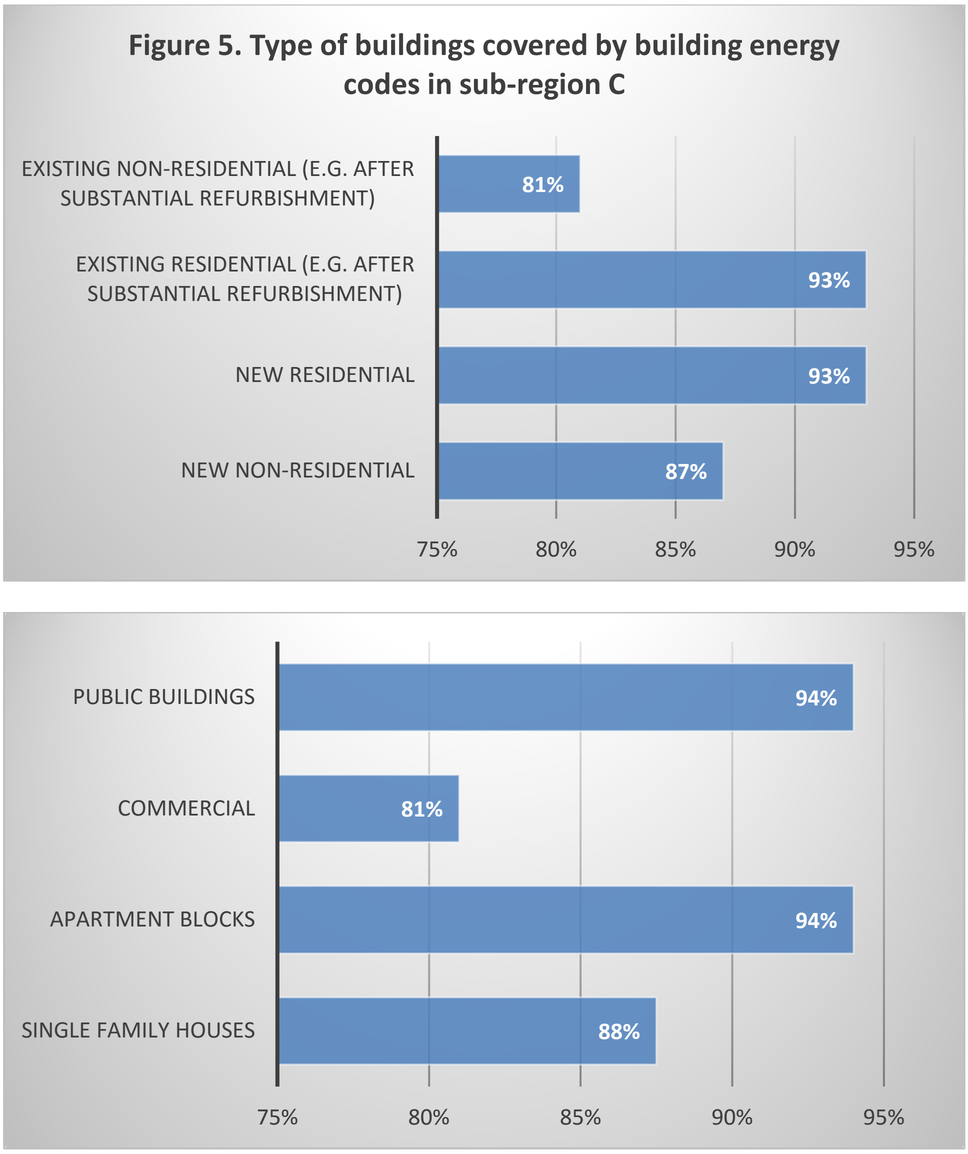
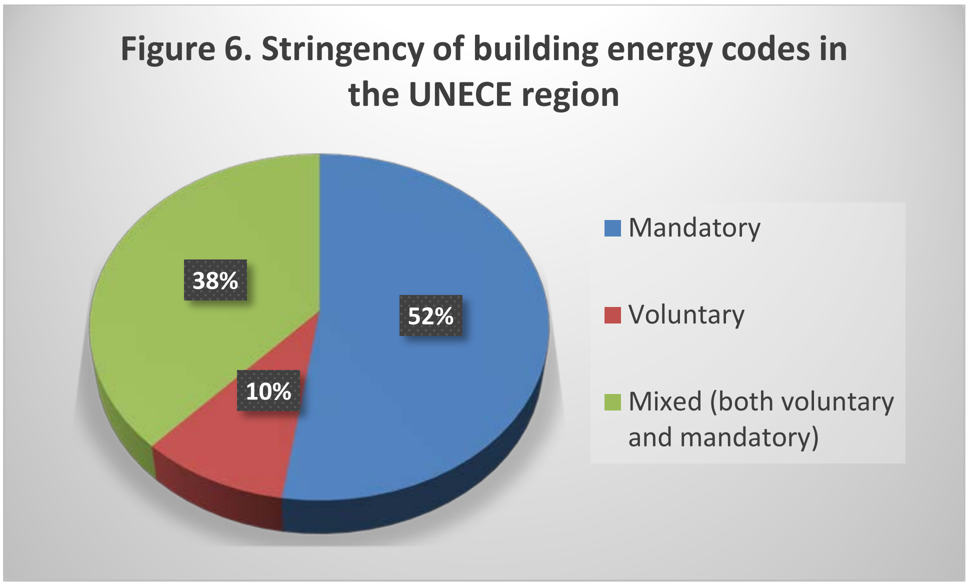


Figure 5. Type of buildings covered by building energy codes in sub-region C

The next question aimed to provide understanding of the level of stringency of building energy codes. 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, for example, the national government does not have authority to pass mandatory building codes; however, many states and provinces have adopted codes[14]. 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 are mandatory 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.

[14]Rachel Young (20140 Global Approaches: A Comparison of Building Energy Codes in 15 Countries. https://aceee.org/files/proceedings/2014/data/papers/3-606.pdf



<u>Performance-based requirements in building energy codes</u>

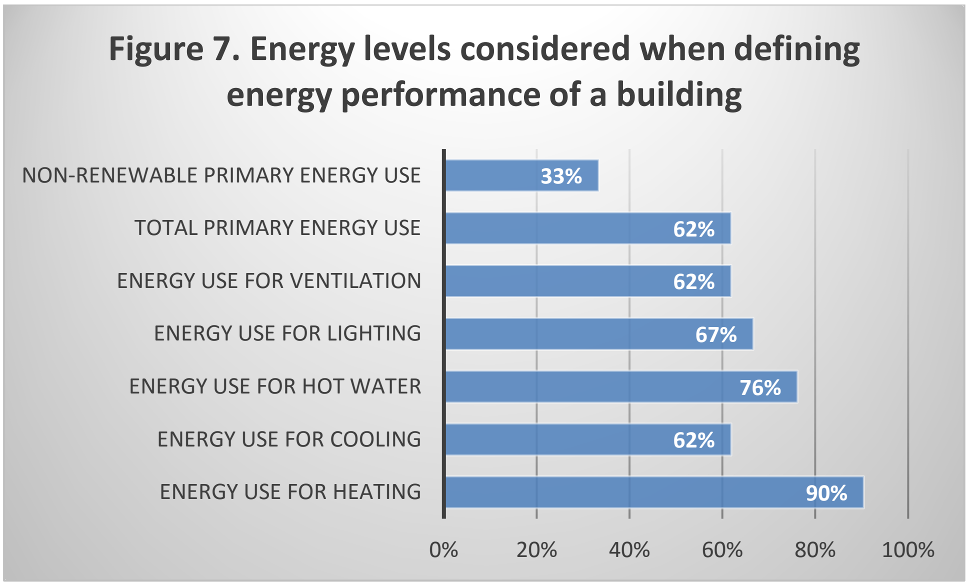
In addition to defining the types of buildings a standard covers, it is important to look at the methodology employed in the standard to calculate energy use. Prescriptive standards have the advantage of being simple to follow and assess, but they tend to be inflexible. Performance standards are more complicated but they allow a designer to vary building characteristics and still comply with the overall requirements.

Many elements influence the energy performance of a building; building energy codes often address the most integrated of these elements: the building envelope and HVAC systems. Other appliances and renewable energy are also included but to a lesser degree.

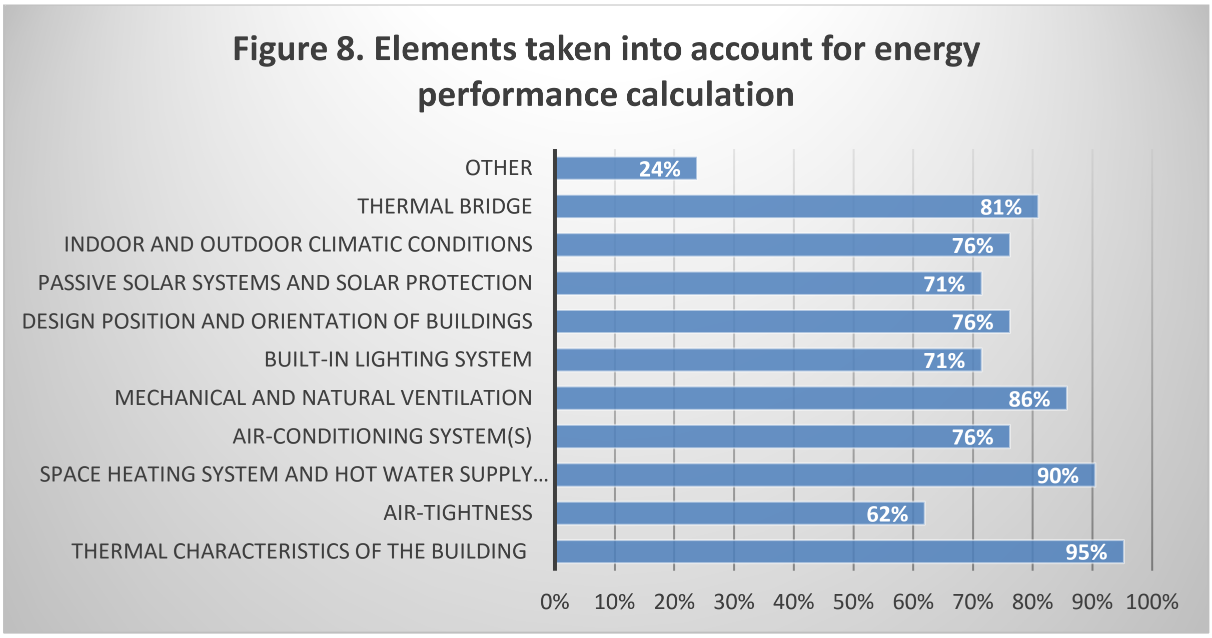
Many building energy efficiency regulations started with requirements for the building shell, and nearly all efficiency regulations for new buildings include requirements for the building envelope. As the building's envelope improves, regulations focus on the energy efficiency of HVAC systems. Finally,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

With the energy performance method, a total requirement for the building is set based on the supply of energy or the resulting environmental impact, for instance in form of CO_2 emissions. This method requires a comprehensive method for calculating the energy performance of a building, with standard values for climate and use of the different types of buildings. Constructors are required to use an advanced computer based model for the calculations, which integrate all the different parts and installations of the building.

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. **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).



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).



<u>Energy performance gap</u>

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[15]. When referring to 'The Performance Gap' we usually compare the results from simplified energy models generated at design stage against operational performance[16].

The results of the survey indicate that only 46 percent of respondents answered questions about energy performance gap. 61 percent responses 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, while 50 percent of responses have confirmed the existence of software used for compliance verification. 68 percent responses 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 a mandatory requirement for the air tightness testing.

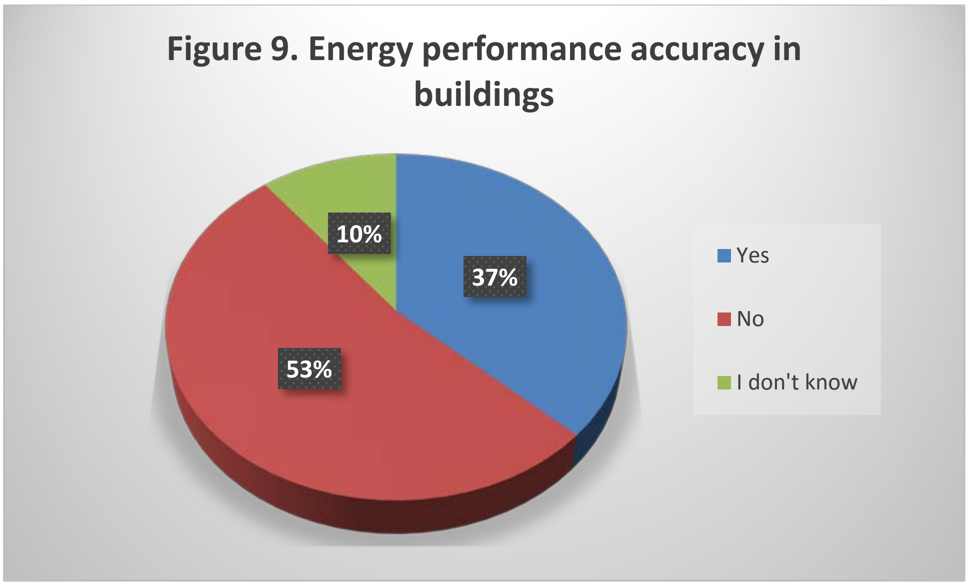
The responses received suggest a significant variation of the mean percentage gap between predicted and actual performance levels. Around 50 percent or respondents didn't know the average percentage gap. Switzerland indicated that this was currently under analysis, with initial findings 30-300 percent measured compared to predicted energy performance in residential buildings. Albania, for example, stated 30-40 percent energy performance gap, Armenia - 60 percent and the former Yugoslav Republic of Macedonia stated that energy performance gap was not currently recorded with only predicted/calculated energy performance being used. In Russia, 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 energy consumption calculated during the design process[17].

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 sufficiently rigorously or designers and builders are failing to satisfactorily deliver the outcome intended[18].

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.

[15] https://pdfs.semanticscholar.org/722e/e437b59aba0a94b193e290a7ed465f045052.pdf
[16] https://www.cibse.org/getmedia/4be5e37f-2821-4d26-b0c3-dd8b183cfffd/hcnwCIBSE_HCNW_presentation_-_Anna_Menezes.pdf.aspx
[17] http://www.europarl.europa.eu/meetdocs/2009_2014/documents/d-ru/dv/dru_20131017_11_/dru_20131017_11_en.pdf
[18] http://bpie.eu/wp-content/uploads/2015/10/HR_EU_B_under_microscope_study.pdf



<u>Prescriptive technical requirements in building energy codes</u>

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 of 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 country’s building energy code and 43 percent of respondents provided their responses to this question. **Fig. 10** below demonstrates that the large majority of the 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.

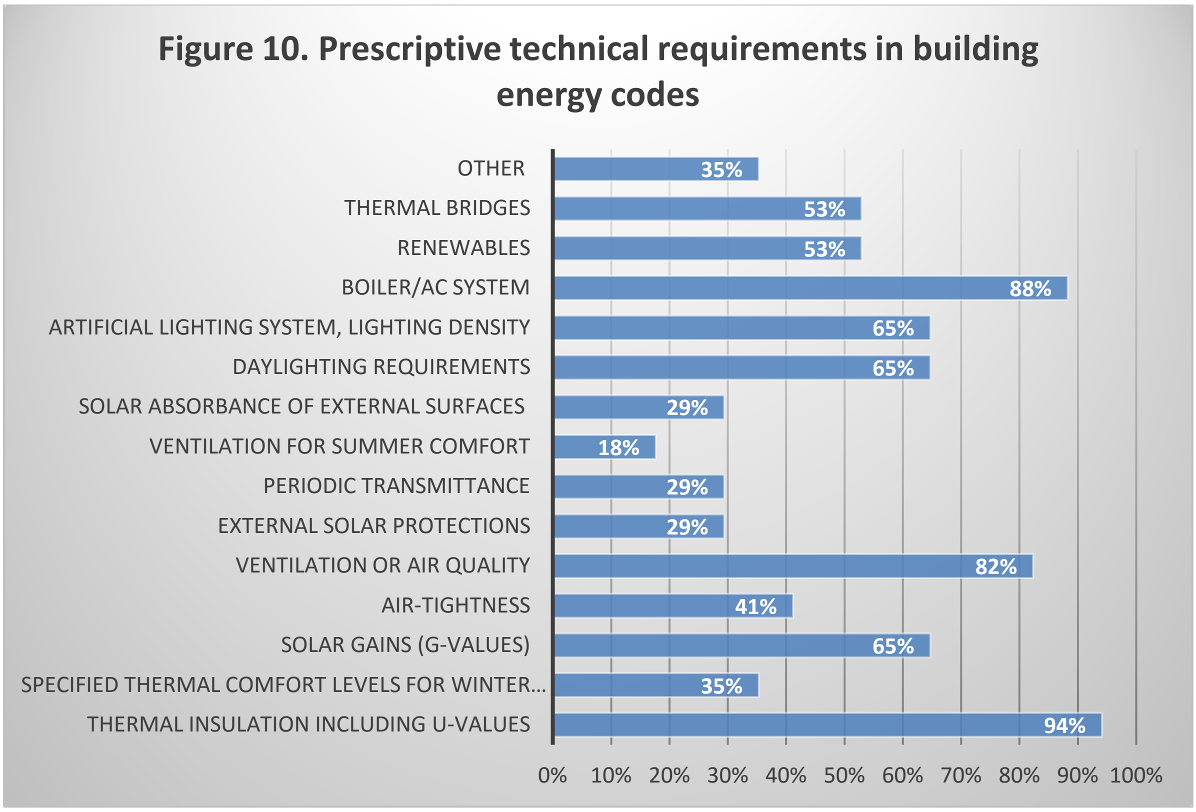
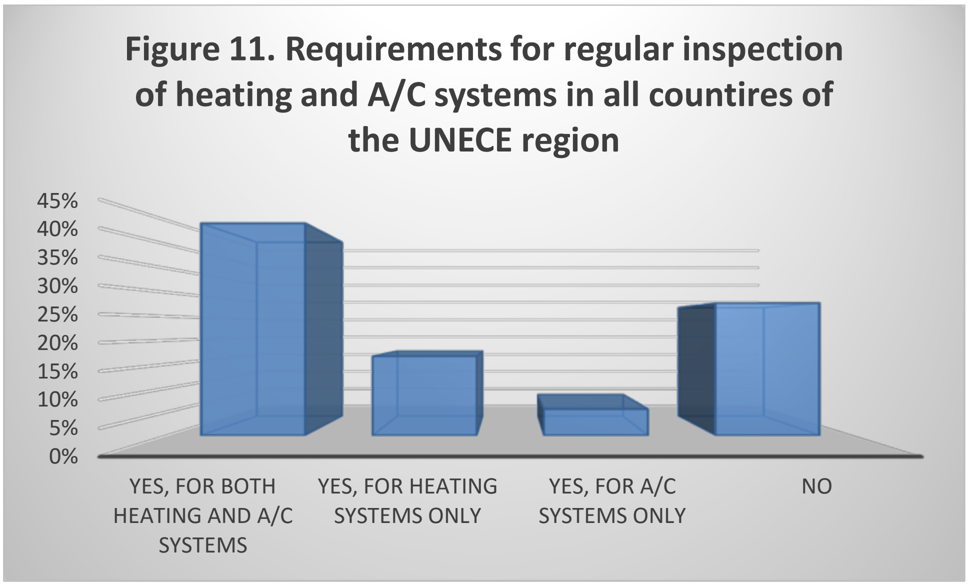
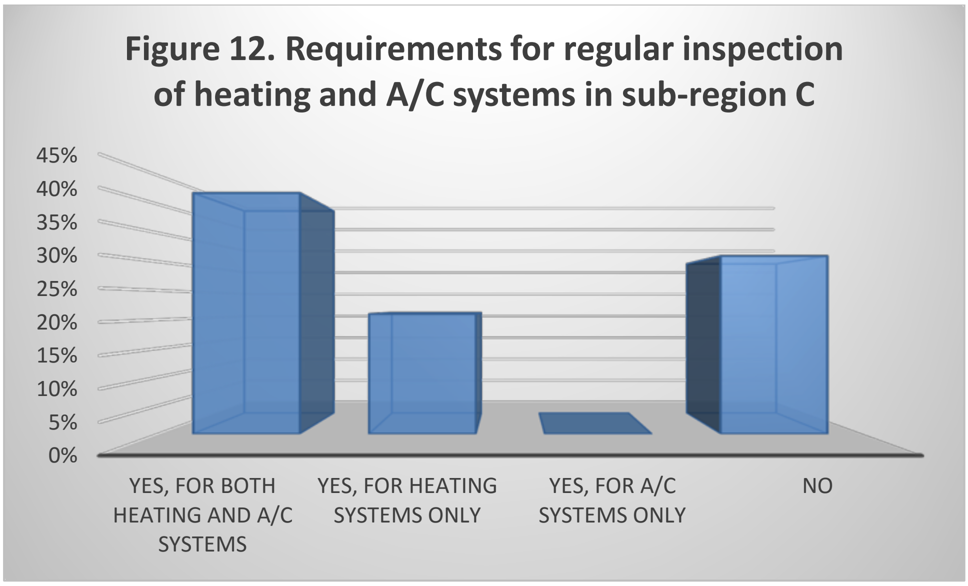


Fig.11 below illustrates the findings across the UNECE region where 44 percent of respondents confirmed the existence of the requirement for regular inspection of heating and A/C systems, while 28 percent stated that such requirement was not included in their country's building energy code. 66 percent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

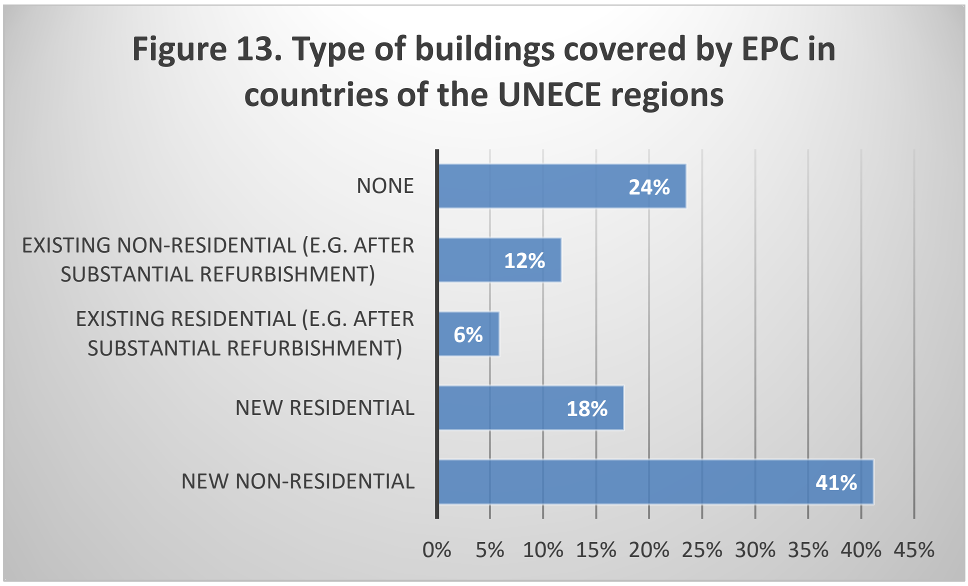


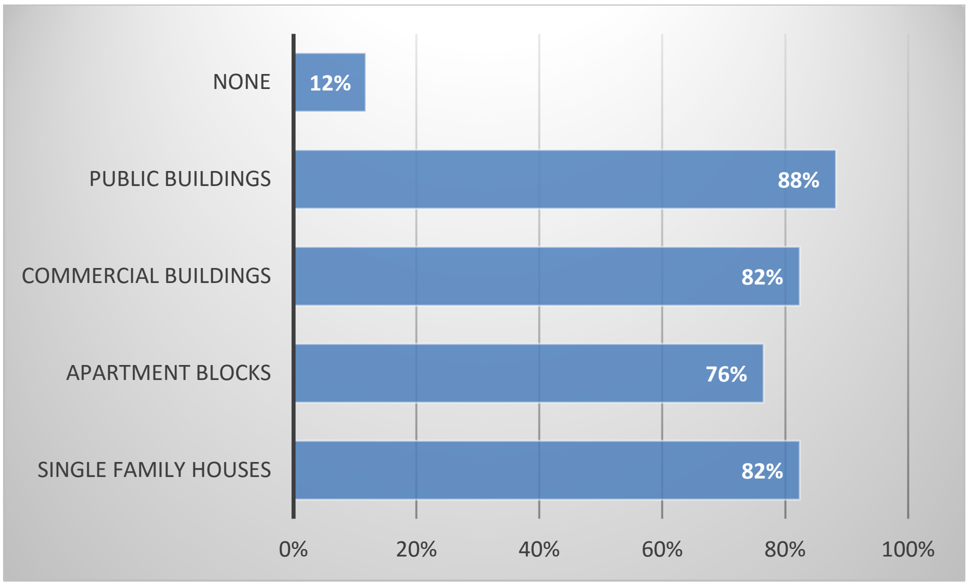
Compared to results for the UNECE region, sub-region C shows slightly different picture. As shown in **Fig.12** below, 42 percent of respondents from sub-region C, a slightly smaller percentage compared to results for the UNECE region, conformed the requirement for a regular inspection of heating and A/C 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.



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

The aim of this part of the questionnaire was to establish the country's coverage and stringency of energy performance certification. **Fig. 13** presents results received with the response rate of 43 percent, showing the coverage of the EPC for different types of buildings. The results suggest that the majority of buildings covered by the EPC are 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 Canada, Macedonia, Armenia, Kazakhstan, Georgia, Albania and Belarus the EPC is not currently used.





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

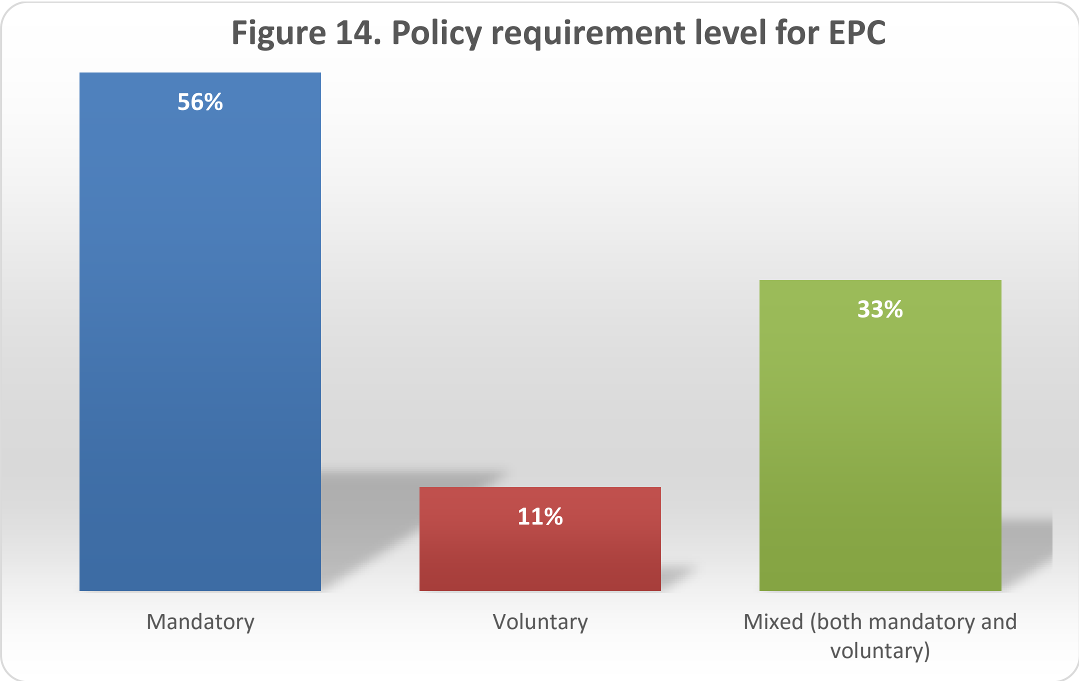
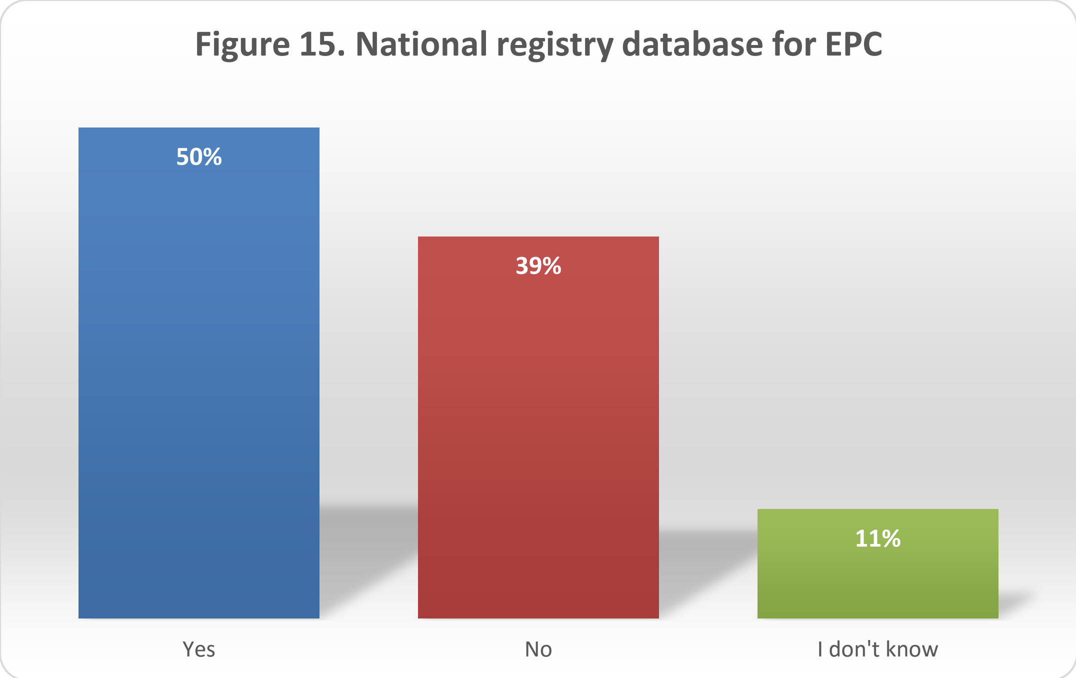
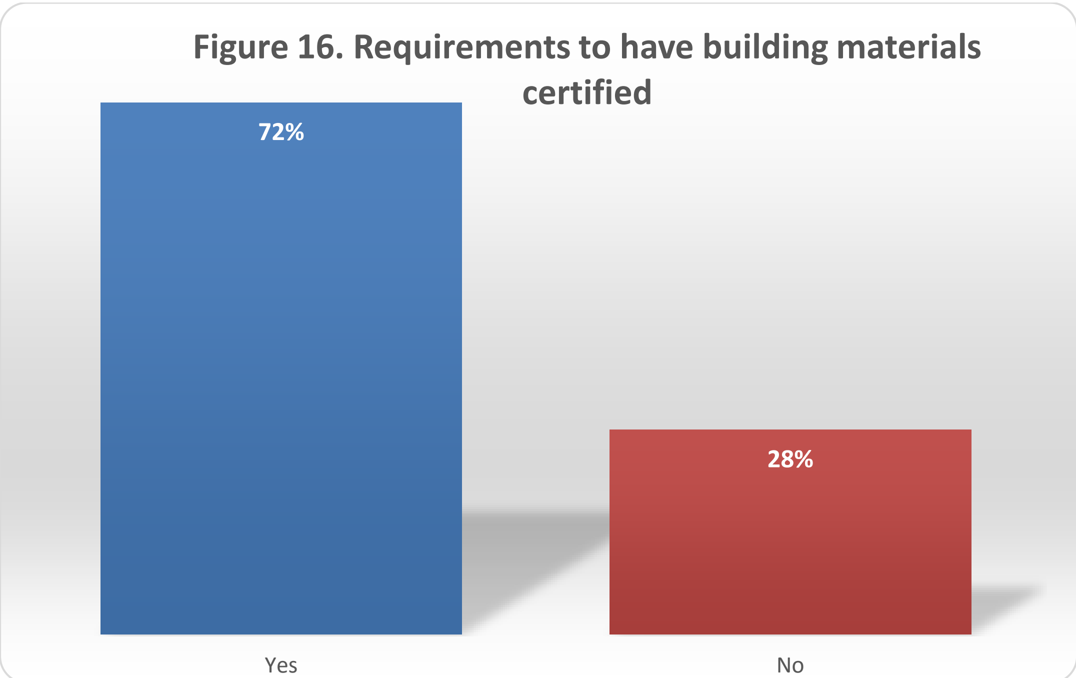


Fig. 15 below illustrates that 50 percent of respondents confirmed the existence of a national registry database for EPC, followed by 39 percent of responses replied “no” and 11 percent did not know. Italy and Spain do not have a national registry database for EPC, although the policy level requirement for EPC is mandatory in both countries.



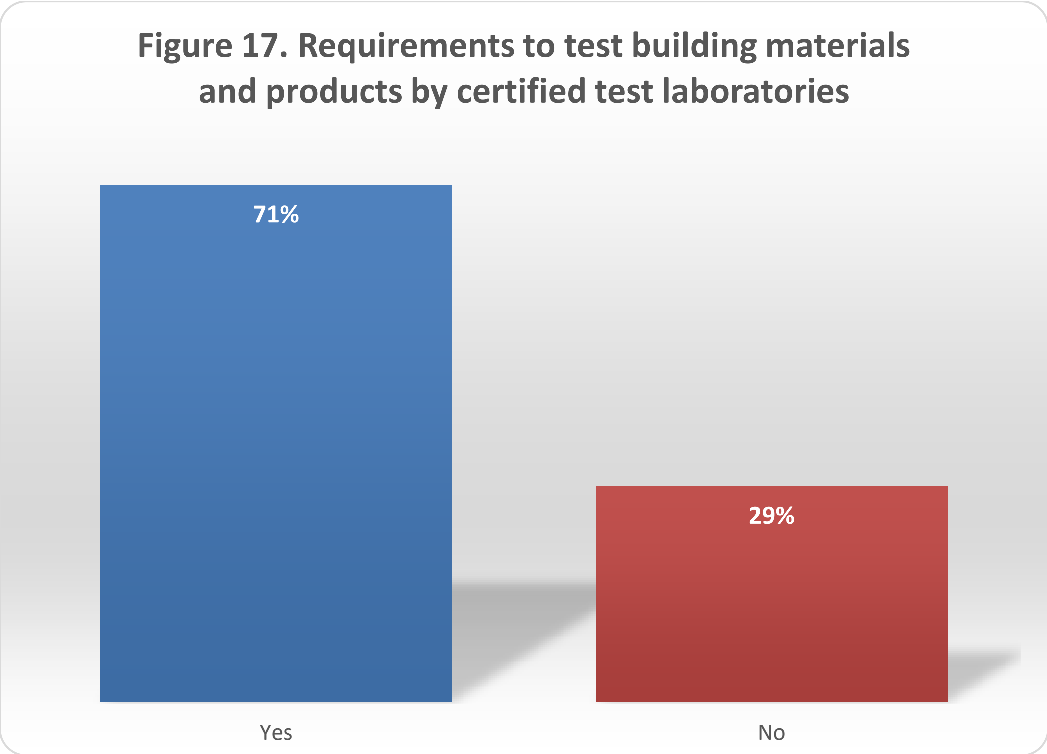
1.4 Part Four – Building Materials and Products

The next set of questions was intended to assess the requirements for building materials and products. Firstly, the respondents were asked whether 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 (see **Fig.16** below).



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).

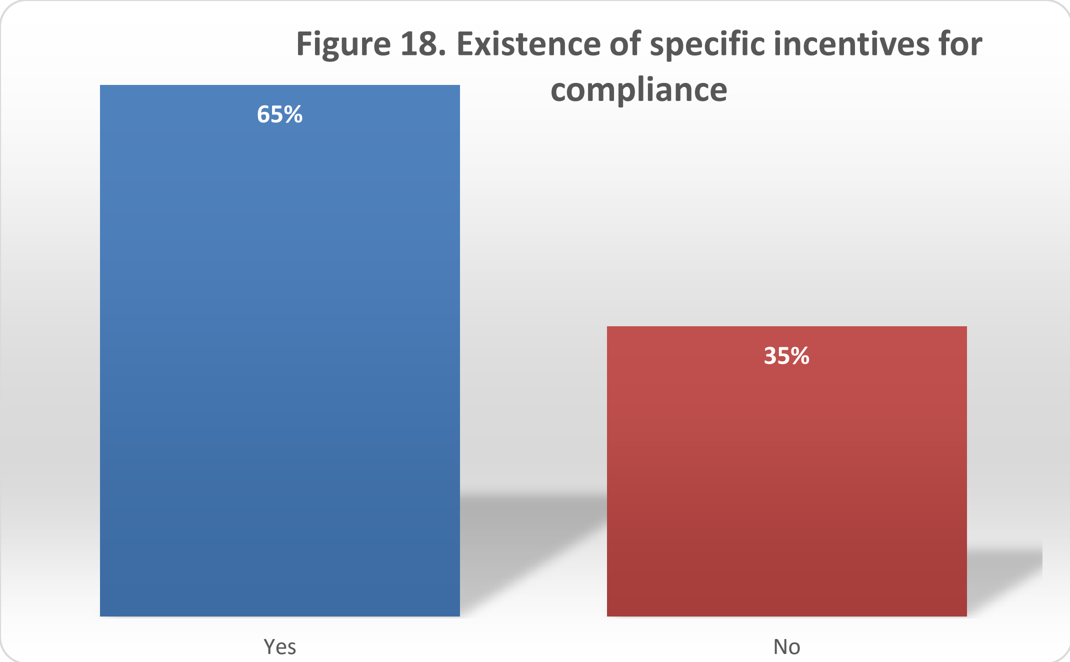
As can be seen in **Fig. 17** below, also the large majority (71 percent) of responses indicated the existence of the requirements to test building materials and products by certified test laboratories.



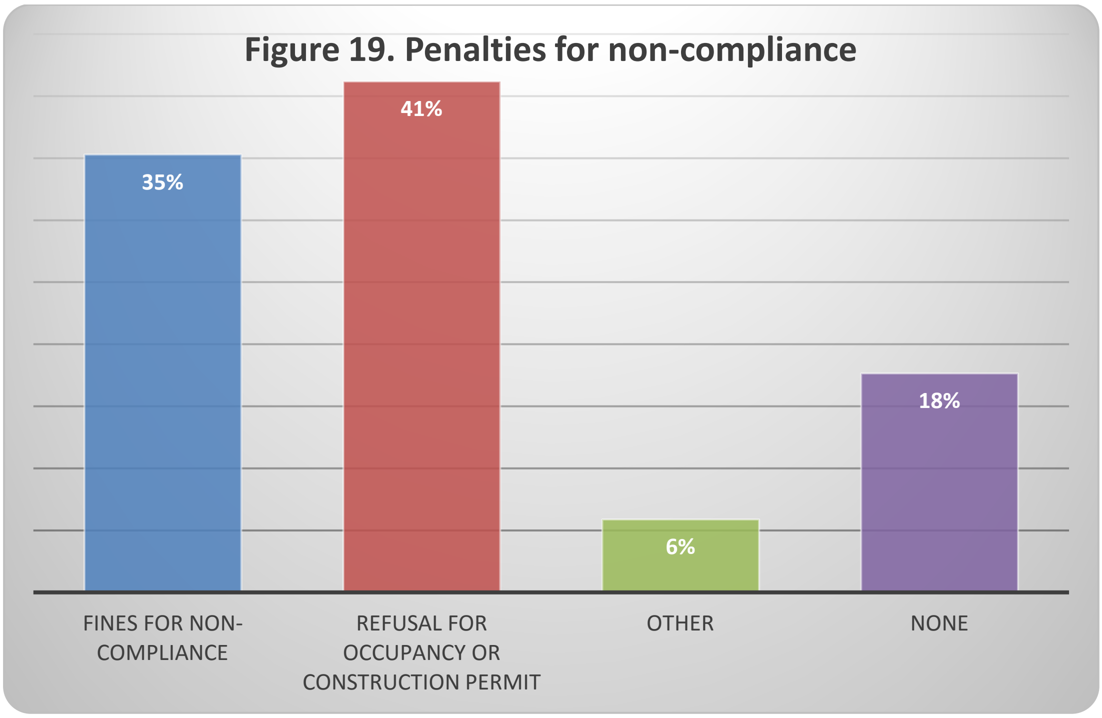
1.5 Part Five – Requirements for enforcement and compliance

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

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 (see **Fig. 18** below). At present, some countries, e.g. Turkmenistan, Montenegro, Ukraine, Kazakhstan, Croatia, Moldova, Azerbaijan, Belarus, Albania, Russia and Serbia, 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), however, the difference is small and incentives do not work sufficiently. In Switzerland, 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. A number of responses indicated that the compliance and enforcement of building energy codes is currently undertaken with less rigour and attention to detail.

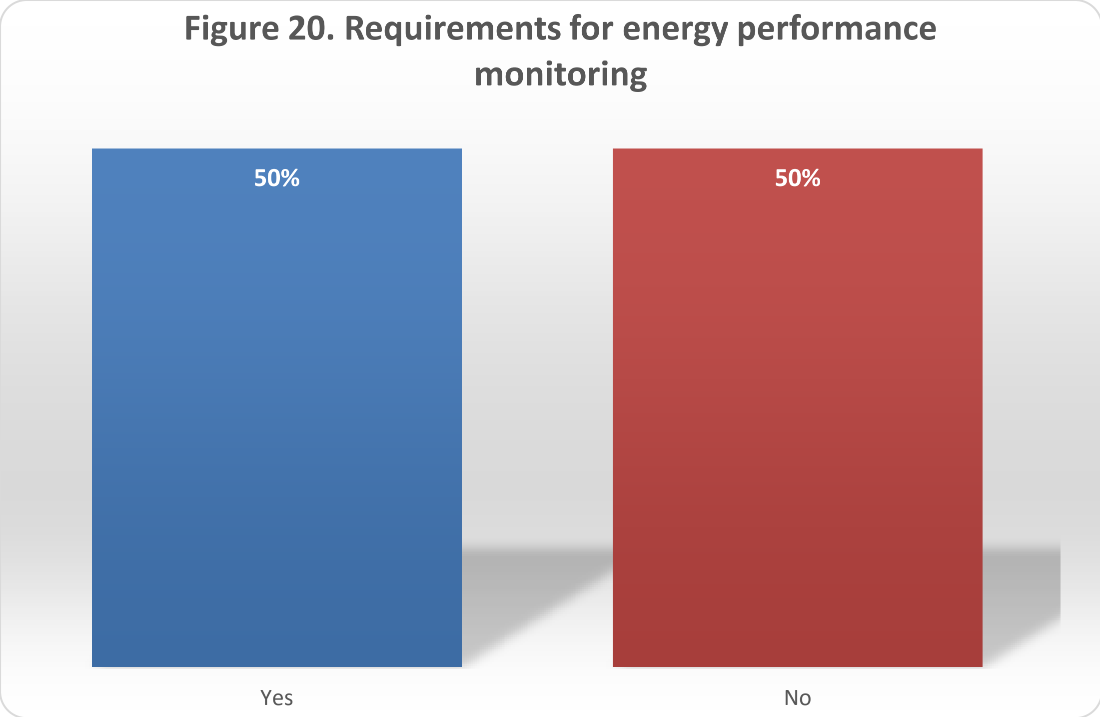


As showed in **Fig. 19**, a large proportion of responses (41 percent) indicated that refusal for occupancy or construction permit was widely used, followed by fines for non-compliance (35 percent). Much smaller proportion of responses (18 percent) stated that penalties for non-compliance were not used.

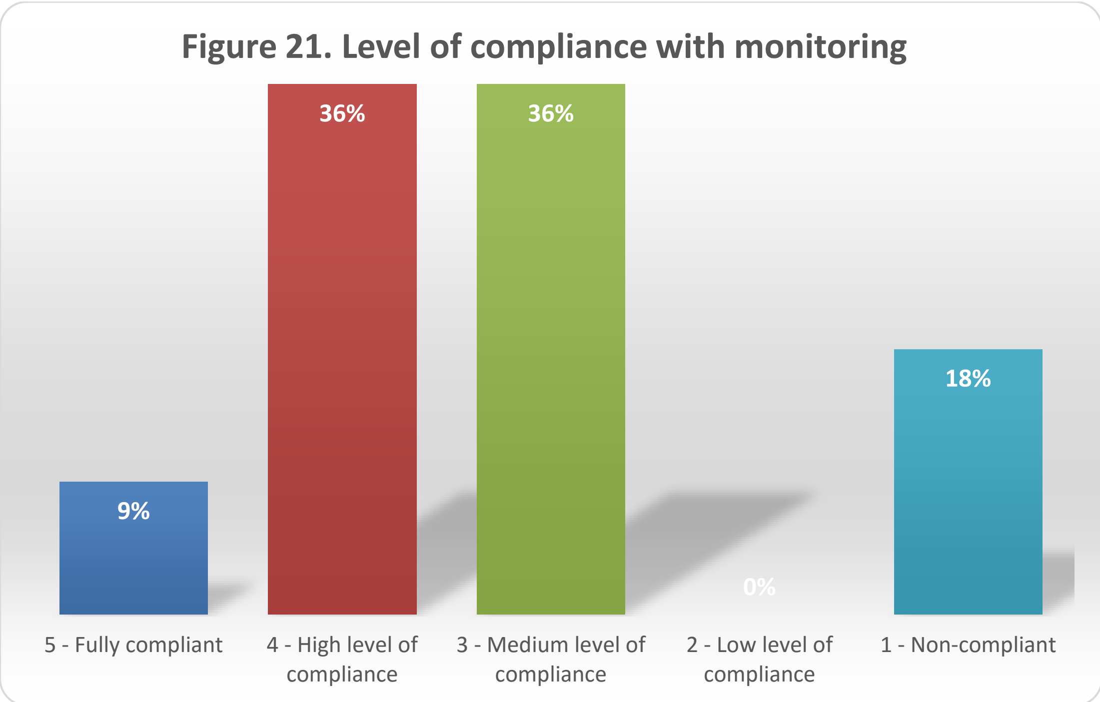


<u>Monitoring of energy performance in building energy codes</u>

According to respondents, the requirements for energy performance monitoring were confirmed by 50 percent of responses, with 45 percent indicating that these requirement for monitoring were mandatory (See **Fig. 20** below).



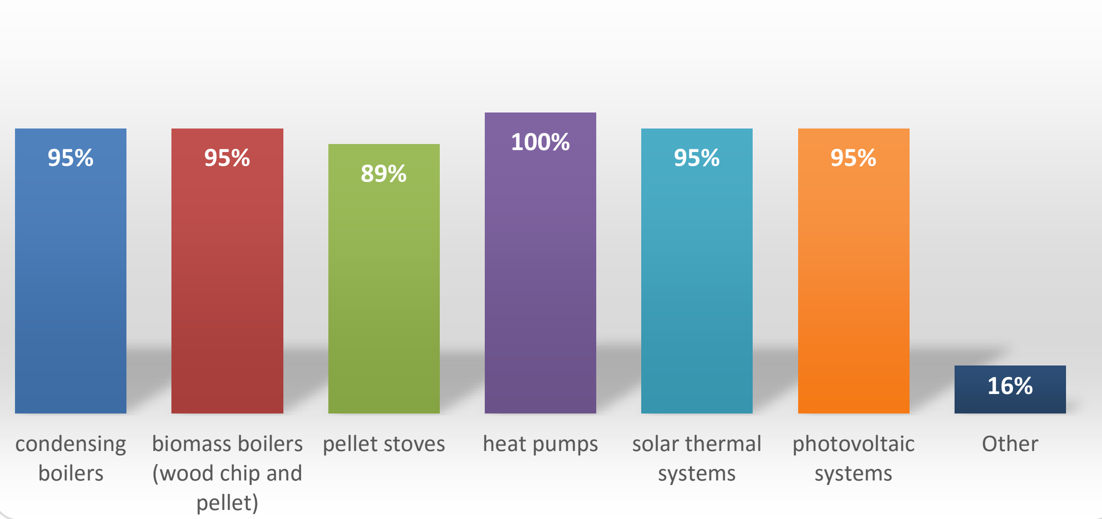
The respondents also were requested to assess (on a scale from 1 (non-compliant) to 5 (fully compliant) the level of compliance with energy performance monitoring contained in building energy codes. As can be seen in **Fig. 21**, only 9 percent of respondents thought that energy performance monitoring 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 monitoring requirements set in country's building energy code.



1.6 Part Six – Energy Efficiency Technologies

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. 22** 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. However, according to the survey results, none of the energy efficiency technologies in **Fig. 22** are currently employed in Turkmenistan.

Figure 22. 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 will be conducted at the later stages of this study and will be reported in **Chapter 3** of this report.

Chapter 2. Analysis of the status of development and implementation of energy efficiency standards in buildings in the UNECE region

The analysis of the status of development and implementation 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 best 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 which only 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 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[19]. Countries can implement codes with various levels of stringency: voluntary codes, mandatory codes, or some mixture depending on the region or state.[20] This stringency metric is a basic reporting of the status of the building codes in a country. For the purpose of this study, we have looked at the 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 0 points for voluntary or no code, giving a total possible point allocation of 1 for stringency. 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[21] and public buildings[22] 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.

[19] https://www.iea.org/publications/freepublications/publication/energy-efficiency-requirements-in-building-codes---policies-for-new-buildings.html
[20] https://aceee.org/files/proceedings/2014/data/papers/3-606.pdf
[21] In the commercial sector, “commercial” means offices, retail and wholesale outlets, hotels, hospitals, and educational buildings, unless otherwise specified.
[22] “Public buildings” means public offices, hospitals, and educational buildings, unless otherwise specified.

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 D 4.3 and 4.2 in sub-region C. 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)						
Portugal	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mandatory	5
Germany	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
Switzerland	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mixed	4.5
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
France	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mandatory	5
Sub-region B - European Union enlargement (EU12)						
Slovakia	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mandatory	5
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
Sub-region C - Russian Federation, South-Eastern Europe, the Caucasus and Central Asia						
Turkmenistan	Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mandatory	4.5
Azerbaijan	Residential; Non-Residential	Residential; Non-Residential	Apartments	Commercial; Public Buildings	Voluntary	3.5

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
Ukraine	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Public Buildings	Mixed	4.0
Moldova	Non-Residential	Residential; Non-Residential	Single Family; Apartments	Public Buildings	Mixed	3.5
Belarus	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mandatory	5
Russian Federation	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Public Buildings	Mixed	4.5
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
Serbia	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mixed	4.5
Montenegro	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mandatory	5
Bosnia and Herzegovina	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mandatory	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	Mandatory	5
Canada	Residential; Non-Residential		Single Family; Apartments	Commercial; Public Buildings	Mixed	3.5

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.[23] 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

[23] For more information, see here: http://www.epbd-ca.eu.

building energy codes, France established complementary categories for efficient buildings and "White Certificate Trading," requiring energy suppliers to meet mandated targets for energy savings through their customers.

California

California has a long 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.[24]

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) and European codes and methodologies. It links building envelope construction and heat loses with established energy limits, taking into account differences in climatic conditions. It also includes a requirement for a building energy passport and an energy efficiency label with energy efficiency classes.[25]

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;

[24] http://www.buildup.eu/en/practices/publications/towards-zero-emission-efficient-and-resilient-buildings-global-status-repor-0
[25] Ibid

- 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. Turkmenistan, Kazakhstan, Macedonia and Serbia). 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 give greater consideration to the renewable energy systems compared to sub-regions C and D. **Table 2** below demonstrates examples for the renewable energy systems requirements in individual countries.

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

Selected countries	Renewables in building energy codes
Norway	Buildings > 500m2 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 < 500m2 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 2000l 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 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.[26]

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.[27] 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, Denmark, France, Estonia, Turkmenistan, Spain, Check Republic, Bosnia and Herzegovina and Poland) have therefore introduced minimum requirements for specific fan power (generally expressed in W/l.s or kW/m³.s.). Non-quantitative requirements also exist in some countries like Latvia and Hungary 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. Italy, Slovakia and Turkmenistan). Some of the requirements are listed in **Table 3.**

Table 3. Examples of the airtightness requirements in country Building Energy Code

Selected countries	Airtightness
Switzerland	Standard infiltration of air = 0.15 m3 /(m2 h)
United Kingdom	10 m3/(h.m2) at 50 Pa
Portugal	Minimum flow rate of 0.6 air changes per hour (ach)
Spain	27 m3/(h.m2) at 100 Pa
Denmark	Dwellings- 1.5 l/(s.m2) at 50 Pa
Sweden	0.61 l/(s.m2) at 50 Pa
Finland	4 m3/(h.m2) at 50 Pa
France	0.60 m3/h.m2 at 4 Pa for single family building; 1 m3/h.m2 at 4 Pa for multi-family building.
Montenegro	The number of changes of the heated air, at the pressure difference between the internal and external space of the building of 50 Pa, must not be greater than n50 = 3.0 h-1 in buildings without mechanical ventilation, and n50 = 1.5 h-1 in buildings with mechanical ventilation.

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

[26] https://www.rehva.eu/publications-and-resources/rehva-journal/2012/032012/energy-performance-requirements-for-buildings-in-europe.html
[27] Ibid

level.[28] 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 UK do not requirements for inspection of boilers in place.

Table 4 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 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 C with average scores of 2.6 and 2.4 respectively.

Whilst there are a small number of countries which are still to implement requirements on heating, cooling, lighting or ventilation, many Member States have now there requirements in place. The most advanced building energy codes or standards for energy efficiency in buildings today include all of 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

Switzerland

Switzerland has adopted a very progressive approach to improving the performance of existing buildings, where the thermal performance of renovated buildings must not exceed 125 percent of the new building limit. A number of Member States have introduced minimum component performance standards when building elements (e.g. windows, doors etc.) or energy using plant (boilers, a/c equipment etc.) are being replaced. Good examples include countries which have a performance-based requirement as well as requirements for any component that is replaced or refurbished.

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.[29]

[28] https://www.rehva.eu/publications-and-resources/rehva-journal/2012/032012/energy-performance-requirements-for-buildings-in-europe.html
[29] https://aceee.org/files/proceedings/2014/data/papers/3-606.pdf

Table 4. 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)													
Portugal	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
Italy	X	X	X	X	X	X	X	-	X	X	X	X	2.8
Switzerland	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
United Kingdom	X	X	X	X	-	X	X	X	X	-	X	X	2.5
France	X	X	X	X	X	X	X	X	X	X	X	X	3.0
Sub-region B - European Union enlargement (EU12)													
Slovakia	X	X	X	X	X	X	X	-	X	X	X	X	2.8
Bulgaria	X	X	X	X	X	X	X	X	X	X	X	X	3.0
Croatia	X	-	X	X	-	X	X	X	X	-	X	X	2.3
Czech Republic	X	X	X	X	X	X	X	X	X	-	X	X	2.8

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 C - Russian Federation, South-Eastern Europe, the Caucasus and Central Asia													
Turkmenistan	X	X	X	X	-	-	X	-	X	-	X	-	1.8
Azerbaijan	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
Kazakhstan	X	X	-	X	-	-	X	X	X	-	X	-	1.8
Armenia	X	X	X	X	X	X	X	X	X	-	X	X	2.8
Ukraine	X	X	X	X	X	X	X	X	X	X	X	X	3.0
Moldova	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

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)**
Russian Federation	X	X	X	X	X	X	X	X	X	-	X	-	2.5
Macedonia	X	X	X	X	X	-	X	X	X	X	X	X	2.8
Albania	X	X	X	X	X	X	X	X	X	X	X	X	3.0
Serbia	X	X	-	-	X	-	X	X	X	-	X	-	1.8
Montenegro	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
Georgia (Not in force yet)	-	-	-	-	-	-	-	-	-	-	-	-	0
Sub-region D - North America													
United States	X	X	X	X	X	X	X	X	X	-	-	-	2.3
Canada	X	X	X	X	X	X	X	X	X	-	X	X	2.8

2.3 Analysis of the comprehensiveness and stringency of the 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.[30]

In order to measure the effectiveness of the EPC we have used similar approach described earlier in this report. The same metrics for stringency and coverage of building types have been selected as well as 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, and 0 points for voluntary or 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 1 point is allotted for coverage for both single- and multifamily housing. For commercial, 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., Italy and 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 5 below 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 5. 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)							
Portugal	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mandatory	Yes	6

[30] 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

Germany	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mixed	Yes	5.5
Italy		Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mandatory	No	3.5
Switzerland	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mixed Voluntary ?	Yes	5.5
Spain	Residential		Single Family; Apartments	Commercial; Public Buildings	Mandatory	No	3.5
United Kingdom	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mandatory	Yes	6
France	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mandatory	Yes	6
Sub-region B - European Union enlargement (EU12)							
Slovakia	Residential; Non-Residential		Single Family; Apartments	Commercial; Public Buildings	Mandatory	Yes	5
Bulgaria	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mixed	Yes	5.5
Croatia			Single Family;	Commercial; Public	Mandatory	Yes	4.0

			Apartments	Buildings			
Czech Republic	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mandatory	Yes	6
Sub-region C - Russian Federation, South-Eastern Europe, the Caucasus and Central Asia							
Turkmenistan	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments		Mandatory	No	4.0
Azerbaijan			Apartments	Commercial; Public Buildings	Mandatory	No	2.5
Uzbekistan	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mandatory	Yes	6.0
Kazakhstan	Currently not in use					No	0
Armenia	Currently not in use				Voluntary	No	0
Ukraine	Currently not in use				Mixed	No	0
Moldova	Non-Residential		Single Family; Apartments	Commercial; Public Buildings	Mixed	No	3.0
Belarus	Currently not in use					No	0
Russian Federation	Residential		Apartments	Commercial; Public Buildings	Mandatory	Yes	4.0
Macedonia (EPC is not functioning at the	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mixed	No	4.5

moment)							
Albania	Non-Residential			Public Buildings	Mandatory	No	2.0
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
Bosnia and Herzegovina	Residential; Non-Residential	Residential; Non-Residential	Single Family; Apartments	Commercial; Public Buildings	Mandatory	Yes	6.0
Georgia	Currently EPC is not in use						0
Sub-region D - North America							
United States (IN SOME STATES)	Residential	Residential	Single Family; Apartments		Mixed		2.5
Canada	Currently EPC is not in use						0

According to the results in **Table 5**, the use of EPC in sub-regions A and B provides much greater coverage and stringency compared to sub-regions C and D, although it is noteworthy that some countries in sub-region C have made progress in developing EPC. It is evident that the average score for this metric differ significantly across sub-regions, with countries for sub-regions A and B taking a leading position with the average score of 4.9, followed by sub-region C 2.8 and 1.3 for sub-region D. Low scoring for sub-region D can be explained by the fact that, at present, Canada does not use EPC, although there are plans to use energy labelling and benchmarking of buildings in the future. Majority 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 compared to European countries. The existence of national registry database for EPC is also more prominent in sub-regions A and B.

Denmark, Sweden, Hungary, Estonia, Lithuania, Slovakia, Portugal and the Netherlands offer access to basic EPC data, such as energy class or energy performance, for any building in the 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.[31]

However, in Spain, for example, there is no centralized analysis of the EPC data by building type. This is because the information that is recorded and then entered into the certification database does not contain data concerning the type of building. The database is currently being expanded to allow for some additional features. From 2015 onwards, it will be possible to begin to register and include more parameters of each certified building. Among these are: type of building, insulation levels, generation systems, energy performance characteristics of systems, etc.[32]

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 for the JTF on Energy Efficiency in Buildings 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 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 is also hindered by a lack of enforcement and monitoring mechanisms which can be observed from the results previously presented in **Table 5** where national registry database for EPC is not deployed consistently across Member States. At present, in some countries, e.g. Kazakhstan, Belarus, Georgia, Armenia, Ukraine and Canada, 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, Construction and Regional Development. Slovakia has had a national database

[31] 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

[32] https://www.epbd-ca.eu/outcomes/2011-2015/CA3-2016-National-SPAIN-web.pdf

since 2010 and has taken significant steps in the direction of developing a functional database 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. 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 the 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. An option to search for EPCs by entering some location characteristics is foreseen on the website. It also provides results for the year of EPC issuance, information about the energy class, building type, its exact address, as well as the name of the qualified assessor.

By the second quarter of 2014, the Slovakian database had about 44,000 certificates, consisting predominately (92 percent) of residential buildings. The whole system seems to be very effectively setup, making use of a very modest annual budget of around 19,200 euros, significantly smaller compared to other Member States. However, the operation of the database, as well as quality checks of the EPCs, are financed by the government and the actual controls are realised by the Ministry of Transport, Construction and Regional Development and by the State Energy Inspection.[33]

Russia

Russia adopted 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.[34]

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

[33] http://www.buildup.eu/sites/default/files/content/BPIE_%20EPC%20across%20the%20EU_2014.pdf
[34] http://www.buildup.eu/en/practices/publications/towards-zero-emission-efficient-and-resilient-buildings-global-status-repor-0

(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.[35]

France

In November 2016, Alliance HQE-GBC launched a voluntary labelling system E+C- (energy plus and low-carbon buildings) in conjunction with the French Government to promote buildings and construction as part of the strategy to meet climate change ambitions. The certified E+C- label covers all energy uses during building operation, including energy consumed by equipment owned by occupants, as well as on-site production of renewable energy and emissions linked to building energy demand (both operational and embodied carbon from construction and buildings equipment). The label also provides results in terms of a life cycle assessment of environmental indicators and also includes GHG emissions due to leaks of refrigerants. The first seven labels were delivered to successful projects in France in July 2017.[36]

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.[37]

Even a well-designed mandatory standard will not save energy if it is not followed. Implementing an energy standard involves a network of social systems and human interactions that stretches from the bureaucrats assigned to administer the standard to the carpenters who apply the weather-stripping.[38] 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. Our report invites further study of 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

[35] http://www.iea.org/W/bookshop/475-Capturing_the_Multiple_Benefits_of_Energy_Efficiency
[36] https://www.globalabc.org/uploads/media/default/0001/01/35860b0b1bb31a8bcf2f6b0acd18841d8d00e1f6.pdf
[37] http://bpie.eu/wp-content/uploads/2015/10/HR_EU_B_under_microscope_study.pdf
[38] http://www.eci.ox.ac.uk/publications/downloads/janda07un.pdf

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:

a. The country has 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, and some countries will even give owners incentives such as relaxed building height and size restrictions;
b. If the building does not comply with the code, then they are refused permission for occupancy or construction; and
c. 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 behaviours. 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.[39]

To reflect the importance of monitoring, two additional metrics has been included in this part of the analysis: the requirements for monitoring and the stringency of monitoring (whether it is 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 max points.

Results

Tables 6 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 and B 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

[39] http://www.modbs.co.uk/news/fullstory.php/aid/16534/How_metering_and_monitoring_boost_energy_efficiency.html

including tax credits. The results for sub-region C present a different picture where specific incentives and enforcement mechanisms are currently not widely used in building energy codes. More information on the status of different incentives to motivate compliance with building energy codes in the UNECE region can be found in the report "Overcoming Barriers to Investing in Energy Efficiency", Geneva 2017.[40]

Table 6. 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)						
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
Spain	-	X	-	X	-	2.0
United Kingdom	X	-	X	X	-	3.0
France	X	X	X	X	-	4.0
Sub-region B - European Union enlargement (EU12)						
Slovakia	X	X	X	X	Mandatory	5.0
Bulgaria	X	X	X	X	-	4.0
Croatia	-	-	X	X	-	2.0
Czech Republic	X	X	X	X	Mandatory	5.0
Sub-region C - Russian Federation, South-Eastern Europe, the Caucasus and Central Asia						
Turkmenistan	-	X	-	-	-	1.0
Azerbaijan	-	-	-	X	-	1.0
Uzbekistan	X	-	X	X	Mandatory	4.0
Kazakhstan	-	-	-	-	-	0

[40] http://www.unece.org/fileadmin/DAM/energy/se/pdfs/geee/pub/Overcoming_barriers-energy_efficiency-FINAL.pdf

Armenia	X	-	-	-	-	1.0
Ukraine	-	-	-	-	-	0
Moldova	-	-	-	X	-	1.0
Belarus	-	-	-	-	-	0
Russian Federation	-	X	-	X	Mandatory	2.0
Macedonia	-	X	-	X	Mandatory	2.0
Albania	-	-	X	X	-	2.0
Serbia	-	X	-	X	Mandatory	3.0
Montenegro	X	X	X	X	Mandatory	5.0
Bosnia and Herzegovina	-	X	-	-	-	1.0
Georgia	X	-	-		-	1.0
Sub-region D - North America						
United States	X	X	X	X	-	4.0
Canada	X	X	X	-	-	3.0

Best Practices

Enforcement

Albania

Albania supports improvement of implementation and enforcement of Building Energy Codes. 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.[41]

Canada

[41] Source: Clean Energy Solutions Center 2015

Canada have 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. 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.[42]

Penalties for non-compliance

Belgium

In Belgium / the Flemish region fines are set for the owners (builders, constructors or installers), who fails compliance. This fine is based on the failure in u-values x the surface area. For example, a one family house with non-compliant glazing was fined €2,500.[43]

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

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.[44]

Incentives

Austria and US

In some countries incentive to fulfil EBC are given through encouragement systems, which support compliance with requirements. There are subsidies, which only be obtained if certain energy efficiency

[42] https://aceee.org/files/proceedings/2014/data/papers/3-606.pdf
[43] https://wec-policies.enerdata.net/Documents/cases-studies/WEC-case-study-Energy-Building-Codes.pdf
[44] Ibid

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.

In different regions of Austria there are subsidies combined with energy efficiency requirements, which are stricter than the minimum requirements in the building codes. This can be additional insulation, improved windows or installation of renewable energy sources such as solar collectors, photo voltage or biomass ovens or boilers. In some Austrian provinces this has lead to nearly all buildings being constructed with an energy efficiency which is better than the requirements in the codes, but as a minimum the requirements are fulfilled. In US tax incentives have been given in the last years to increase the level of insulation and to encourage the constructer and building owners to go further than the minimum requirements. These incentives have probably also helped to increase the compliance with the codes.[45]

France

France is leading the way in supporting measures. They incentivize and reward 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.[46]

Energy performance monitoring

The European Union started testing a new voluntary reporting framework called Level(s) in late 2017. Using existing standards, Level(s) seeks to improve the sustainability of buildings through a common framework of indicators and metrics that can be used to measure the environmental performance of a building. The tool will encourage life cycle planning from the design stage through to building operation and occupation. It will also take into account other aspects related to building energy and environmental performance, ranging from health and comfort to life cycle costs and potential future risks association with a building's performance. The framework has been developed for both existing and new buildings as well as for various types of residential and commercial buildings. It is targeted for professionals that play a critical role in buildings development and management, including design teams, construction firms, property owners and facility managers. Initial testing of the framework is planned for the next two years.[47]

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

[45] https://wec-policies.enerdata.net/Documents/cases-studies/WEC-case-study-Energy-Building-Codes.pdf
[46] Hilke, A.; Ryan, L. Mobilising investment in energy efficiency: Economic instruments for low energy buildings. IEA Energy Pap. 2012, 10, 156.
[47]https://www.globalabc.org/uploads/media/default/0001/01/35860b0b1bb31a8bcf2f6b0acd18841d8d00e1f6.pdf

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.[48] 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 7 below provides a brief overview of how selected countries meeting each criteria 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, with an exception of Italy which, according to the survey responses, does not currently implement requirements for materials and products to be certified, harmonized and does not follow requirements to test building materials by certified test laboratories. Member States of the sub-region C have shown a lower level of 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-region C, e.g. Turkmenistan, Georgia, Ukraine, Moldova, Albania and Macedonia, showed relatively low level of implementation for this metric, while other countries, e.g. Uzbekistan, Kazakhstan, Russia, Armenia, Serbia, Bosnia and Herzegovina and Montenegro exhibited greater level of commitment to implement energy efficiency materials and products in their building energy codes. The results for sub-region D suggest that the status of implementation of energy efficient materials in building energy codes is more advanced compared to sub-region C.

[48] https://www.gfdrr.org/sites/default/files/publication/BRR%20report.pdf

Overall, sub-regions A and B are leading with an average score of 3 (max score), followed by equally distributed average scores of 2 for both sub-region C and D.

Table 7. Building materials and products requirements

Selected countries	Requirements to have building materials certified	Building materials a harmonized with CE Marking or ISO	Requirements to test building materials by certified test laboratories	Points (Max 3)
Sub-region A - European Union (EU15)				
Portugal	X	X	X	3.0
Germany	X	X	-	2.0
Italy	Not in use	-	-	0
Switzerland	X	X	X	3.0
Spain	X	X	X	3.0
United Kingdom	X	X	X	3.0
France	X	X	X	3.0
Sub-region B - European Union enlargement (EU12)				
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 - Russian Federation, South-Eastern Europe, the Caucasus and Central Asia				
Turkmenistan	X	-	-	1.0
Azerbaijan	X	-	X	2.0
Uzbekistan	X	X	X	3.0
Kazakhstan	X	X	X	3.0
Armenia	X	X	X	3.0
Ukraine	X	-	-	1.0
Moldova	-	X	-	1.0
Belarus	X	-	X	2.0

Russian Federation	X	X	X	3.0
Macedonia	-	X	-	1.0
Albania	-	X	-	1.0
Serbia	X	X	X	3.0
Montenegro	X	X	X	3.0
Bosnia and Herzegovina	X	X	X	3.0
Georgia	-	-	-	0
Sub-region D - North America				
United States	X	-	X	2.0
Canada	X	-	X	2.0

Best Practices

Armenia

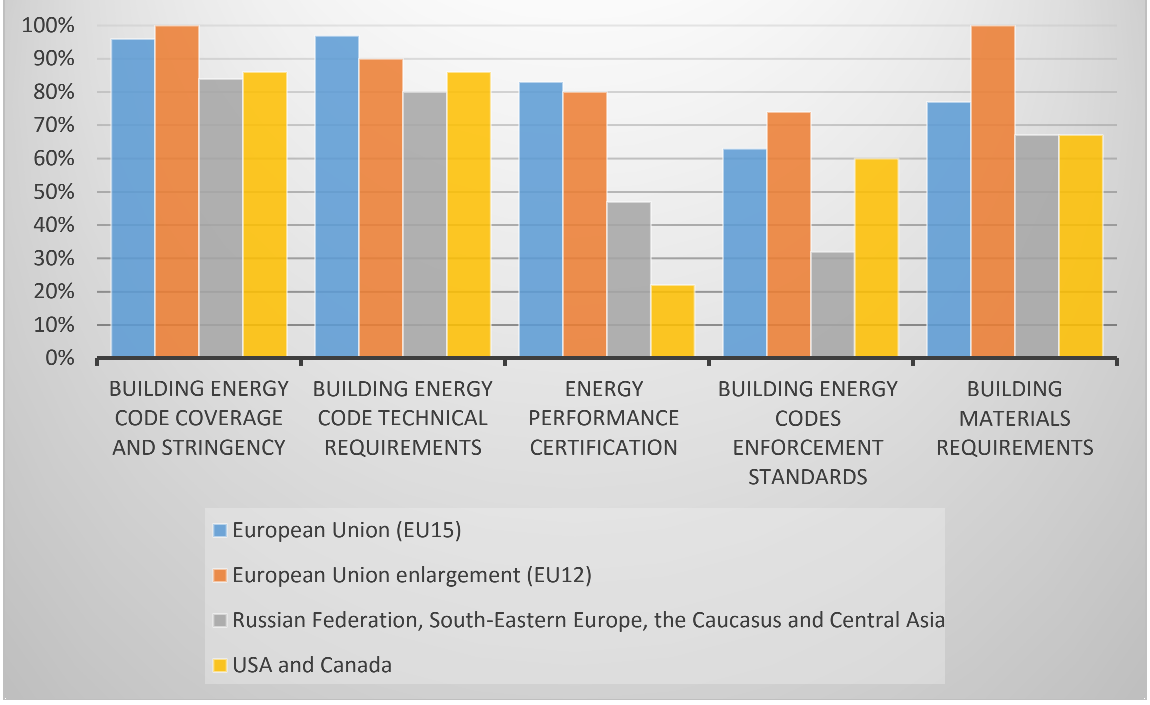
In Armenia, technical regulation on Safety of Buildings and Structures, Materials and Pre-fabricates developed in 2012, was enforced in early 2016. New building code on Thermal Protection of Buildings was developed and adopted in July 2016. 17 EU and ISO standards on energy efficiency developed/adopted and registered. Database of insulation construction materials and lighting equipment produced in and imported to Armenia (with technical parameters) in 2013 and 2016. Advisory Handbook on Technical Solutions in Insulation was adopted by the resolution of the Minister of Urban Development in 2013. In addition, replicable design of energy efficient residential houses full package of design documents for 5 buildings (published on the web-site of the Ministry of Urban Development) is available for free use since 2014. A modern thermal physics laboratory was established for testing and certification of building insulation materials and lighting equipment. More than 13 types of insulation materials were tested and certified since then. An educational energy efficiency laboratory was established for students of architectural-engineering specialties.[49]

Overview of the results of the gap analysis

Fig. 23 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).

[49]https://www.unece.org/fileadmin/DAM/energy/se/pp/eneff/7th_IFESD_Baku_Oct.2016/3GEEE_UNDP.GEF/2_Vahram.Diana_Armenia.pdf

Figure 23. Comparison of the effectiveness of building enegy codes by sub-region



In Europe, Energy Performance of Buildings Directive (EPBD, 2002/91/EC) was a step forward through which sub-regions EU15 and EU12 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. 23** 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.

Chapter 3. Preliminary analysis of the recent trends in the energy efficiency technologies deployment in countries of the UNECE region

This part of the study is currently being prepared.

Chapter 4. Conclusions and recommendations

The information gathered in this report is another step toward fostering cooperation among countries with building energy standards and those contemplating standards or other policies for increasing energy-efficiency in buildings. 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.

Recommendations

Building Energy Codes coverage and stringency

Analysis of the coverage and stringency of building energy codes across 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. The more comprehensive the code, the more types of buildings the code should apply to.

Recommendation 1:

Member States of the UNECE should continue the process of harmonization of building energy codes by ensuring comprehensive coverage of all types of buildings in their regulations.

Recommendation 2:

Member States of the UNECE shall lay down the necessary measures to include a national energy efficiency target, based either on primary or final energy consumption, or on primary or final energy savings, or on energy intensity.

Technical requirements

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. The most advanced building energy codes or standards for energy efficiency in buildings today include all of 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.

Recommendation 3:

Member States of the UNECE to continue the process of harmonization through further strengthening the requirements for insulation, ventilation and technical installations:

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

Energy Performance Certification (EPC)

The results of the gap analysis identified a large disparity between the EPC implementation across Member States, with sub-regions C lagging behind on the use, stringency and coverage as well as quality and monitoring of EPC. A number of responses as well as 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 is also constrained by the lack of enforcement, training and monitoring mechanisms.

Recommendation 4:

Member States of the UNECE to continue introduce quality assurance measures, especially during the early state of the certification process:

- *The requirements for the qualified experts should be harmonised across Member States of the UNECE region;*
- *The certifier needs to be physically present onsite;*
- *There is a need to further harmonize the quality check of the EPC;*
- *Facilitate harmonization of the EPC through integration of ventilation, cooling and lighting into the certificate;*
- *Need for guidance in development of the centralised EPCs databases and digitalisation of the EPC process; and*
- *UNECE to consider to providing further technical assistance and capacity building activities to the countries where the EPC scheme is not yet in use or not fully developed based on the recognized best practice approaches.*

Performance Gap/Monitoring/Compliance/Enforcement/Incentives

The results of the survey pointed to a lack of knowledge, inconsistencies in statistics and a lack of appropriate studies in the field of energy performance gap. This suggests one or more of the following issues: 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 are to deliver the climate and environmental targets related to buildings.

A number of responses suggested that the compliance and enforcement of building energy codes is currently undertaken with less rigor and attention to detail. An appropriate level of enforcement compliance with building energy codes should also be of concern and a point of attention for policy makers as it is necessary to ensure that enough attention to detail is undertaken when applying energy efficiency measures.

According to the results of the gap analysis, specific incentives and enforcement mechanisms are currently not widely used in building energy codes in some countries, particularly in countries in sub-region C.

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. 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 UK do not include requirements for inspection of boilers in place.

Recommendation 5:

Member States of the UNECE should consider making the challenges of the energy performance gap to be a priority area for research.

Recommendation 6:

Member States of the UNECE should continue establishing proper (electronic) monitoring systems of compliance, enforcement and quality control processes through a qualified workforce to ensure compliance with building codes and standards.

Recommendation 7:

Member States of the UNECE shall lay down the necessary measures to establish a regular inspection of boilers and air-conditioning systems in building energy codes.

Recommendation 8:

Member States of the UNECE shall lay down the necessary measures to continuously monitor, analyze and adjust energy usage in building energy codes.

Recommendation 9:

Member States of the UNECE, particularly countries with economies in transition, should consider creating incentives for companies for improving energy efficiency through appropriate policies, tax incentives and low-interest loans for energy efficiency projects.

Building materials and products

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 the others when it comes to materials certification and testing. A number of countries from sub-region C has shown a relatively low level of implementation for this metric.

Recommendation 10:

Member States of the UNECE shall lay down the necessary measures in building energy codes to 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 income countries of the UNECE region, regard should be given to the types of construction that these countries can afford to ensure that building energy codes effectively promote research and development for improving local traditional techniques, materials testing and quality control, and do not create dependency on imported building materials that may stiff local innovation.

Recommendation 11:

Member States of the UNECE shall lay down the necessary measures in building energy codes to 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 resistance test and seismic resistance, ensuring they do not cause threat to the safety of life and property.

Recommendation 12:

Member States of the UNECE should 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.*

Other considerations

Recommendation 13:

a) *UNECE should consider the matter in relevant UN committees on the feasibility of creating and publishing a printed set of national building energy codes for all 56 countries of the UNECE, followed by the release of the Yearbook. All such printed publications are to be distributed in all countries of the UNECE region and beyond;*

b) *Member States of the UNECE, particularly countries with economies in transition, should consider to post free of charge accessible full-featured versions of their building energy codes with the applicable calculation methods on the relevant websites;*

c) *UNECE (GEEE) to consider to set up a new webpage containing free of charge online information with links to the full versions of building energy codes of all Member States of the UNECE, including information on countries' best practices;*

d) *Member States of the UNECE, especially neighbouring countries who have already developed their building energy codes in detail and are at the stage of their practical implementation with real positive effects, to provide methodological assistance and other types of assistance to countries in need of such development; and*

e) *Member States of the UNECE, particularly countries with economies in transition, to 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.*

Opportunities for additional studies

Recommendation 14:

a) *UNECE to consider carrying out further studies on mapping of national approaches 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; and*

b) *UNECE to consider 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.*

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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[50] 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

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

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
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

<u>Prescriptive requirements in building energy codes</u>

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 A/C systems? Please select where applicable:

    a. Yes, for both heating and A/C systems

b. Yes, for heating systems only
c. Yes, for A/C 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 A: Definitions of energy levels and other relevant terms

3.4.13 "*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

3.4.12 "*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

3.4.6 "*delivered energy*" energy, expressed per energy carrier, supplied to the technical building systems through the assessment boundary, to satisfy the uses taken into account or to produce the exported energy

(Note that delivered energy can be calculated for defined energy uses or it can be measured.)

3.4.29 "*primary energy*" energy that has not been subjected to any conversion or transformation process

Note 1 to entry: Primary energy includes non-renewable energy and renewable energy. If both are taken into account it can be called ***total primary energy***.

3.5.17 "*non-renewable primary energy factor*" non-renewable primary energy for a given energy carrier, including the delivered energy and the considered energy overheads of delivery to the points of use, divided by the delivered energy

3.5.21 "*renewable primary energy factor*" renewable primary energy for a given distant or nearby energy carrier, including the delivered energy and the considered energy overheads of delivery to the points of use, divided by the delivered energy

3.5.25 "*total primary energy factor*" sum of renewable and non-renewable primary energy factors for a given energy carrier

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 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]

Derived heat: Derived heat covers the total heat production in heating plants and in combined heat and power plants. It includes the heat used by the auxiliaries of the installation which use hot fluid (space heating, liquid fuel heating, etc.) and losses in the installation/network heat exchanges. For autoproducing entities (= entities generating electricity and/or heat wholly or partially for their own use as an activity which supports their primary activity) the heat used by the undertaking for its own processes is not included. [Eurostat definition]

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 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 performance certificate: a certificate recognised 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.

Net present value: The net present value (NPV) is a standard method for the financial assessment of long-term projects. It measures the excess or shortfall of cash flows, calculated at their present valueat the start of the project.

Payback time: the length of time required to recover the cost of an investment.

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: documents, established by consensus and approved by a recognized body, that provide, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context [ISO].

Third-party financing: a contractual arrangement involving a third party — in addition to the energy supplier and the beneficiary of the energy efficiency improvement measure — that provides the capital for that measure and charges the beneficiary a fee equivalent to a part of the energy savings achieved as a result of the energy efficiency improvement measure. That third party may or may not be an ESCO [ESD, 2006/32/EC].

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. The calculation of U-values can be rather complex - it is measured as the amount of heat lost through a one square meter of the material for every degree difference in temperature either side of the material. It is indicated in units of Watts per meter Squared per Degree Kelvin (W/m2 K) [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: Countries Information Sheets

Attached as a separate document