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The status and needs for implementation of Fire Safety Engineering approach in Europe

Support to policies and standards for sustainable construction

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Contents

Abstract

Fire safety in the built environment remains a major societal issue, despite improvements achieved over the past decades thanks to the continuous adjustments and implementation of fire safety strategies in the European countries. *Fire Safety Engineering* (FSE) deals with the application of engineering methods to the development or assessment of designs in the built environment, through the analysis of specific fire scenarios or through the quantification of risk for a group of fire scenarios.

This report presents the results of an enquiry, organised and coordinated by the European Commission, namely JRC, in the period November 2020-October 2021 addressed to the principal fire regulators of all EU MS, 3 EFTA MS (Iceland, Norway and Switzerland) and 2 countries with National Standardisation Bodies members of European Standardisation Committee CEN (United Kingdom and Serbia). The enquiry was performed through a questionnaire; it aimed to collect and assess the information necessary to facilitate the provision of guidance to the EU/EFTA MS for a wider application of the fire safety engineering approach and its possible incorporation in the national regulatory framework and/or national practices.

It is concluded that the FSE approach is not fully implemented at the current state, even in case of recently issued or updated national regulations. In principle, the need to implement the performance-based approach in the future is widely acknowledged in the countries. Work has to be done to ensure the availability of performance-based methods for fire design, the feasibility of FSE-based fire design, especially for innovative buildings, and the standardisation supporting the definition of design scenarios, design fire and safety criteria.

Foreword

The construction ecosystem is of strategic importance to the European Union (EU), as it delivers the buildings and infrastructures needed by the rest of the economy and society, having a direct impact on the safety of persons and the quality of citizens' life. The construction ecosystem[1] includes activities carried out during the whole lifecycle of buildings and infrastructures, namely the design, construction, maintenance, refurbishment and demolition of buildings and infrastructure. The industrial construction ecosystem employs approximately 24.9 million people in the EU and provides an added value of EUR 1 158 billion (9.6% of the EU total).

The construction ecosystem is a key element for the implementation of the European Single Market and for many other important EU strategies and initiatives. Ensuring more sustainable and climate resilient buildings and infrastructure, i.e., adapting the construction ecosystem to inevitable impacts of the changing climate is one of the central priorities of the European Green Deal (COM(2019) 640)[2]. The European Green Deal aims to achieve climate neutrality for Europe by 2050, and relies on numerous initiatives, noteworthy:

- the **New Circular Economy Action Plan** (COM(2020) 98 final)[3] and the **New Industrial Strategy for Europe** (COM(2020) 102 final)[4] intending to accelerate the transition of the EU industry to a sustainable model based on the principles of circular economy;
- the **Renovation Wave for Europe** (COM(2020) 662 final)[5] addressing the twin challenge of energy efficiency and energy affordability and aiming to double, at least, the annual renovation rates of the building stock (currently around 1%) and launching the **New European Bauhaus** (COM(2021) 573 final)[6] initiative;
- the **review** (COM(2022) 144) [7] of the **Construction Products Regulation** (Regulation (EU) No 305/2011)[8] and the proposal for the **revision of the Energy Performance of Buildings Directive** (COM(2021) 802 final)[9] to ensure that the design of new and renovated buildings at all stages is in line with the needs of the circular economy, and lead to increased digitalisation and climate-proofing of the building stock.
- the **new EU Climate Adaptation Strategy** (COM(2021) 82 final)[10] that sets out how the EU can adapt to the unavoidable impacts of climate change and become climate resilient by 2050. The Strategy has four principle objectives: to make adaptation smarter, swifter and more systemic, and to step up international action on adaptation to climate change.

Recognizing that the EU's ambition towards a climate neutral, resilient and circular economy cannot be delivered without leveraging the European standardisation system, the European Commission presented a new **Standardisation Strategy** (COM(2022) 31 final)[11], to enable global leadership of EU standards in promoting values and a resilient, green and digital Single Market. The Strategy spots standards as "*the silent foundation of the EU Single Market and global competitiveness*", since they are "*invisible but a fundamental part of our daily life*". European standards are embedded in the EU policy objectives and have a key role to achieve a climate-neutral, resilient and circular economy.

The EU has already put in place a number of policy and regulatory instruments for the construction sector, including related European Standards (EN). Within this framework, the Eurocodes are a series of 10 European Standards, EN 1990 to EN 1999, comprising 59 parts and providing common technical rules for the design of buildings and other civil engineering works. They cover in a comprehensive manner the basis of structural design, actions on structures, the design of structures of the principal construction materials such as concrete, steel, composite steel-concrete, timber, masonry and aluminium, and the geotechnical, seismic and structural fire design as well.

[1] https://ec.europa.eu/docsroom/documents/47996
[2] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2019%3A640%3AFIN
[3] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2020%3A98%3AFIN
[4] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0102
[5] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0662
[6] https://europa.eu/new-european-bauhaus/index_en
[7] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52022PC0144
[8] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32011R0305
[9] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021PC0802&qid=1641802763889
[10] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2021:82:FIN
[11] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52022DC0031

Fire safety in the built environment is regulated by the EU Member States but technological developments and the need for improved energy-performing buildings have changed significantly the built environment, bringing a new challenge for the European policy makers and regulators. Following the 2017 Grenfell Tower fire (U.K.), the European Commission launched the **Fire Information Exchange Platform** (FIEP); an initiative that facilitates the cooperation of Member States representatives, fire safety practitioners and stakeholders by exchanging best practices and lessons learnt, sharing data and anticipating needs.

In view of these facts, the Joint Research Centre (JRC) of the European Commission started in 2019 to explore the needs and options for further harmonisation of the Fire Safety Engineering approach and its underpinning education in the EU/EFTA Member States (MS) with direct link to FIEP's scope and activities. The activities are performed in the framework of a series of Administrative Arrangements between JRC and Directorate General (DG) for Internal Market, Industry, Entrepreneurship and SMEs (DG GROW) of the European Commission on support to policies and standards for sustainable construction. Moreover, since 2019, the JRC steers an Expert Network on Fire Safety Engineering aiming at exploring needs, possibilities and feasibility of fire safety engineering approach at European level.

The JRC Technical Report "*The status and needs for implementation of Fire Safety Engineering approach in Europe*" presents the enquiry on the status and implementation needs for fire safety engineering approach in the EU built environment. The enquiry has been conceived by DG GROW and DG JRC to collect, analyse and assess the information necessary to support the work in the context of FIEP and facilitate the provision of guidance to the EU Member States for a wider application of the fire safety engineering approach. The report presents technical analysis on the enquiry intended to stimulate debate and serves as a basis for further work towards the incorporation of fire safety engineering approach in the regulatory framework of the European countries.

The report is available to download from the "Eurocodes: Building the future" website (http://eurocodes.jrc.ec.europa.eu).

We hope that this report will provide a sound and helpful basis for discussions related to the harmonisation and incorporation of the fire safety engineering approach in the regulatory frameworks of the EU Member States.

The editors and authors have sought to present useful and consistent information in this report. However, users of information contained in this report must satisfy themselves of its suitability for the purpose for which they intend to use it.

Ispra, January 2023

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The work presented in the report was developed under the coordination of the Safety and Security of Buildings Unit of the Directorate for Space, Security and Migration of the European Commission's Joint Research Centre with contribution from the JRC Expert Network on Fire Safety Engineering. All members of the Expert Network are listed in Annex A to this report.

The Joint Research Centre would like to express appreciation and acknowledgement to all members of Expert Network on Fire Safety Engineering for the support to the activities since the establishment of the network. The input and reviews received by the network and the fruitful discussions during the working meetings and various exchanges have been essential for the preparation of the report.

The contribution of the fire regulators of the National Authorities of all EU Member States, Norway, Switzerland, Iceland, U.K. and Serbia, who provided answers to the enquiry and information on the implementation and standardisation needs for the fire safety engineering approach is gratefully acknowledged. The analysis presented in this Technical Report was discussed with the Expert Network during the plenary meeting in April 2022. The useful insight provided by Nick Malakatas (CEN TC 250) in interpreting some of the enquiry results is thankfully acknowledged, as well as the contributions by Patrick Van Hees (Lund University, Sweden) and Perrine Ethuin (formerly Modern Building Alliance). The independent review of the report by Georgios Tsionis (JRC) is greatly appreciated. Finally, the authors express gratitude and acknowledgement to Heikki Väänänen (DG GROW) for the consultations and feedback provided throughout the activities and for reviewing the final draft of the report.

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Executive Summary

Fire safety in the built environment remains a major societal issue, despite improvements achieved over the past decades thanks to the continuous adjustments and implementation of fire safety strategies in the European countries. New buildings may incorporate innovative designs that push forward the boundaries of fire safety design practices and question the limits and applicability of conventional *prescriptive* design guidance. *Performance-based* design methods can address entire buildings, consider explicit fire safety objectives and quantifiable criteria and take into account the interaction between building components and its occupants; the necessary assessments are made using *Fire Safety Engineering* (FSE) tools. FSE deals with the application of engineering methods to the development or assessment of designs in the built environment, through the analysis of specific fire scenarios or through the quantification of risk for a group of fire scenarios.

Even though fire safety is a national competence, the European Commission plays an important role with complementary activities to regulatory fire safety at the EU level. Complementary to the EU policies, the Eurocodes address the structural fire design, making possible the application of fire safety engineering approach, but providing still no data to perform advanced modelling.

This report presents the results of an enquiry conceived by DG GROW and JRC to collect, analyse and assess the information necessary to facilitate the provision of guidance to the EU/EFTA MS for a wider application of the fire safety engineering approach and its possible incorporation in the national regulatory framework and/or national practices. Other similar work, i.e., enquiries/surveys undertaken at European and international level targeting the responses from relevant experts in different countries, inspired the present enquiry and are also compared in detail to it.

The enquiry was carried on through a questionnaire – developed by the JRC after consultation with DG GROW and the JRC expert network – focused on the built environment (housing, offices, theatres, shopping malls, hotels, airports, etc., excluding industrial buildings or plants).

Most of the questions are aimed at providing a detailed description on the status of Fire Safety Engineering implementation in each country. Thus, 12 main Technical Areas (TAs) or technical details were selected, to describe the nature and extent of technical detail through the different countries or regions, obtaining a detailed mapping of the level of integration for the FSE approach in fire design regulations of the countries.

32 countries provided responses to the questionnaire, namely the 27 EU MS, 3 EFTA MS (Iceland, Norway and Switzerland) and finally 2 countries with National Standardisation Bodies members of the European Standardisation Committee CEN (United Kingdom and Serbia). Two regions as well (Flanders from Belgium and North Rhine – Westfalia from Germany) sent responses referring to the region, for a total of 34 collected answers. The analysis presented in the report reflects the state of Fire Safety Engineering approach implementation in 2020-2021.

Most of the responders (30 out of 34) declare that FSE approach is allowed for fire design in their countries / regions, motivating this mainly with the possibility of innovation given by FSE both from the point of view of fire safety technology and building space design. The declared non-allowance might be interpreted at least in two cases as the non-application of FSE in practice.

Prescriptive solutions are predominant (i. e. are used in more than half of the technical areas) in 16 out of the 34 responding countries and regions. The prescriptive approach is the only one providing the technical solutions in eight countries and regions, three of which have declared that performance-based methods are not allowed to be used in the current regulatory framework.

However, performance-based solutions are at least available in 22 of 34 countries and regions; in 12 of these, the availability and use of performance-based solutions is 50% or greater. It is noticeable that in nine countries and regions, despite the performance-based regulatory framework, the percentage of effectively available performance-based technical solutions is less than the 50% considering the 12 technical areas.

Different approaches coexist in some countries / regions and within the same TA. Approximately 60% of the countries / regions allow for one method only. The technical area of Structural Fire Safety appears to be the most developed.

The availability of assessment methods for the prediction of fire, smoke, structural response, evacuation etc. across the 12 technical areas largely depends on international standards and national regulations, in all responding countries / regions. Of the 30 countries / regions allowing for FSE, 15 mainly provide one type of calculation method per technical area.

In the 70% of the FSE-allowing countries, the FSE approach can be applied practically to any type of construction; the exceptions very often include residential buildings. Only in 13% the FSE approach is reserved to specific types. FSE application also strongly relates to the lack of code-established solutions for the construction projects exceeding certain limits of size or complexity, or hosting certain activities, or for repair and reconstruction.

In most of the 34 countries / regions, two authorities are required to approve the fire design project, either in a complementary or (less frequently) alternate way. The liability for fire safety design, and its compliance to regulations, shows important differences through the responding countries / regions.

The body performing the regulatory review of fire design projects with FSE approach is generally the competent authority (19 out of 30 cases), possibly supported by other bodies (6 cases), or no review (4 cases).

The required qualifications for FSE reviewers and practitioners are very variable across the 30 FSE-allowing countries / regions, revealing a deep connection to the underpinning educational and training framework. From this point of view, the prevalence of the fire consultant as the specifier of design fires, safety criteria and fire scenarios within FSE approach is also very significant.

It can be concluded that the FSE approach is not fully implemented at the current state, even in case of recently issued or updated national regulations. In principle, the need to implement the performance-based approach in the future is widely acknowledged in the countries. Work has to be done to ensure the availability of performance-based methods for fire design, the feasibility of FSE-based fire design especially for innovative buildings and the standardisation supporting the definition of design scenarios, design fire and safety criteria.

The comparison with other studies (ISO/TC 92, CEN/TC 127/WG 8, Modern Building alliance enquiries) conducted on partially similar country bases, has partly confirmed the results of the present enquiry.

1 Introduction

1.1 Fire safety engineering for the built environment

Fire safety in the built environment remains a major societal issue despite improvements achieved over the past decades thanks to the continuous modifications and implementation of fire safety strategies in the European countries. Fire safety knowledge and engineering expertise has advanced substantially and designers have the opportunity to use sophisticated simulation models providing tools for modelling fire, smoke, evacuation, and structural outcomes. New buildings may incorporate innovative designs that push forward the boundaries of fire safety design practices and question the limits and applicability of conventional prescriptive design guidance.

Traditionally, most designs for the fire safety of structures have been based on prescriptive requirements set by building regulations, building codes and associated standards known also as fire resistance. When approaching fire safety design with prescriptive regulations, the requirements are given in physical terms and fire safety objectives are usually not explicit. The evaluation of fire resistance of construction elements is mainly determined by fire tests that involve:

— a single fire represented by a standard time-temperature curve (such as that given in ISO 834-1[12]); and

— isolated elements or assemblies with defined boundary conditions and sizes.

Performance-based design methods addressing products under standard conditions provide requirements, mainly regarding reaction to fire and fire resistance. Such methods specify explicitly some components of the objectives but rarely consider the possible interaction between products. However, performance-based requirement addressing the entire building consider explicit fire safety objectives and quantifiable criteria, considering the interaction between building components and its occupants.

When approaching fire safety design with a performance-based method addressing the entire building, the necessary assessments are made using Fire Safety Engineering tools. As defined by the International Organisation for Standardisation (ISO/TC92/SC4[13]), "*Fire Safety Engineering (FSE) is the application of engineering principles, rules and expert judgment based on a scientific appreciation of the fire phenomena, of the effects of fire, and of the reaction and behaviour of people, in order to: (a) save life, protect property and preserve the environment and heritage; (b) quantify the hazards and risks of fire and its effects; (c) evaluate analytically the optimum protective and preventative measures necessary to limit, within prescribed levels, the consequences of fire*"[14].

Thus, fire safety engineering deals with the application of engineering methods to the development or assessment of designs in the built environment through the analysis of specific fire scenarios or through the quantification of risk for a group of fire scenarios. Fire safety engineering can be considered under several headings, including (Caird 1998):

- "The process of fire safety engineering, which is about measurements and relationships, backed by scientific study, for engineering applications to the required problems, but where experience and judgment can contribute, as in other engineering disciplines".
- "The context of fire safety engineering, which is the need to evaluate fire hazard and risk, and to offer fire safety strategies and designs based on performance not prescription".
- "The tools supporting fire safety engineering, which are the calculation methods (also called models), that describe the measurements, relationships and interactions".
- "The inputs, which are the physical data for the calculation methods, derived from measurement methods (test etc.)".

The framework of fire safety engineering basically comprises the foundation, and, in addition, the transfer of knowledge, which permits an engineering approach.

Such an engineering approach when used in fire safety design practices may offer many benefits, including:

- the provisions for better and more reliable fire safety in the built environment;

[12] ISO 834-1:1999 Fire-resistance tests — Elements of building construction — Part 1: General requirements
[13] ISO Technical Committee 92 "Fire Safety" Sub-committee 4 "Fire Safety Engineering"
[14] ISO 13943:2017 (E) Fire safety – Vocabulary

- potential cost-effective fire safety measures, and more options with regard to the choice of these measures;
- a better communication with other professionals involved in the design, construction process and approval process;
- innovative solutions not allowed by traditional prescriptive regulations.

1.2 Why the enquiry on FSE implementation status and standardisation needs

The European Commission has acknowledged the importance of cooperation and information sharing related to fire safety for the built environment and established the Fire Information Exchange Platform (FIEP)[15] in 2017. The scope for FIEP is to enhance cooperation among the EU Member States, as well as to facilitate the exchange of knowledge, information and best practices, and cross-learning from fire safety activities. Five priority areas of work have been identified within FIEP, namely:

- statistics,
- fire prevention,
- innovation in products and applications including high-rise buildings,
- experience from fire accidents, and
- fire safety engineering.

Appreciating and acknowledging the advances in fire safety engineering and the opportunities that fire safety engineering may bring to cope with the societal challenges, and also inspired by the success of the development and implementation of the common European standards for structural design – the EN Eurocodes[16], the Joint Research Centre (JRC) of the European Commission in the framework of Administrative Arrangements with the European Commission's Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs (DG GROW) is exploring the needs and options for further harmonisation of the fire safety engineering approach in EU/EFTA Member States.

JRC's work on fire safety engineering aims at assessing the status and implementation needs for incorporation of fire safety engineering approach in the regulatory framework of the EU Member States (MS). Moreover, the activity will also contribute to the definition of needs for guidance and training of professionals about fire engineering approach, to be explored and discussed with relevant stakeholders.

The enquiry presented in this document on the status and implementation needs for the fire safety engineering approach in the EU built environment has been conceived by JRC and DG GROW to collect, analyse and assess the information necessary to support the work in the context of FIEP and facilitate the provision of guidance to the EU/EFTA MS for a wider application of the fire safety engineering approach and its possible incorporation in the national regulatory framework and/or national practices.

The data presented in this report were provided by the principal fire regulators in all 27 EU MS, and additionally Iceland, Norway, Switzerland, U.K., and Serbia. Some inconsistencies in the answers were clarified on the grounds of responder's optional comments (if they were provided) or interpreted case-by-case based on logical assumptions. However, the European Commission accepts no responsibility or liability whatsoever regarding the data provided by the responders to the enquiry and that are presented and analysed in this report.

1.3 Organisation of the report

Chapter 1 of the report introduces the concept of fire safety engineering in the built environment and justifies the need for the enquiry on the implementation status and standardisation needs for fire safety engineering.

Chapter 2 discusses the context of the activities and the work, within the European policies related to the construction sector. It also provides a short discussion on related standardisation activities in Europe and internationally while commenting on some previous related studies on fire safety engineering.

[15] https://firesafeeurope.eu/fiep/

[16] The EN Eurocodes are a series of 10 European Standards, EN 1990 - EN 1999, providing a common approach for the design of buildings and other civil engineering works and construction products, https://eurocodes.jrc.ec.europa.eu/

Chapter 3 describes the scope and methodology of the enquiry on the status and implementation needs for fire safety engineering approach. It provides also useful terminology related to the concepts of fire safety engineering.

Chapter 4 follows with the detailed presentation and analysis of all data, responses and views collected through the enquiry. The analysis focuses on the following topics: allowance or not for the application of fire safety engineering in the regulatory frameworks, the technical areas and types of construction in which fire safety engineering is applied, the process for the FSE design approval and qualification framework. Topics related to education, training and research needs are also discussed in the chapter.

Chapter 5 summarises the main conclusions from the enquiry and provides recommendations for further work.

The members of the JRC Expert Network on Fire Safety Engineering are listed in Annex A. Annex B provides the questionnaire replied by the fire regulators and Annex C is a summary of the regulations currently in place for buildings' fire design in the responding the countries, as provided in the enquiry.

2 Background and policy context

2.1 EU policy background

Under the subsidiarity principle, fire safety of buildings is regulated at EU Member States' level due to the significant differences in local conditions and traditions between different Member States (MSs). In the area of fire safety, the EU regulates mainly through the **Construction Products Regulation** (Regulation (EU) No 305/2011)[17] which outlines harmonised rules for the marketing of construction products in the EU. The regulation provides a European framework to assess the performance of construction products. Out of the seven basic work requirements, from which essential characteristics are established, one addresses fire safety. Thus, fire safety for buildings is addressed through relevant harmonised technical specifications (harmonised standards and European Assessment Documents) which may address the product behaviour when exposed to fire (e.g., reaction to fire).

Even though fire safety is a national competence, the European Commission plays an important role with complementary activities to regulatory fire safety at the EU level. The most prominent of those in the construction sector was the establishment of the **Fire Information Exchange Platform** (FIEP) in 2017, created by the Commission with support from the Estonian Council Presidency. The scope for FIEP is to enhance cooperation among Member States, as well as to facilitate the exchange of knowledge, information and best practices, and cross-learning from fire safety activities. FIEP targets for a broad participation both from regulatory and non-regulatory perspectives and supports an open discussion about the success stories as well as challenges encountered. Five priority areas of work have been identified within FIEP´s scope: statistics, fire prevention, innovation in products and applications including high-rise buildings, experience from fire accidents and fire safety engineering.

The construction ecosystem is a key element for the implementation of the **European Single Market** and for many other important EU strategies and initiatives. Ensuring more sustainable and climate resilient buildings and infrastructure are central priorities of the **European Green Deal** (COM (2019) 640)[18]. In this framework, fire safety in the built environment is embedded in several EU initiatives and plans for action related to the construction ecosystem. The **Renovation Wave for Europe** (COM (2020) 662 final) initiated by the European Commission to reach the objectives of climate neutrality for Europe by 2050 set by the **European Green Deal** (COM (2019) 640) will massively boost the renovation of the EU building stock. The Renovation Wave addresses the twin challenge of energy efficiency and energy affordability, aiming to double, at least, the annual renovation rates of the building stock (currently around 1%). Deep renovations in the buildings for energy performance purposes are a prime opportunity to address aspects related to fire safety.

The Commission proposal for revision of the **Energy Performance of Buildings Directive** (COM (2021) 802 final)[19] also brings attention to fire safety in the built environment. Article 7 on New Buildings requests Member States to address fire and seismic safety. Article 8 on Existing Buildings requests Member States to address fire and seismic safety in relation to buildings undergoing major renovations. Annex II, referred to in Article 3, suggests as optional indicator in the National Building Renovation Plans, the overview of policies and measures regarding the increase of fire safety. Thus, for new buildings Member States shall address important dimensions going beyond energy performance, including fire safety.

In support of the European Green Deal and the Renovation Wave, the review (COM(2022) 144)[20] of the Construction Products Regulation (Regulation (EU) No 305/2011)[21] and the proposal for the revision of the Energy Performance of Buildings Directive (COM(2021) 802 final)[22] ensure that the design of new and renovated buildings at all stages is in line with the needs of the circular economy, and lead to increased digitalisation and climate-proofing of the building stock.

[17] Regulation (EU) No 305/2011 of the European Parliament and of the Council (the 'Construction Products Regulation' or CPR) lays down harmonised conditions for the marketing of construction products. The Commission's proposal for a revised Construction Products Regulation (CPR) was adopted on 30 March 2022 (COM(2022) 144 final).

[18] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2019%3A640%3AFIN

[19] COM (2021) 802 final 15.12.2021

[20] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52022PC0144

[21] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32011R0305

[22] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021PC0802&qid=1641802763889

Moreover, the joint report on the proposed EU regulation creating a **Social Climate Fund** (SCF)[23] includes several references to fire safety measures accompanying energy-related building renovations. These measures have been included into the definition of "building renovation" to be supported by the Social Climate Fund[24].

In addition, the European Commission adopted its new EU strategy on adaptation to climate change COM (2021) 82 final)[25] on 24 February 2021. The new **EU Climate Adaptation Strategy** sets out how the EU can adapt to the unavoidable impacts of climate change and become climate resilient by 2050. The Strategy has four principle objectives: to make adaptation smarter, swifter and more systemic, and to step up international action on adaptation to climate change.

Numerous other EU initiatives support the European Green Deal, ensuring more sustainable and climate resilient buildings, including the **New Circular Economy Action Plan** (COM(2020)98 final)[26] and the **New Industrial Strategy for Europe** (COM(2020) 102 final)[27] intending to accelerate the transition of the EU industry to a sustainable model based on the principles of circular economy. Moreover, the **New European Bauhaus i**nitiative (COM (2021) 573 final)[28] brings a holistic approach to the design of the built environment and any aspect related to fire safety should not be overlooked.

The **scenarios for a transition pathway for a greener, more digital and resilient construction** (SWD (2021) 419)[29] provide a vision on the needs for faster recovery from the pandemic and increasing the resilience of the construction industrial ecosystem. The construction ecosystem is called to decarbonise its activities and protect them - against the unavoidable impacts of climate change but also from natural and human-made disasters (floods, heatwaves, fires, earthquakes, landslides). Among the priority actions is the enhancement of safety, sustainability and climate resilience in the built environment in the context of the upgrade of the European standards for the design of structures (the EN Eurocodes) and other relevant building standards.

Further, the recent EU plan for major investment in infrastructure development around the world – the **Global Gateway** (JOIN (2021) 30 final)[30], put focus on physical infrastructure (such as fibre optic cables, clean transport corridors, clean power transmission line) with mobilization of investments of up to €300 billion between 2021 and 2027. The guiding principles point to smart, clean and secure investments in quality infrastructure while connecting goods, people and services around the world in a sustainable way.

Complementary to the EU policies in support of improvements in the construction ecosystem, European standards are fundamental for reaching objectives such as the Green Deal, Digital Strategy and New Industrial Strategy and have indeed played a leading role in creating the EU Single Market. Standards can drive innovation, competitiveness, sustainability and consumer protection and they are an indispensable tool for raising product safety and environmental performance.

Recognizing that the EU's ambition towards a climate neutral, resilient and circular economy cannot be delivered without leveraging the European standardisation system, the European Commission presented a **new Standardisation Strategy** (COM(2022) 31 final)[31], to enable global leadership of EU standards in promoting values and a resilient, green and digital Single Market. The Strategy spots standards as "*the silent foundation of the EU Single Market and global competitiveness*", since they are "*invisible but a fundamental part of our daily life*". European standards are embedded in the EU policy objectives and have a key role in achieving a climate-neutral, resilient and circular economy.

The Strategy notes that standards are an important instrument to regulate the construction sector, describing five key set of actions:

- Anticipate, prioritise and address standardisation needs in strategic areas;
- Improve the governance and integrity of the European standardisation system;

[23] The proposed EU regulation creating a Social Climate Fund (SCF) was adopted by the European Commission on 14 July 2021 as part of the 'fit for 55' legislative package, which is part of the European Green Deal. The Fund should provide funding to Member States to support measures and investments in increased energy efficiency of buildings, decarbonisation of heating and cooling of buildings, including the integration of energy from renewable sources, and granting improved access to zero and low-emission mobility and transport.

[24] in the EPBD, some amendments were tabled to ensure One-stop-shops will provide technical assistance for holistic building renovation. Fire safety is one of consideration to be addressed- See AM 88 https://www.europeanfiresafetyalliance.org/wp-content/uploads/2022/04/ITRE-PR-703281_EN.pdf

[25] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2021:82:FIN

[26] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2020%3A98%3AFIN

[27] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0102

[28] https://europa.eu/new-european-bauhaus/index_en

[29] Scenarios for a transition pathway for a greener, more digital and resilient construction ecosystem - SWD (2021) 419, 14.12.2021

[30] The Global Gateway – JOIN(2021) 30 final, 1.12.2021

[31] The EU Strategy on Standardisation – COM (2022) 31 final, 02.02.2022, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52022DC0031

- Enhance European leadership in global standards; standards for cybersecurity or the resilience of critical infrastructure carry a strategic dimension;
- Support innovation;
- Enable the next generation of standardisation experts.

The EU has already put in place a comprehensive legislative and regulatory framework for the construction sector, including related European Standards (EN). Within this framework, the Eurocodes are a series of 10 European Standards, EN 1990 to EN 1999, comprising 59 parts and providing common technical rules for the design of buildings and other civil engineering works. They cover in a comprehensive manner the basis of structural design, actions on structures, the design of structures of the principal construction materials such as concrete, steel, composite steel-concrete, timber, masonry and aluminium, and the geotechnical, seismic and structural fire design as well.

The Eurocodes contain specific parts – the "fire parts" – dealing with the fire resistance of structures. The application of fire safety engineering approach is possible in the general framework of the Eurocodes. In particular, EN 1991-1-2 Annex E "Fire Load Densities" introduces the fire safety engineering approach, which is based on design fire scenarios. It establishes links between active and passive fire protection measures and determines a procedure for the calculation of the design fire load density to be used in natural fire models.

Within JRC's past activities in support of the EN Eurocodes, JRC coordinated a working group and published a report in 2008 (EUR 23523 EN)[32] on the needs to achieve improved fire protection in Europe, which analyses the national regulatory environments for application of the fire design parts of the Eurocodes and identifies research needs for improved fire design in Europe. The latter served as a basis for conception of the Commission Mandate M/515[33] to CEN on the second generation of the Eurocodes as regards the development of the fire design parts of the standards.

In the frame of its activities on promoting the use of the Eurocodes, JRC has long experience in facilitating the exchange of best practices and supporting the Eurocodes implementation. In 2012, JRC organized a European training event on structural fire design with emphasis on worked examples. As a follow-up of this event, JRC published a manual on structural fire design with the Eurocodes (EUR 26698 EN)[34].

In view of these facts, the Joint Research Centre (JRC) of the European Commission started in 2019 to explore the needs and options for further harmonisation of the fire safety engineering approach and its underpinning education in the EU/EFTA MS with direct link to FIEP's scope and activities. The activities are performed in the framework of a series of Administrative Arrangements between JRC and Directorate General (DG) for Internal Market, Industry, Entrepreneurship and SMEs (DG GROW) of the European Commission on support to policies and standards for sustainable construction.

JRC's work on fire safety engineering encompasses the following tasks:

- Assessing the status and implementation needs for the incorporation of fire safety engineering approach in the regulatory framework of the EU MS.
- Providing definition of needs for guidance and training of professionals about fire engineering approach, to be explored and discussed with relevant stakeholders.

In support of the work on fire safety engineering, the JRC steers an Expert Network on Fire Safety Engineering aiming at exploring needs, possibilities and feasibility of using the fire safety engineering approach at European level and supporting the exchange of information on standardisation work and research findings.

2.2 Related standardisation activities

Several international standardisation committees have links to fire safety engineering. Some of the most relevant committees are highlighted below, noting the list is not exhaustive:

- ISO/Technical Committee 92 "Fire Safety" and in particular its SC4 "Fire Safety Engineering",

[32] Kruppa J, Sedlacek G, Heinemeyer C, Dimova S, Pinto Vieira A, Oztas A. Needs to Achieve Improved Fire Protection as regards the Implementation and Development of the EN Eurocodes. EUR 23523 EN. Luxembourg (Luxembourg): OPOCE; 2008. JRC47512.

[33] M/515 Mandate for amending existing Eurocodes and extending the scope of structural Eurocodes, https://ec.europa.eu/growth/tools-databases/mandates/index.cfm?fuseaction=search.detail&id=523

[34] Vassart O, Zhao B, Cajot L, Robert F, Meyer U, Frangi A, authors Poljansek M, Kamenarova B, Raposo De M. Do N. E S. De Soto Mayor M, Dimova S, Pinto Vieira A, editors. Eurocodes: Background and applications. STRUCTURAL FIRE DESIGN. Worked examples. EUR 26698. Luxembourg (Luxembourg): Publications Office of the European Union; 2014. JRC90239

— ISO/ Technical Committee 21 “Equipment for Fire Protection and Fire Fighting”,

— ISO/ Technical Committee 61 “Plastics”,

— International Maritime Organisation, Sub-Committee "Fire Protection"

— IEC/ Technical Committee 20 "Electrical Cables",

— IEC/ Technical Committee 89 "Fire Hazard Testing"

— TC 65/SC7 "Off-shore structures",

— TC 59/SC15 "Single family dwelling",

— TC 136 “Furniture”,

— TC 8 “Ships and Marine Technology”

Among these, the work by ISO/TC92 “Fire Safety”[35] and in particular its Sub-committee SC4 “Fire Safety Engineering” (ISO/ TC92/ SC4) is of relevance. More than 30 standards have been published by the technical committee before 2022, including Fire Safety Engineering General Principles (ISO 23932-1)[36], Verification & Validation of codes (ISO 16730-1)[37], Fire Risk Assessment (ISO 16732-1)[38] and examples of performance of structures. The most important fields of activities for the Sub-committee include the performance of structures in fire, design fires, fire evacuation experiments, application examples of general principles, verification and validation of models and requirement for algebraic equations. Moreover, a technical report[39] was published in 2021 with the summary of the results of a questionnaire survey, which was conducted to gather information on the current state of performance-based fire safety design practices in various countries worldwide. Even the other Sub-committees in ISO/TC92 work with specific items of Fire Safety Engineering, e.g., Sub-committee 1 related to input data for fire safety engineering related to fire growth, Sub-committee 2 with respect to fire resistance and Sub-committee 3 with respect to effect of fire effluents on humans.

There are also European Standardisation Committees whose work is strongly linked to Fire Safety Engineering, namely:

— CEN/TC 127 "Fire safety in buildings"

— CEN/TC 250 "Structural Eurocodes" – Horizontal Group (HG) Fire

— CEN/TC 191 "Fixed firefighting systems"

Of particular interest is the work of CEN/TC127 and its Working Group (WG) 8 “Fire Safety Engineering”. The working group experts are developing European Guidelines for a performance-based design code. The work on the code is currently a Preliminary Work Item and thus the expected timeline for publication is after 2024. This guidance document does not deal with methods but provides guidance on how to apply the performance-based design approach within the regulatory framework of each country and provides links to the prescriptive codes.

CEN/TC250 HG “Fire” looks into the Eurocodes fire parts. The Eurocodes fire parts provide only the check for the resistance of the structures and the application of Fire Safety Engineering is possible in the general framework of the Eurocodes. However, the Eurocodes do not allow to deal in all cases with natural fires. Some parts are only given for the conventional curve ISO 834 and no properties are available to perform advanced modelling. In the coming second generation of the Eurocodes, no significant modification in the organisation of the fire parts is expected.

2.3 Previous related studies

The features of similar work, i.e., enquiries/surveys undertaken at European and international level targeting the responses from relevant experts in different countries are briefly outlined in this section. The results of these enquiries are analysed in detail in Chapter 4 of this report, at the relevant occurrences.

[35] https://www.iso.org/committee/50492.html
[36] ISO 23932-1:2018 “Fire safety engineering — General principles — Part 1: General”;
[37] ISO 16730-1:2015 “Fire safety engineering — Procedures and requirements for verification and validation of calculation methods — Part 1: General”;
[38] ISO 16732-1:2012 “Fire safety engineering — Fire risk assessment — Part 1: General”;
[39] “Fire safety engineering — Survey of performance-based fire safety design practices in different countries”

2.3.1 The BeneFEU programme – the CEN/TC 127/ WG 8 survey

On May 2001, the Benefeu[40] project started with a consortium managed by Warrington Fire Research (UK) composed on CTICM (now Effectis France), DIFT, IST, RUG and TNO (now Effectis Nederland). The program was financed by the European Commission (EC contract EDT/01/503480). The activity aimed to identify the potential benefit of applying the Fire Safety Engineering approach in the European Union and among the tasks was to conduct a survey to the EU MS to assess the regulations and FSE use at national level.

The outcomes of the BeneFEU programme (2001-2002) were published in July 2002 (Deakin, Cooper et al., 2002) and updated by the CEN/TC 127/WG 8 in 2017-18 (Joyeux, 2018). The two reports mirror the European scenarios in 2001 and 2016.

Task A of the BeneFEU programme aimed to provide information about the current regulatory practice and any planned changes in Europe (EU and EFTA MS) related to fire safety and an analysis of the state-of-the-art in fire safety engineering. 18 countries – Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the U.K. – provided a reply to the questionnaire. In the cited document, the results presented allow appreciating the responses of the single countries.

The BeneFEU questionnaire consisted of 27 questions and was circulated to the principal national fire regulator, any additional national fire regulators, and a fire safety practitioner in each addressed country. The overall summary of each national position was prepared from the different responders' replies, after discussion with BeneFEU consortium, and agreed with the relevant fire regulator.

The questionnaire identified 5 technical areas, called subsystems, which are usually present in building design, on which the nature and level of the technical detail was evaluated. All these technical areas have been considered by the enquiry developed by JRC and DG GROW presented in this report.

The replies provided useful information about the legislative framework of each country, especially the possible interaction between national/local systems, as well as about the approval authorities. In 2001, the dominant prescriptive systems were oriented to accept FSE approach to some extent for special cases or derogations, or to allow for it as an alternative within some years. The survey also showcased the need for promoting a more homogeneous level of engineering education, as well as for continuous professional development, within the FSE aspects.

In 2016, the CEN/TC127/WG 8 (created in 2014 with the aim of pre-standardisation and standardisation) revised the BeneFEU questionnaire to: (i) include the EU MS at the year of 2016, and (ii) identify the work performed in the previous 15 years in the countries originally contacted in 2001. After the re-launch of the survey, 8 of the 13 countries which had entered the EU between 2001 and 2016 provided response to the questionnaire (Latvia, Lithuania, Slovakia, Estonia, Croatia, Poland, Bulgaria and Romania). Out the previous 18 responders, 16 countries updated the questionnaire, of which 11 had changed their fire regulations during the 15 years from the first survey.

The update of the survey led to the following observations:

- Countries are adapting regularly their regulation;
- FSE approach and concepts have been included in many countries;
- Enforcement is available in Europe;
- The subsystem "Fire Intervention" has been modified - there is need of research to be included in FSE;
- Initial training is now available in Europe.

The overall conclusions of the enquiry[41] stated that, despite the changes in regulations during the previous 15 years, the situation of FSE use and implementation status had not fundamentally changed. Generally, single steps were made to assist the use of FSE with some modifications, either in regulations and their enforcement, or in education. On the other hand, the educational support for professionals in the FSE field had significantly increased between 2001 and 2016, meaning that the number of FSE practitioners and FSE activity should increase. The countries contacted in 2016 for the first time confirmed that the implementation of performance-based fire-related codes was not accomplished, however this was planned in the near future. The same

[40] Benefeu: The Benefits of Fire Safety Engineering within the European Union

[41] CEN/TR 17524:2020(MAIN), Fire safety engineering in Europe - Review of national requirements and application

countries showed a lack of FSE education, particularly for authorities, but also the development of initial training (at post-graduate university level).

2.3.2 The ISO/TC 92 survey

In 2019, ISO/TC92/SC4 presented the results of the survey on the performance-based fire safety design practices in different countries. This survey covered eight EU MS – Austria, France, Germany, Hungary, Netherlands, A technical report containing the aggregated results, as well as the detailed answers given by each country was published in 2021 (ISO/TR 20413:2021).

The ISO questionnaire aimed at gathering information of the performance-based fire safety design practices; the 17 questions of the ISO survey have almost all been addressed as topics in the enquiry performed by the JRC and DG GROW. The responders were architects, fire safety engineers, building officials etc., selected by the ISO mirror committee of each country / region. Nine FSE-related technical areas are identified in the survey, all of which have been considered by the JRC and DG GROW enquiry.

The conclusions of this survey showed that the global trend to transition from prescriptive to performance-based regulations for fire design is driven by the emergence of various non-traditional buildings (e.g. super-high rise buildings, multi-purpose large-scale facilities, etc.) and innovative spaces, which cannot comply with traditional prescriptive rules. However, the current knowledge and understanding of FSE of both practitioners and regulators, as well as available education for them, is not enough to promote an effective and smooth reception of the performance-based fire design approach. The design fires and design fire scenarios, which are key factors in the performance-based fire safety design, are determined mostly by expert judgement, and very rarely by procedures explicitly defined in the regulations and/or codes.

2.3.3 The MBA architects survey

In 2020, the Modern Building Alliance (MBA[42]) promoted a survey targeted at architects from 8 countries (Belgium, France, Germany, Italy, Netherlands, Poland, Spain and U.K.). The survey aimed at discovering how fire safety competencies are considered during the building design phase. 835 responses were collected from architects working in offices composed of at least two architects, mainly focused on residential buildings and engaged both in new building and renovation project. The results were presented in a report published in 2020 (de Hults, 2019). The report[43] allows appreciating the breakdown of results per single country. The results are analysed assuming that the involvement of dedicated fire experts in construction projects is indicative of the consideration paid to fire safety.

The MBA questionnaire consisted of five questions about the involvement of specific experts during the design, the reasons to involve / not involve them, and the responsibility of the fire safety of the buildings designed by the responders. The conclusions point out that fire experts are less involved than structural engineers and energy experts, and more considred than sustainability experts. According to the results' analysis, the involvement of fire experts should be increased particularly in housing renovations. National differences are significant especially about the extent of architects' and other parties' responsibility of fire safety.

[42] https://www.modernbuildingalliance.eu/

[43] https://www.modernbuildingalliance.eu/assets/uploads/2020/11/ArchitectsSurvey_on_Fire_Safety_Competency.pdf

3 Scope and methodology of the Fire Safety Engineering enquiry by JRC

3.1 Background

The enquiry to assess the status and implementation needs of fire safety engineering in Europe was organized and coordinated by the European Commission, namely JRC, in the period November 2020-October 2021.

The objectives of the enquiry are:

— Understand the differences and similarities in the application of FSE across Europe.

— Identify the challenges in FSE application and its underpinning education.

— Assess the standardisation needs in support of a wider harmonisation in the application of FSE approach in Europe.

— Collect and analyse examples of best practice.

The enquiry aims to support JRC's work towards a proposal for the harmonisation of FSE application on European level, defining the needs for guidance and training of professionals, promote the acceptance and/or incorporation of the approach in the national regulatory frameworks and facilitate an increased awareness of the status across Europe. The evaluation of the responses should identify and shed light on possibilities for harmonisation on European level. Thus, the enquiry establishes the basis for future activities, at European level, on fire safety engineering and performance-based fire safety standards and policies in relation to construction works and products.

3.2 The structure of the questionnaire

The enquiry was performed with a questionnaire[44] developed by the JRC after consultation with DG GROW and the JRC expert network (see also Section 2.1). The questionnaire was inspired by previous work carried on by ISO/TC92 and CEN/TC127 (see Section 2.3 for details).

The focus of the questionnaire is on the built environment (housing, offices, theatres, shopping malls, hotels, airports, etc.;) and it does not deal with industrial buildings or plants. The questions were developed targeting replies from relevant regulatory authorities

The questionnaire is divided into six parts; **Annex B** reports all the questions in full.

— Part 1: Responder's general information [question 1]

— Part 2: General information on the existing fire regulation(s) at national level [questions 2 to 4]

— Part 3: Allowance of Fire Safety Engineering approach (yes/no) [question 5]

— Part 4: [if yes to question 5] Status of implementation of Fire Safety Engineering approach [questions 6 to 17] / [if no question 5] Reasons for not applying Fire Safety Engineering approach [question 18]

— Part 5: Fire Safety Engineering training, education and research [question 19 to 23]

— Part 6: Comments and recommendations [question 24]

The questionnaire was launched in November 2020 with the invitation for a reply sent first to the contact points of DG GROW Advisory Group Sub-Group Fire; other fire regulators were contacted with the help of the JRC Expert Network on Fire Safety Engineering when necessary. Principal national fire regulators were contacted in all EU/EFTA MS and additionally in the U.K. and Serbia, being countries whose national standardisation bodies are full members of the European Standardisation Committee (CEN).

The questions in Part 4 of the questionnaire aimed at providing a detail description on the status of Fire Safety Engineering implementation in each country. Thus, 12 main Technical Areas (TAs) or technical details were selected, in general agreement with the technical areas already used in the previous surveys by ISO, BeneFEU and CEN/TC127/WG8 but providing more details. The 12 TAs are listed in Table 1, which also provides the abbreviations to be used in the following chapters of the report.

[44] The questionnaire was available through the EU Survey platform, https://ec.europa.eu/eusurvey/runner/FSE-Survey-EU-MS-2020.

The TAs selected are used to describe the nature and extent of technical detail through the different countries or regions, obtaining a detailed mapping of the level of integration for the FSE approach in fire design regulations of the countries.

Table 1. The 12 Technical Areas (TAs) referred in the JRC enquiry on the FSE implementation status.

Definition	**Abbreviation**
Fire detection	FireDete
Early suppression / suppression systems	EarlySup
Evacuation routes	EvacRout
Smoke control systems	SmokCoSy
Structural fire safety	StructFS
Fire compartmentation	FireComp
Smoke compartmentation	SmokComp
Prevention of fire spread to neighbouring buildings	PrFiSpre
Material / system selection for façades	MaSelFaç
Material / system selection for all other relevant areas (e. g. interior finishing, cables, internal insulation, furniture, etc.)	MaSelOth
Firefighting (fire brigade access and intervention)	FireFigh
Building installations (e. g. electricity, gas, lifts)	BuilInst

3.3 Responses to the enquiry

A map with the countries which replied to the Fire Safety Engineering enquiry is presented in Figure 1. Fire experts from 32 countries provided responses to the enquiry, namely: the 27 EU Member States, 3 EFTA Member States (Iceland, Norway and Switzerland) and 2 countries with National Standardisation Bodies members of CEN (Serbia and United Kingdom).

In total, 36 replies were obtained from the 32 replying countries, of which:

— two countries provided one reply for the country and one for a specific region; these are Belgium providing an additional reply for the Flanders region (*BE2*), and Germany with an additional reply referring to the North Rhine-Westphalia region (*DEA*)[45].

— two countries (France and Luxemburg) provided two replies, referring to different fire design codes;

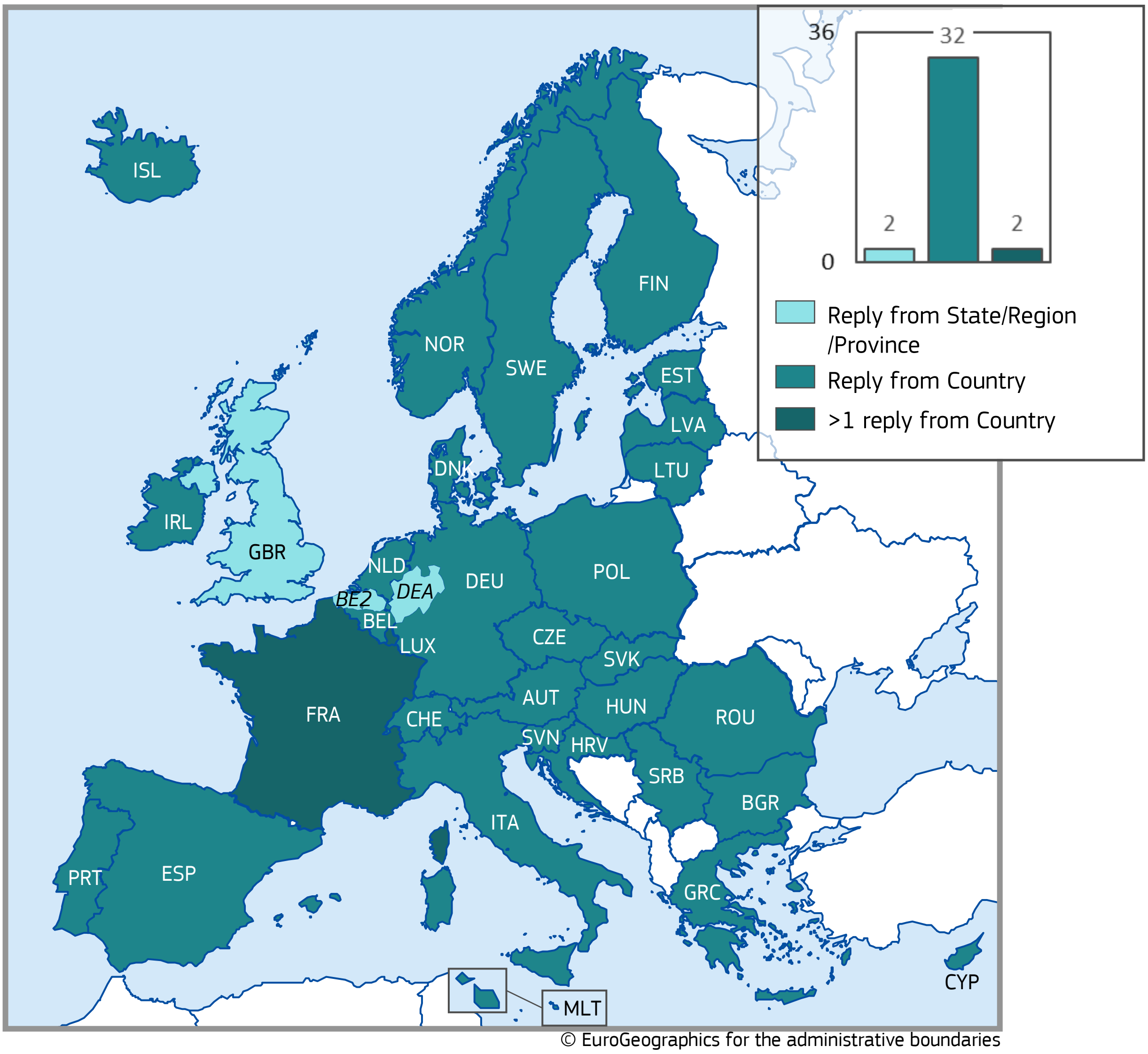
— the United Kingdom provided a reply related to England, which is part of the whole union of countries.

The replies were received from November 2020 to September 2021. Delays were observed in collecting answers due to difficulties in identifying the appropriate contact point (i.e., principal fire regulator) in some countries.

Thus, as far as the data was collected in the period 2020-2021, the analysis presented in the report reflects the state of Fire Safety Engineering approach implementation in 2020-2021.

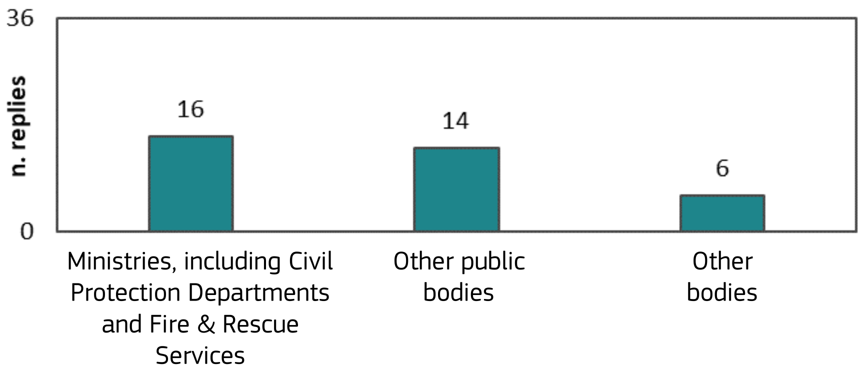
[45] The abbreviations used henceforth for the Flanders and North Rhine-Westphalia are taken from the NUTS1 classification https://ec.europa.eu/eurostat/web/nuts/background. NUTS is the Nomenclature of Territorial Units for Statistics. In the maps and graphs presenting the results (Section 4), the countries are denoted by the ISO 3166-1 Alpha-3 code abbreviations.

Figure 1. Countries and regions which replied to the FSE implementation status enquiry



The responders to the enquiry are mostly affiliated to public bodies, especially Civil Protection Departments and Fire & Rescue Services, which generally depend on a relevant Ministry (see Figure 2).

Figure 2. The principal affiliations of the responding fire regulators



3.4 Methodology for the analysis

The analysis presented in the following sections considers the responses from all 32 countries and also the two replies of the Flanders (*BE2*) and North Rhine-Westphalia (*DEA*) regions. The reply submitted for England is assumed to hold for most of the United Kingdom[46]. In the case of the two countries submitting two replies (France and Luxemburg), these referred to different codes and have been merged for the results analysis and visualisation. Thus, in the following sections, the analysis presented refers to 34 responses obtained by 32 countries and 2 regions.

The analysis of the results is presented in Chapter 4. The questions of reference are recalled in the text and figure captions by the abbreviation Q [Q: Question] followed by the question numbering in the questionnaire (available in **Annex B** to this report).

The subsections in Chapter 4 present analysis to the enquiry following a logical order which is delineated by the subject of the questions and the evaluation made. This order differs from the structure of the questionnaire (see Section 3.1), and is as follows:

1. Allowance / non-allowance for the application of FSE approach, enforcement and/or last update of current regulation for each answering country / region (Q1, Q5, Q8 and Q18);
2. Detailed results analysis:
    (a) Implementation of FSE approach related to the Technical Areas (Q2, Q7, Q9, Q16);
    (b) Implementation of FSE approach related to the types of constructions (Q6);
    (c) Process for FSE design approval and qualification framework (Q3, Q4, Q10-Q15);
3. Opinions of the answering experts:
    (a) Education and training needs for FSE (Q19-Q22);
    (b) Standardisation and research needs for FSE (Q17, Q23);
    (c) Additional comments (Q24).

3.5 Terminology

In the following Chapters, the terminology used follows the 2001 BeneFEU report (Joyeux 2002) to ease comparison of the results. For completeness, the basic terms used are defined below, quoting the BeneFEU report.

Prescriptive regulations: Regulations that achieve their fire safety objectives, and/or components of those objectives, by specifying what has to be provided. In some cases, these may be on the basis of performance requirement(s) e.g. fire resistance test performance, reaction to fire performance. However, usually they will be on the basis of requirements given in physical terms e.g., maximum building height, maximum compartment size(s), length or width of escape routes, that are dependent upon the intended use of the building. In this case, the fire safety objectives are usually not explicit, and deviation from the regulatory prescription requires generally some compensating protection measures within form of relaxation or derogation.

Performance based regulations: Regulations that specify explicitly their objectives and/ or components of these objectives, in terms of quantifiable criteria that shall be satisfied. Within these performance-based regulations, differentiation has to be made between:

Performance-based requirements for products under standard conditions, it is generally the case for requirement for reaction to fire or fire resistance (the requirement express the level of performance to be reached under the standard fire exposure conditions for reaction to fire or for fire resistance, leaving to the designer the freedom to choose the product desired). This approach considers very seldom the possible interaction between products.

Performance-based requirements for the entire building, considering explicit fire safety objectives (in terms of quantifiable criteria that shall be satisfied e.g., in terms of 'maximum tenable conditions' for effective escape of people or intervention of fire service) and/or functional requirements. The assessment of the fire

[46] According to the 2001 BeneFEU report, section 2.2 "*…each region of Belgium has its own sub-regulation, complementary to the federal law*"; in Germany, the national code "*… may be overruled by the legislation of the individual Länder*"; finally, in the United Kingdom, the principal regulations are the same for England, Wales and Northern Ireland.

safety level of the building is made using fire safety engineering tools, considering possible interaction between products.

Deemed to satisfy: A provision in a regulation that is met by a specified solution without the need for providing supporting technical information, e. g. acceptance of a particular form of construction, product or material (perhaps without test data) or building design.

Fire safety engineering is defined in ISO TR 13387-1 as 'the application of engineering principles, rules and expert judgment based on a scientific appreciation of the fire phenomena, of the effects of fire, and of the reaction and behaviour of people, to:

- save life, protect property and preserve the environment and heritage;

- quantify the hazards and risk of fire and its effects;

- evaluate analytically the optimum protective and preventative measures necessary to limit, within prescribed levels, the consequences of fire.

4 FSE regulation and implementation status in the MS: results analysis

This chapter provides an overview of the current regulations and an analysis of the current state of implementation of fire safety engineering approach in Europe, based on the data from the enquiry.

A comparison of the results of the enquiry with previous similar studies (discussed in Section 2.3) is presented within the section in the specific text boxes.

4.1 Allowance for the application of Fire Safety Engineering

Q1. Please provide the year in which your current national/regional fire regulation(s) referred in question above (if relevant) was (were) enforced.

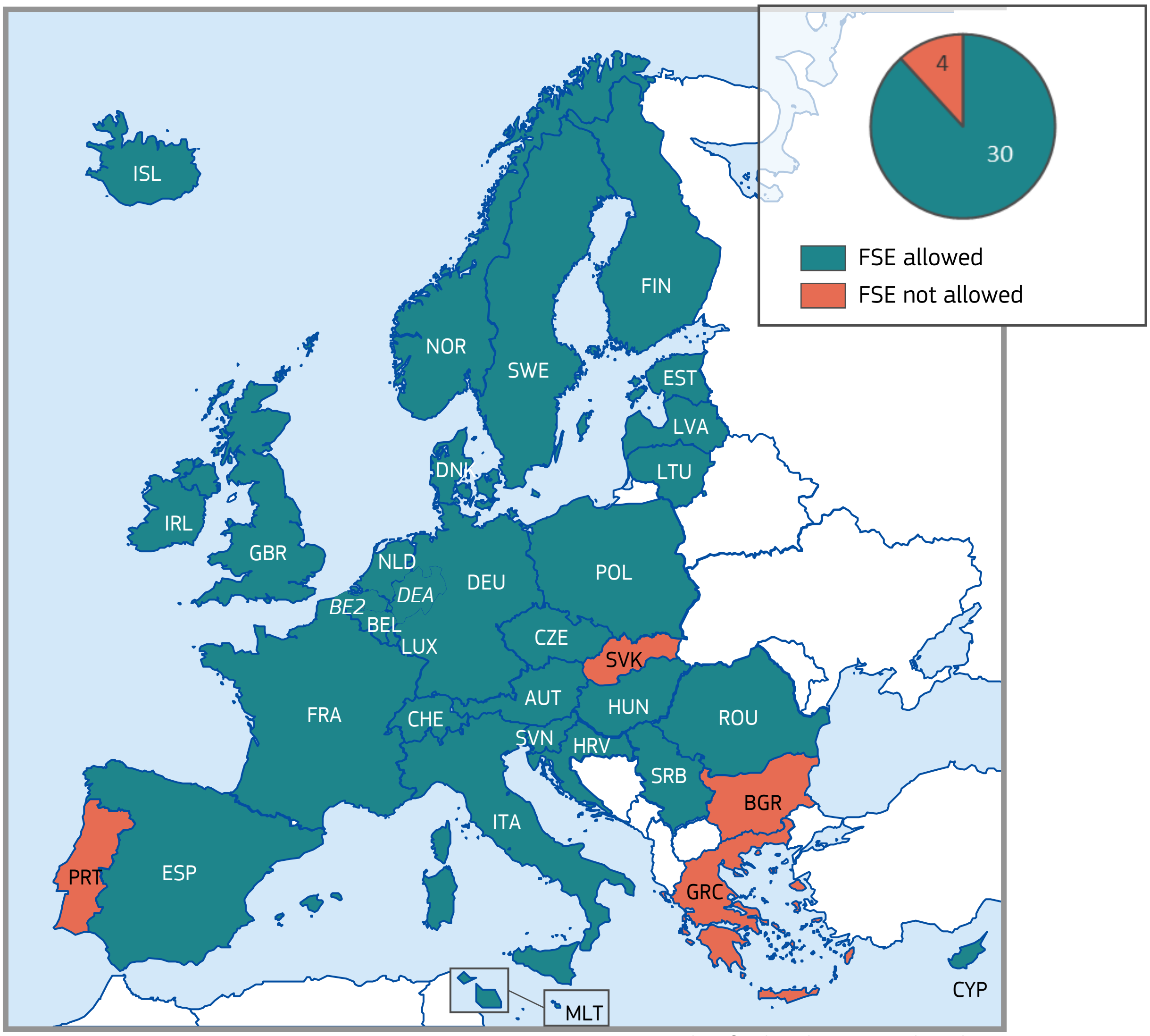
Q5. Is a FSE approach allowed for construction works in your country/state/region?

Q8. What are the main reasons to apply FSE approach?

Q18. Why FSE approach is not being used in your country/region?

Figure 3 presents the overall status on the allowance for the fire safety engineering approach in construction works, as reported by the fire regulators.

Figure 3. Countries/regions allowing/not allowing for the use of FSE approach in construction works in the framework of the national regulatory system (Q5)



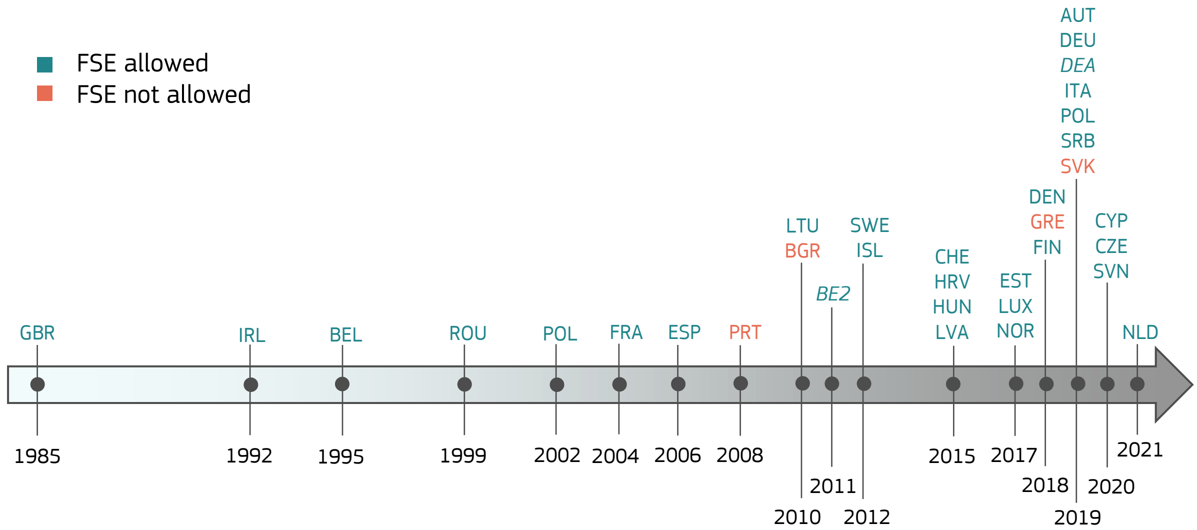
© EuroGeographics for the administrative boundaries

Of the 34 responding countries/regions, the vast majority allows the application of the FSE approach within the current national regulatory framework for fire design; only Bulgaria, Greece, Portugal and Slovakia have answered that FSE approach is not allowed for construction works in the country [Q5].

The fire regulators that responded to the enquiry provided details on the year of the last issue or update of the current national fire design regulations in each responding country or region. Some fire regulators have indicated more than one act of reference; in such cases, the most recent issue or update is accounted for in the figure. Figure 4 illustrates the responses. A table listing the latest regulation reported by each country is provided in **Annex C**.

It is noted that 21 countries/regions (out of the 34 responses) declare that a new or updated fire regulation was issued after 2015, highlighting the recent and growing focus of policy makers and national authorities' regulatory bodies in the field of fire safety for the built environment.

Figure 4. Year of last issue/update of current national fire regulations – all responding countries / regions (Q1)



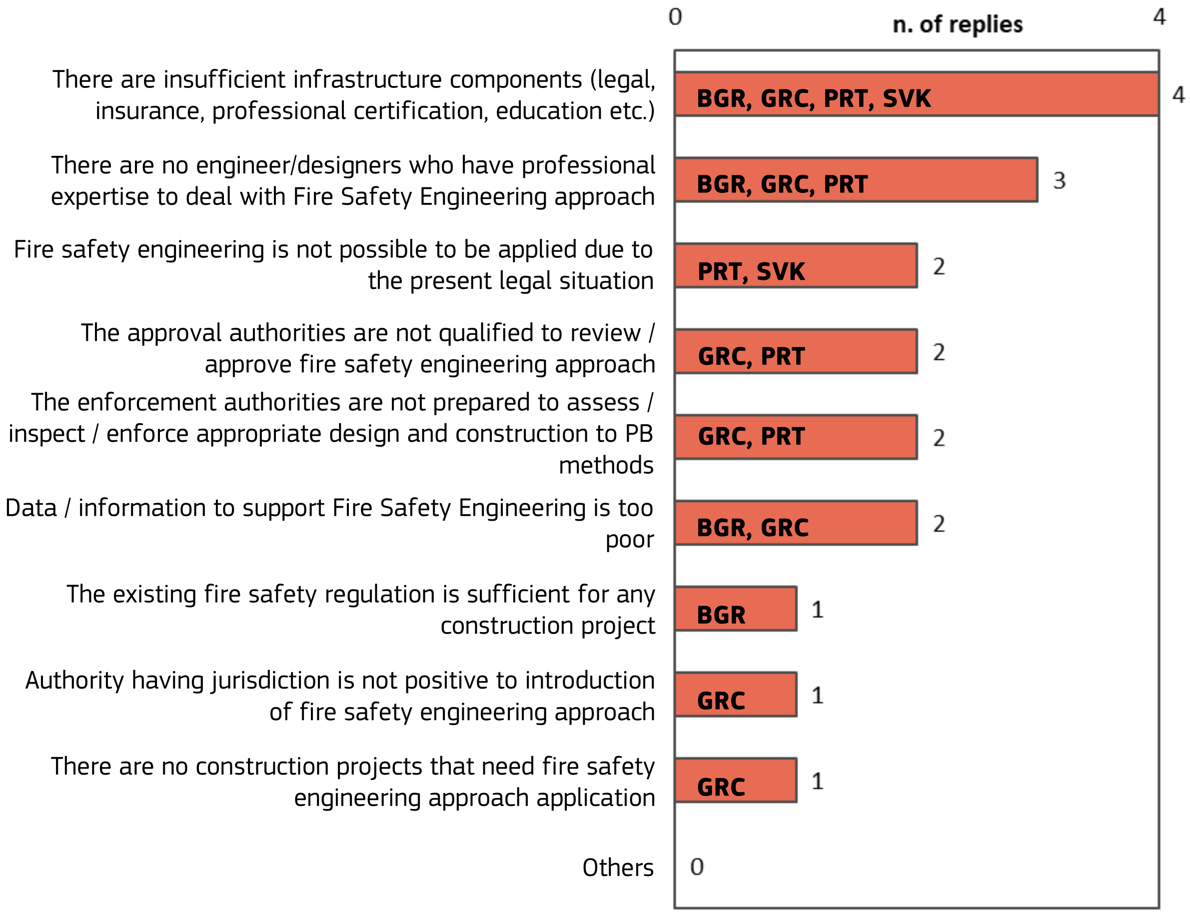
The reasons for the allowance or non-allowance for the use of the fire safety engineering approach are supported by the answers to questions Q8 and Q18 respectively, as illustrated in Figure 5 and Figure 6. It should be noted that in this case the answers refer to facts as well as to the responders' opinions.

The countries or regions allowing for FSE in their current fire design regulations have mainly motivated such choice with the possibility of innovation given by FSE, both from the point of view of fire safety technology and building space design (Figure 5). Other experts reported that reasons supporting the adoption of FSE are the insufficiency of the traditional fire design approaches (i.e., prescriptive regulations) in covering certain types/categories of buildings and the cost effectiveness in the construction and maintenance process. Among other reasons noted for implementing the FSE approach in the national regulatory framework, the most prevalent relates to the renovation / reconstruction of existing buildings as in such projects the application of prescriptive or deemed-to-satisfy solutions is rather challenging.

The four countries not allowing for the use of FSE approach report the absence of infrastructure components (e. g. legal provisions, insurance / professional certification systems, educational programmes) that support the application of FSE in fire safety designs (Figure 6). Moreover, Bulgaria, Greece and Portugal also note the lack of FSE expertise in the professionals involved in fire safety for the built environment. It should be noted that, of the four countries not applying FSE approach, only Portugal and Slovakia mention that the legal situation hinders its application. In the cases of Bulgaria and Greece, the declared non-allowance in the enquiry (answer "no" to Q5) might be interpreted as the non-application of FSE in practice; in fact, the use of FSE might be allowed within the existing regulatory frameworks (e. g. applying the fire parts of the Eurocodes), but under conditions not specified and/or clarified in the regulatory frameworks.

Figure 5. Reasons to allow for FSE approach in building constructions – replies only by countries/regions reporting allowance for FSE approach (Q8)

Figure 6. Reasons not to allow for FSE approach in building constructions – replies only by countries/regions reporting non-allowance for FSE approach (Q18)



Box 1. ISO enquiry: reasons for allowance / non-allowance of performance-based approach

Within the ISO enquiry, the answers to the question "*What are the main reasons to apply Performance-Based Fire Safety Design (P-B FSD) approach to the buildings*?" show that:

— the majority of responders indicate "A desired aspect of the building does not comply with the building or fire regulations", and "The type of building is out of scope of the existing prescriptive regulations";

— secondary reasons are "To realise attractive / innovative building space" and "To economise the construction/running costs of the building".

Three countries (Slovakia, Spain and Turkey) answered the question "*What are the main reasons that P-B FSD is not adopted in your country?*"; the results demonstrate that:

— all responders indicate the reasons "The approval authorities are not qualified to review / approve P-B FSD", "The enforcement authorities are not prepared to assess / inspect / enforce appropriate design and construction to P-B methods", and finally "There are insufficient infrastructure components";

— two of three countries point out that "Authority having jurisdiction is not positive to introduction of P-B FSD", "There are no engineers / designers who have professional expertise to deal with performance-based fire safety design", and finally "Data / information to support FSE and P-B FSD is too poor".

4.2 Countries / Regions allowing for FSE approach: the Technical Areas

Q2. What is the nature and level of the technical detail in your fire regulation, considering the following technical details?

Q7. How many technical areas does FSE apply to in your Country/State/Region?

Q9. What is the regulatory framework that allows for the application of FSE approach?

Q16. What assessment methods for FSE are used for the prediction of fire, smoke, structural response, evacuation etc.?

Questions Q2, Q7 and Q16 pivot on the 12 Technical Areas (TAs) or technical details listed in Table 1 (Sect. 3.2).

4.2.1 Fire design approaches prevailing across TAs and across countries / regions

Figure 7 presents the nature and level of the technical detail in the fire regulation of the responding countries/regions, considering the 12 TAs. It shows the shares of prescriptive (P), deemed-to-satisfy (DTS) and performance-based (PB) approaches in each TA – i. e. number of answers "PS", "PBS" or "DTSS" over the total ("PS" + "PBS" + "DTSS") answers for the same TA, expressed in percentage – considering all the responding countries/regions. The analysis of the same data allows to represent the prevailing approach for each responding country / region in the map of Figure 8.

Figure 7. Shares of P, DTS and PB approaches in fire safety regulations for the 12 TAs (Q2)

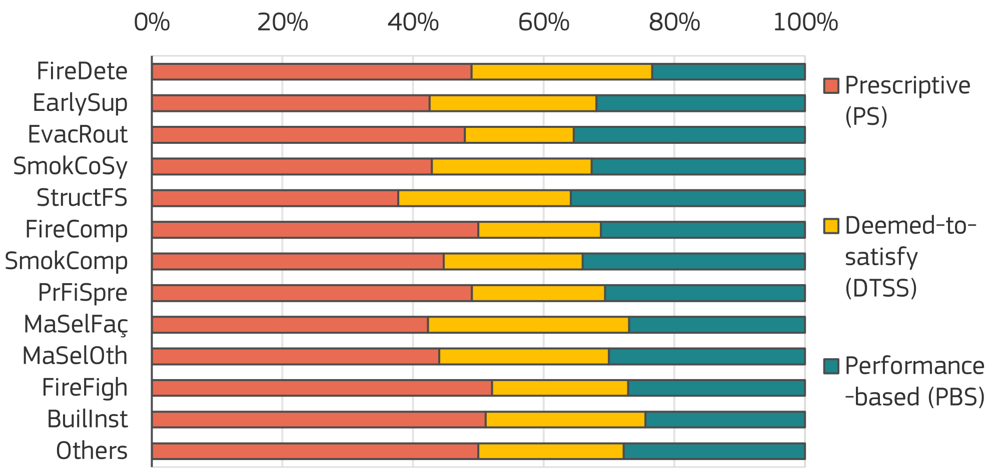
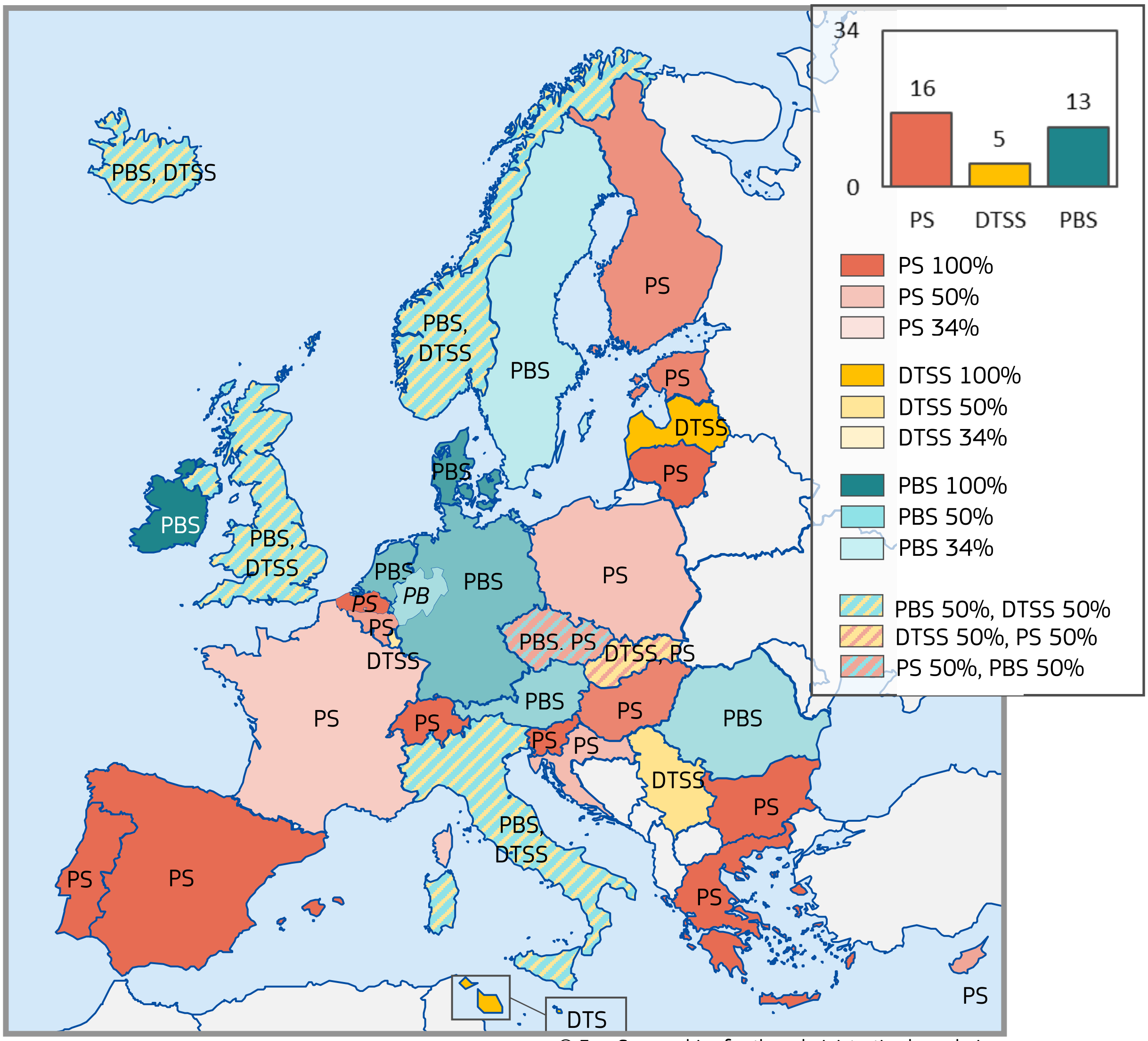


Figure 8. Prevailing approach in fire safety regulations considering the 12 TAs – all responding countries / regions (Q2)



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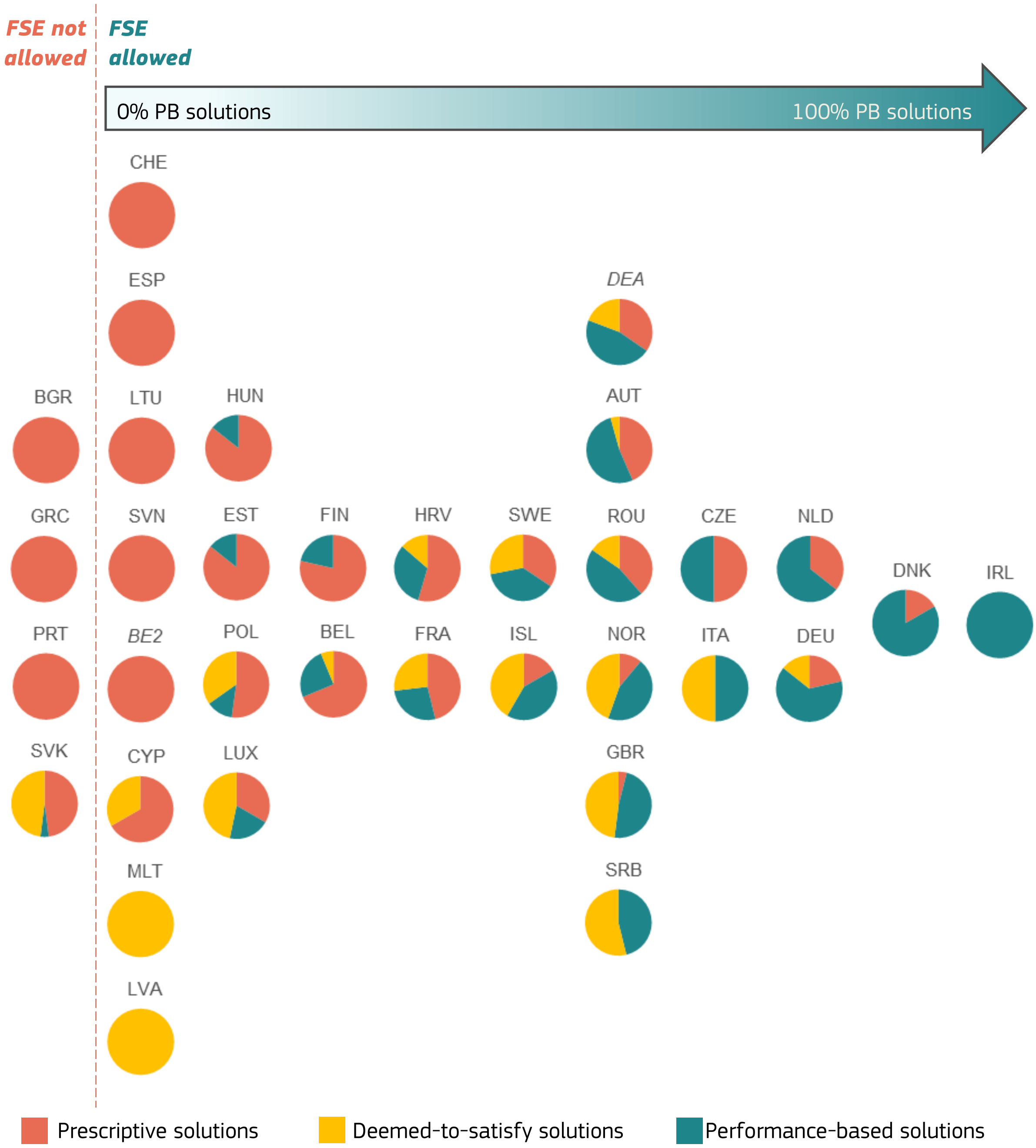
Following the analysis of the FSE-related technical areas, the percentage of use of the three approaches for the considered TAs is represented for each country in

Figure 9. The pie charts are arranged from left to right by an increasing implementation level of performance-based solutions, showing the balance of the different approaches in each country / region. For example, in Bulgaria prescriptive approaches are used in all considered TAs (thus 100%). To the other end, in Ireland performance-based solutions are used in all 12 TAs. All other countries have a mixed percentage of prescriptive, deemed-to-satisfy and performance-based approaches considering the 12 TAs of the enquiry.

The data represented in Figure 7 to Figure 9 demonstrate that the prescriptive approach for fire safety design is still predominant in the European countries. Prescriptive methods provide the 40% to 50% of technical solutions in the FSE related technical areas (Figure 7); however, performance-based solutions (ranging from 25% to 35%) are more used than the deem-to-satisfy ones (ranging from 20% to 30%).

It is observed in Figure 9 that prescriptive solutions are predominant (i.e. prescriptive solutions are used in more than half of the technical areas) in 16 out of the 34 responding countries and regions; in detail, the prescriptive approach is the only approach providing the technical solutions in eight countries and regions, three of which have declared that performance-based methods are not allowed to be used in the current regulatory framework (Figure 3). However, Figure 9 shows that performance-based solutions are at least available in 22 of 34 countries and regions, including Slovakia, which has answered “no” to Q5 “*Is a FSE approach allowed for construction works in your country/state/region?”.* Ireland declares that only performance-based solutions apply to each TA, while in 11 other countries (Austria, Czechia, Germany, Denmark, United Kingdom, Iceland, Italy, Norway, Netherlands, Romania and Serbia) the availability and use of performance-based solutions is 50% or greater, considering the 12 FSE-related technical areas. In most countries and regions, deem-to-satisfy solutions also provide for the technical details in some areas.

Figure 9. Shares of P, DTS and PB approaches in the 12 TAs – all responding countries / regions (Q2)



4.2.2 Application FSE approach in the TAs across the countries / regions

The answers to Q7 allow to appreciate how many technical areas are included in FSE application in the different countries and regions, and which technical areas are the most (or least) involved in performance-based fire design applications in Europe. In the map shown in Figure 10, ten countries (Czechia, Switzerland, Finland, United Kingdom, Hungary, Ireland, Italy, Netherlands, Serbia and Sweden) and one region (Flanders) apply performance-based solutions to all, or almost all, of the 12 technical areas. On the other hand, six countries (Belgium, Cyprus, Germany, Spain, Luxembourg and Poland) limit the use of performance-based solutions only to some technical areas.

Figure 10. Number of TAs included in FSE applications – FSE-allowing countries (Q7)

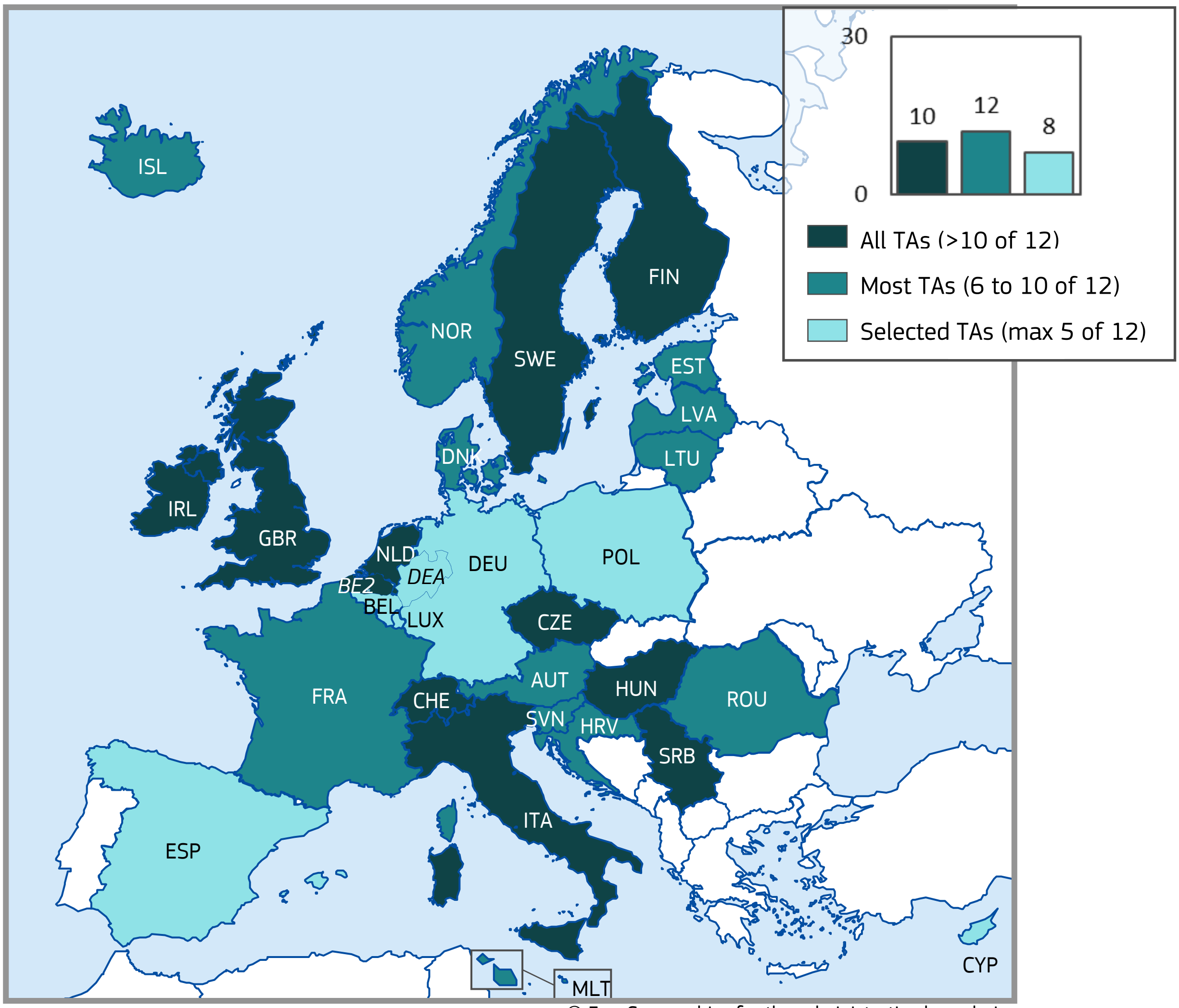


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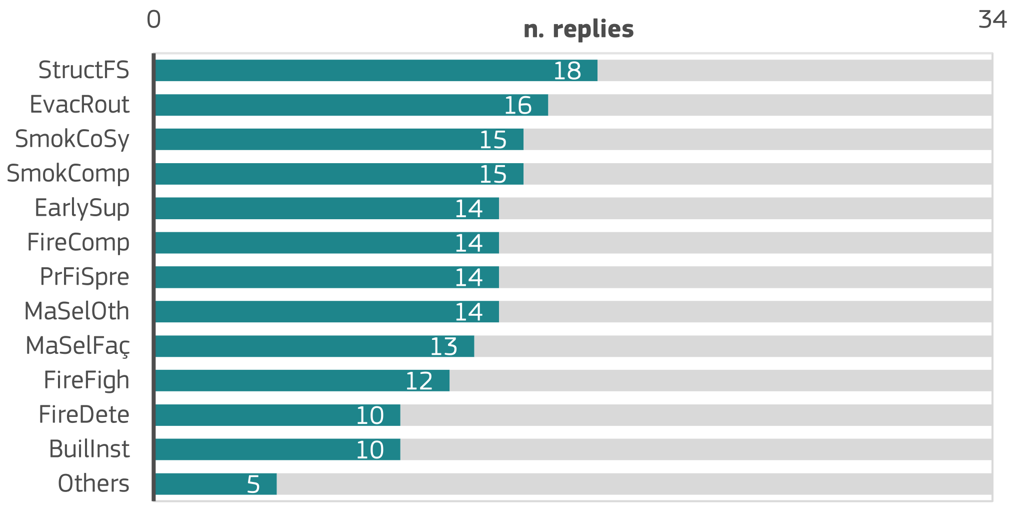
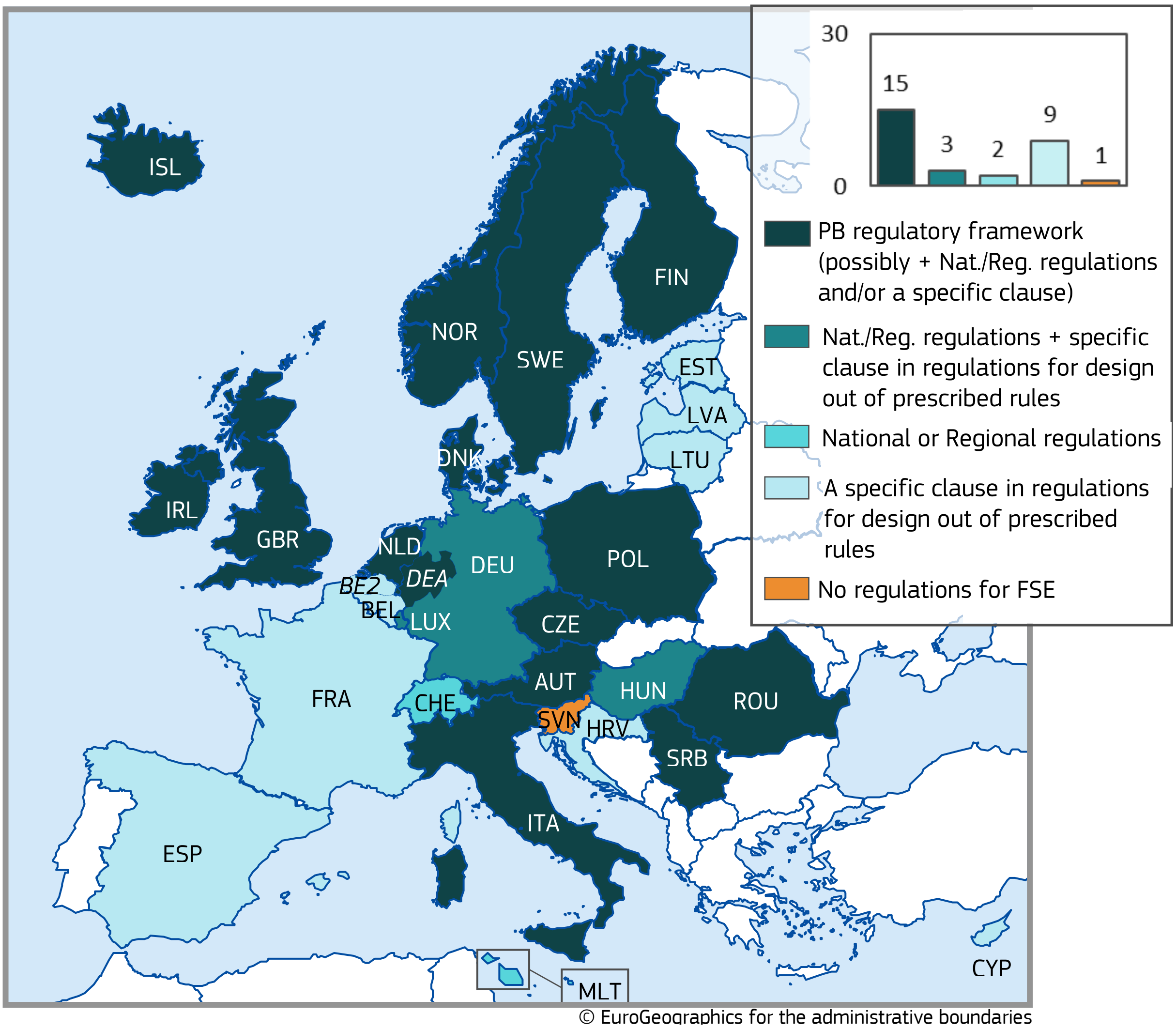
Figure 11 illustrates the technical areas in which performance-based solutions are most used, namely Structural Fire Safety, Evacuation Routes, Smoke Control Systems and Smoke Compartmentation.

Figure 11. Tas included in FSE applications – FSE-allowing countries / regions (Q7)



To obtain a further insight in the implementation status of FSE approach, the availability of performance-based technical solutions is compared to the nature of the regulatory framework for fire design in each country / region. Figure 12 shows the regulatory framework that allows for the application of the FSE approach (Q9); it also lists the 15 countries and regions which have indicated to have a performance-based regulatory framework, as well as the respective percentage of performance-based solutions across the technical areas (answer to Q2). It is noticeable that in nine countries and regions, despite the performance-based regulatory framework, the percentage of effectively available performance-based technical solutions is less than the 50% considering the 12 technical areas (numbers in red font).

Figure 12. Nature of regulatory framework allowing for FSE – FSE-allowing Countries / Regions (Q9 and Q2)



PB framework (Q9)	AUT	CZE	*DEA*	DNK	FIN	GBR	IRL	ISL	ITA	NLD	NOR	POL	ROU	SRB	SWE
PB solutions available (Q2)	52%	50%	*46%*	83%	21%	48%	100%	41%	50%	64%	44%	13%	46%	46%	38%

Box 2. ISO enquiry: regulatory systems making possible to apply P-B FSD to the buildings

The answers to the question "*What regulatory systems make it possible to apply P-B FSD to the buildings*?" show that the most common system enabling P-B FSD is that building/fire regulations have some clause to allow buildings that do not comply with the current specifications. In detail, all the EU Member States confirm this approach (Austria, France, Hungary, The Netherlands, Spain and Sweden), except Germany, which indicates that the whole regulatory system is performance-based.

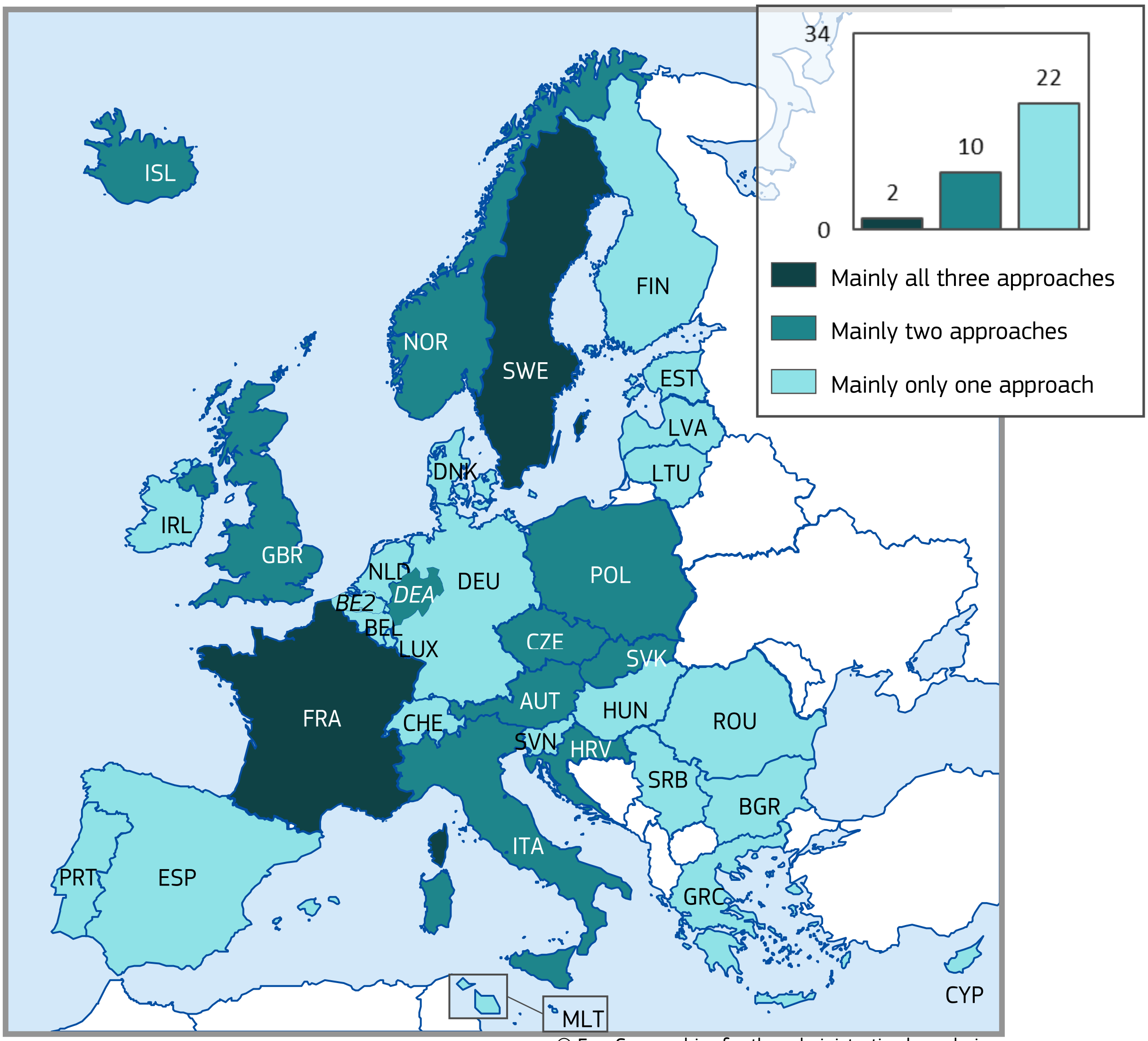
However, the majority of the countries also indicate other ways enabling P-B FSD application – i. e. the building regulatory system is performance-based, national or local regulations exist for the approval of P-B FSD, by discretion of the building / fire officers in charge, or by a designated approval organisation – which may depend on the different technical areas, or type of building / construction.

4.2.3 How many fire design approaches are available for each TA

The data collected in this study also allow appreciating the coexistence of different design approaches (P, PB and DTSS) in some countries / regions, as illustrated in Figure 13.

Assuming that the possibility to choose the design approach is an advantage for building practitioners, the availability of such flexibility differs significantly through the countries / regions.

Figure 13. Availability of different fire design approaches for the same TA – all responding Countries / Regions (Q2)



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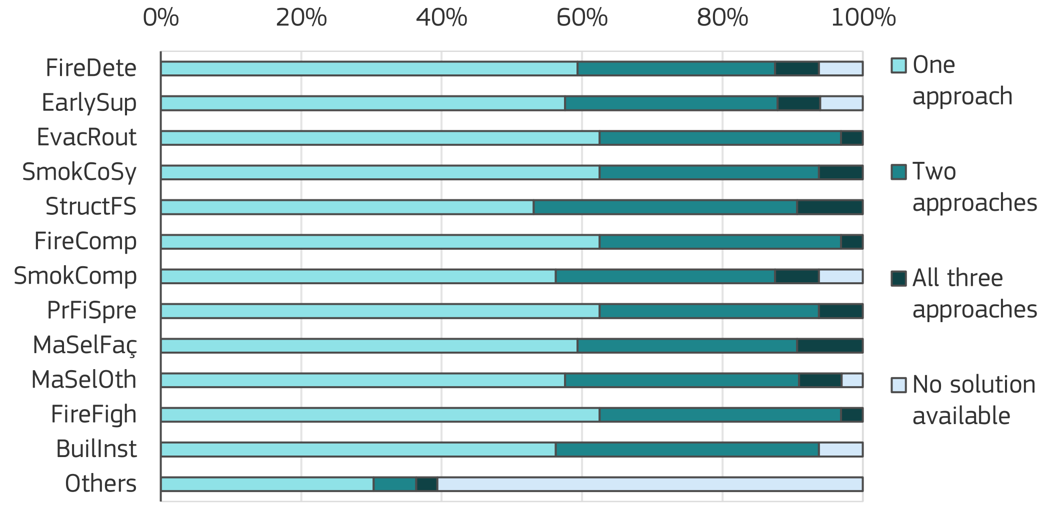
Then, the bars chart in Figure 14 allows appreciating the availability of one, two or all three approaches across the TAs in the whole group of responders.

In particular, 22 out of 34 countries / regions allow mainly for only one approach (Figure 13); all across the FSE-related technical areas, the availability of design approaches is rather uniform. The technical area of Structural Fire Safety appears to be the most developed, with the largest percentage of countries / regions providing for more than one design approaches.

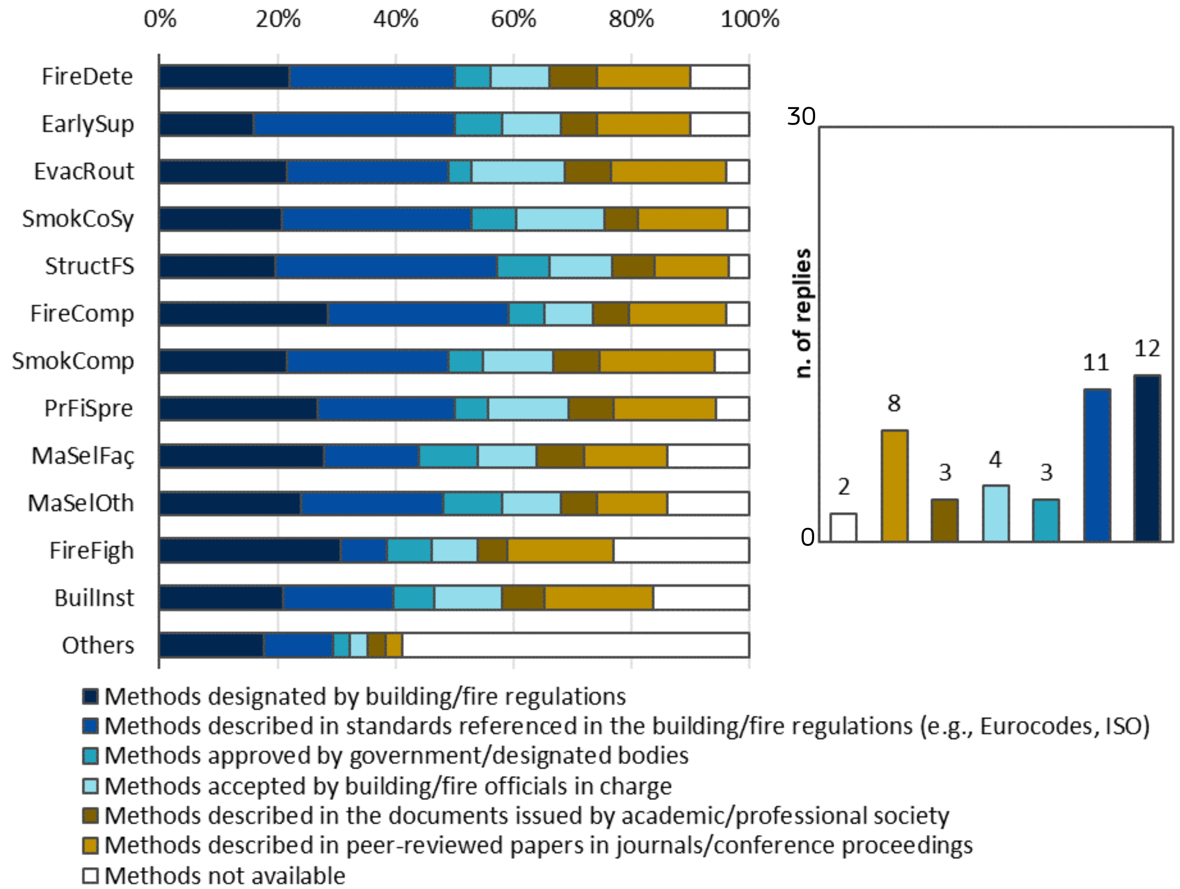
Figure 14. Number of different approaches for the same TA – all responding Countries / Regions (Q2)



4.2.4 Assessment methods across TAs and across countries / regions

The fire regulators were asked to provide details on the FSE assessment methods for the prediction of fire, smoke, structural response, evacuation (Q16). The analysis of the responses is shown in Figure 15 to Figure 17.

Figure 15. Sources of assessment methods for the 12 TAs – FSE-allowing Countries / Regions (Q16)

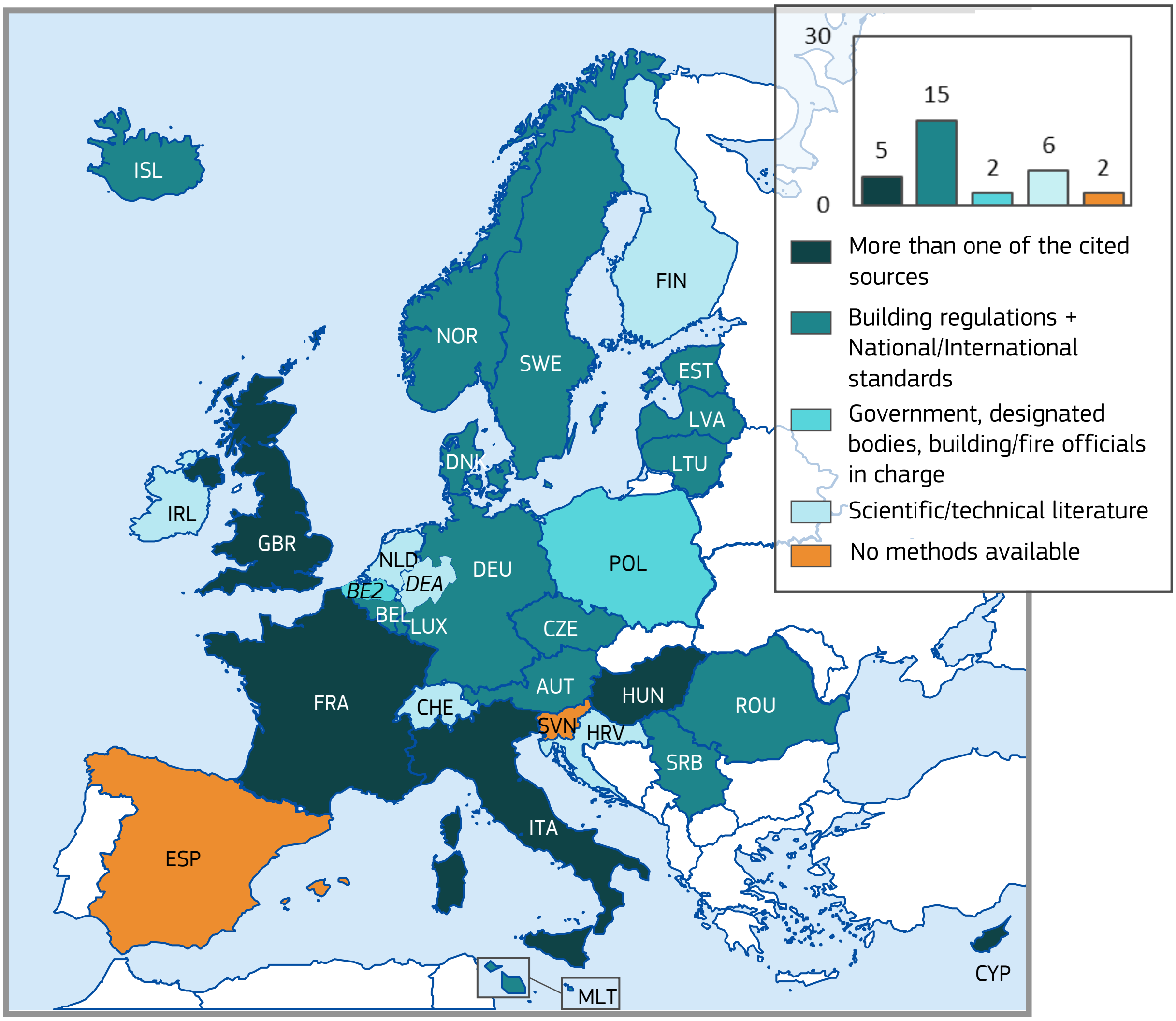


In Figure 15, the bars chart on the left presents the responses of the countries / regions per technical area, while the bars chart on the right indicates the most used sources across the countries / regions, considering all technical areas. Both charts demonstrate that international standards and national regulations are the most used sources for assessment methods for the prediction of fire, smoke, structural response, evacuation etc. across the 12 technical areas in all responding countries / regions.

The national / international standards and building / fire regulations particularly cover Fire Compartmentation, Structural Fire Safety and Smoke Control Systems (50-60% of countries / regions indicate that such sources provide assessment methods in such areas). While these sources have generally a higher share than 40%, they apply to Fire Fighting and Building Installations at a lesser extent. Scientific / technical literature (in particular journal papers and conference proceedings) is also an important source for assessment methods. Finally, methods accepted by building / fire officials in charge or approved by the government or government designated bodies generally hold a 10-15% share across the technical areas. It should be noted that, for the areas where the national / international standards and regulations are less used, the share of "no method available" increases (see left chart in Figure 15). This points out that the availability of assessment methods likely depends on such sources.

The map in Figure 16 shows the geographic distribution for the prevalent sources of calculation methods, indicating that National / international standards and building / fire regulations prevail in 15 of the 30 countries / regions where FSE approach can be applied; only Spain and Slovenia declare that calculation methods are unavailable in most cases.

Figure 16. Prevailing sources of assessment methods for the 12 TA – FSE-allowing Countries / Regions (Q16)



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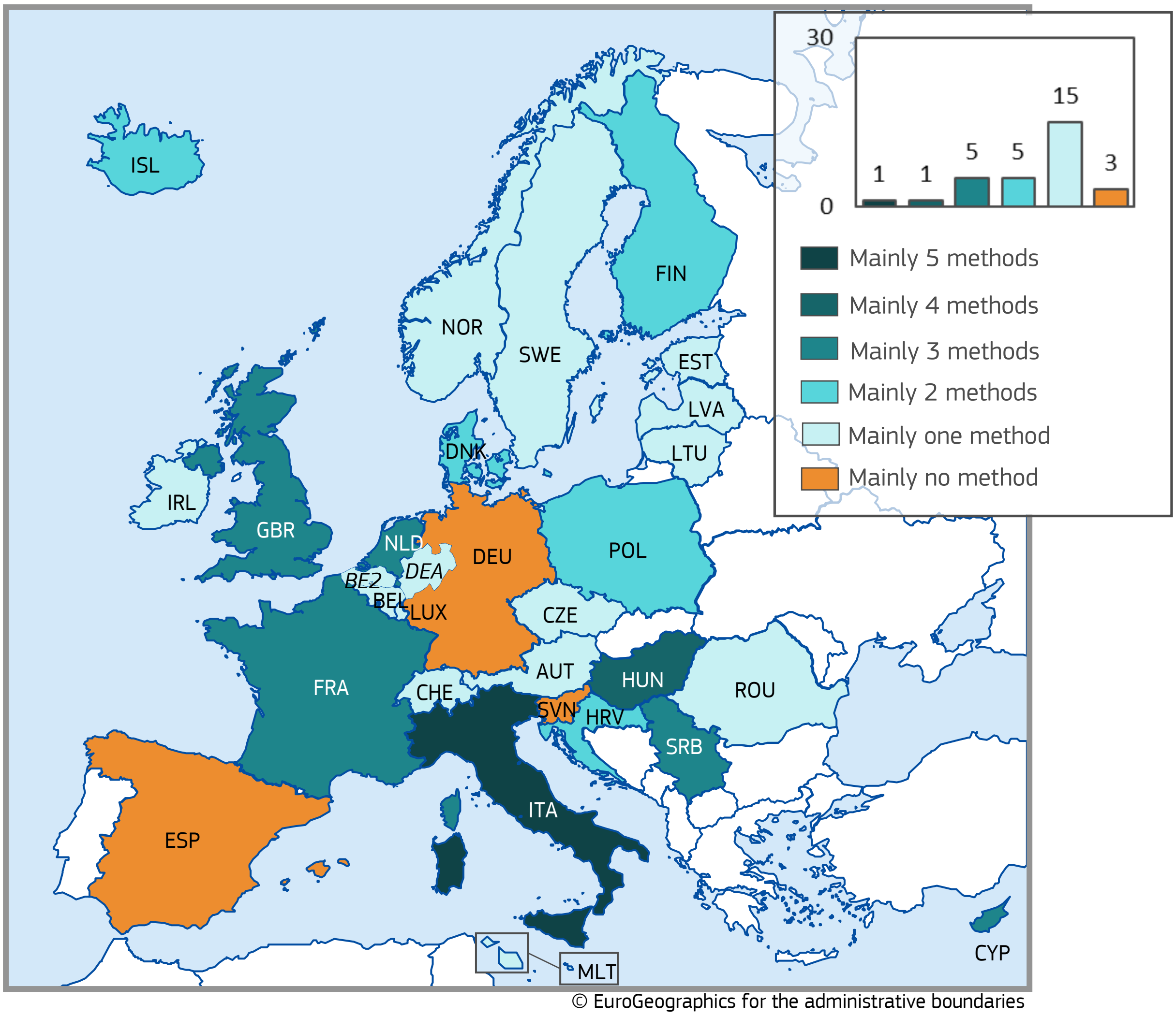
Finally, Figure 17 shows how many methods (referring to the sources, listed in Figure 15) are mainly available for each technical area. It shows that 15 of the 30 countries / regions allowing for FSE mainly provide one type of calculation method per technical area; among the countries / regions that provide more than one method of assessment per technical area, Italy and Hungary offer the widest choices to practitioners.

Figure 17. Number of available assessment methods for each of the 12 TA – FSE-allowing Countries / Regions (Q16)



Box 3. ISO and BeneFEU / CEN/TC 127 enquiries: fire safety systems or features (Technical Areas) included in P-B FSD analyses; sources of calculation methods used.

The ISO enquiry makes reference to nine Technical Areas, of which Smoke Control Systems and Structural Fire Safety are indicated by all the responding European Countries; moreover, these two TAs are also prevalent among all the other Countries which gave answer to the ISO questionnaire. This confirms the outcomes of the present enquiry (see Figure 11 above).

Concerning the calculation methods for P-B FSD predictions of fire, smoke, structural response, evacuation etc., statutory methods prevail over the reliance on experts; in fact, 12 of 14 responding Countries apply international standards. The seven European Countries show a balanced picture; in fact, all of them (except France) apply methods designated by building/fire regulations and/or described in international standards, as well as methods described in documents issued by academic / professional societies; other methods are also indicated. However, it must be noticed that the question "*What calculation methods are used for the prediction of fire, smoke, structural response, evacuation etc.*?" in the ISO questionnaire was not detailed per Technical Area as in the present enquiry.

The BeneFEU / CEN TC127 enquiry covers five Technical Areas, of which Smoke Propagation and Compartmentation and Stability are the most frequently applied performance-based requirements in the regulations of responding Countries. The responders mainly deem that such TAs need little work to become mature to form the basis of regulatory compliance. This outcome matches the results of the present enquiry and of the ISO enquiry.

4.2.5 Feedback on other Technical Areas related to FSE aproach

Several countries have indicated that some additional FSE-related technical areas are covered by their national fire safety regulations (see the details in Table 2). Five of those countries indicate that performance-based methods are available for other technical areas than those considered in the questionnaire.

These additional technical areas include the risk of explosions, protective measures and emergency provisions. However, most of the other areas have not been clearly identified within the framework of the questionnaire. Further work would be useful to get a deeper insight.

Table 2. Other Technical Areas in all the responding countries / regions

Country	Other Technical Areas	Methods
CYP	unspecified	P
CZE	unspecified	P
HUN	unspecified	P
ISL	unspecified	PB
ITA	risk of explosive atmospheres (ATEX)	DTS, PB
LTU	all parameters that can be determined by standards or tests	P
LVA	Explosion protection, firefighters’ elevators, emergency lighting	DTS
MLT	unspecified	DTS
POL	unspecified	P
PRT	self-protection measures (emergency plans)	P
ROU	unspecified	PB
SVN	unspecified	PB
SWE	Protection against ignition, fireplaces, chimneys	P, PB

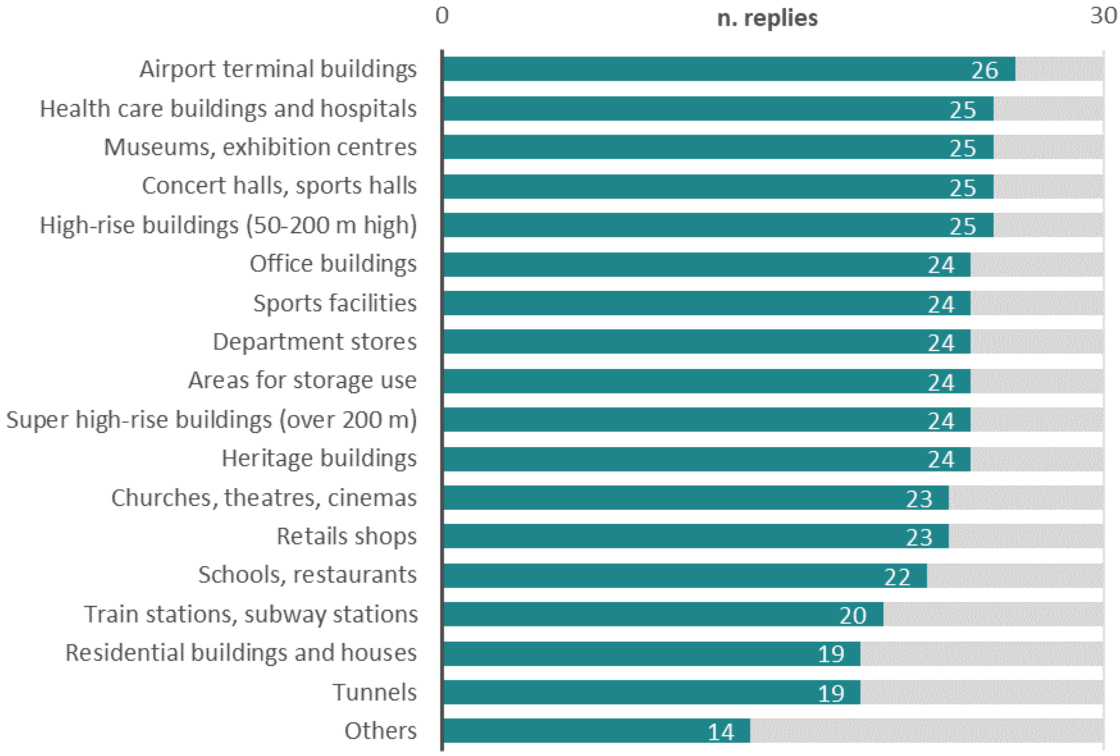
4.3 Types of construction projects

Q6. How many types of constructions does FSE apply to in your country/state/region?

Figure 18 to Figure 20 illustrate the information collected on the type of construction projects for which the FSE approach is applied.

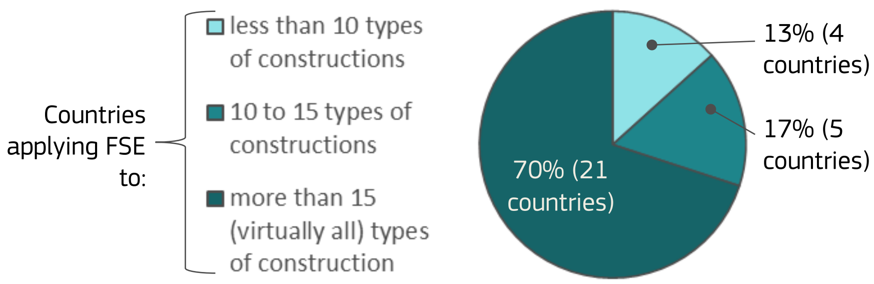
The data offer a generally positive picture for the potential of FSE approach application methods in Europe. As shown in figure 18, the categories most addressed are the following: airport terminal buildings, museums and exhibition centres, concert/sports halls and high-rise buildings up to 200 m high; other building types are also covered in some countries. Residential buildings are among the least indicated construction types for which the FSE approach is applied. In detail, FSE design approach is not applicable to residential buildings in Belgium, Cyprus, Germany, Ireland, Latvia, Luxembourg, Norway, Poland and Slovenia. In the 70% of the countries, the FSE approach can be applied practically to any type of construction – or any type with a few exceptions; only in four countries / regions (13%) the FSE approach is tied to specific types (see Figure 19).

Figure 18. Types of constructions FSE is applied to – FSE-allowing countries / regions (Q6)



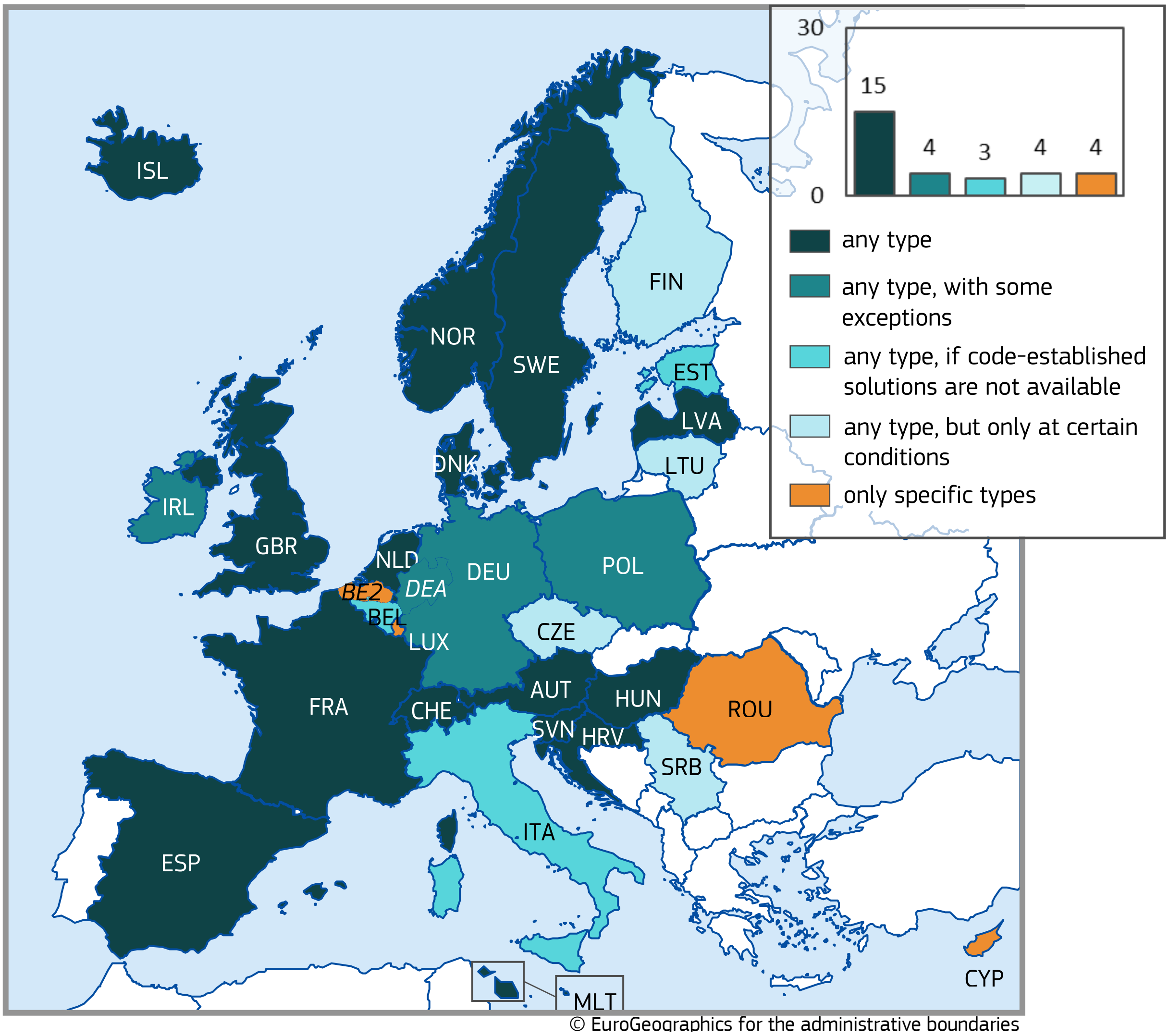
Country	Other types of constructions which FSE applies to
CYP	Basement car parks, buildings with atria
DEU	Any, except residential
LTU	Factories, garage buildings, livestock farms, strategic buildings (but NOT for new
MLT	build)
NLD	Underground / multilevel car parks, fuel stations, fireworks factories, industrial sites
SRB	Bridges
CZE, FRA, HUN, ISL, LVA,	Public buildings, regardless of the area
NOR, SVN	Virtually any type

Figure 19. Number of countries applying FSE to different extents of construction types – FSE-allowing Countries/Regions (Q6)



The map in Figure 20 illustrates different conditions under which FSE approach is applied. The most significant exception to the applicability of FSE approach is the residential occupancy, for which prescriptive or deemed-to-satisfy solutions are often deemed sufficient. FSE application also strongly relates to the lack of code-established solutions for the construction projects of certain size or complexity, or hosting certain activities (Belgium, Estonia and Italy). In Finland, the FSE approach is applicable if certain thresholds of surface, height or capacity are exceeded; Serbia sets dimensional as well as functional criteria. Lithuania allows for the FSE approach use only for the repair and reconstruction of buildings of any type.

Figure 20. Application of FSE to types of constructions – FSE-allowing Countries / Regions (Q6)



Box 4. ISO enquiry: Types of facilities / uses to which P-B FSD is applied

The overall results of the ISO enquiry demonstrate that Performance-Based Fire Safety Design (P-B FSD) can be applied to every kind of built-environment. The most frequent types are high-rise and large-scale buildings and facilities, while only three out of the 14 countries apply such approach to residential buildings.

As well, only five countries apply FSE to schools and educational buildings, of which Sweden is the only one covered by the present Enquiry.

The detailed answers of the seven European countries to the ISO questionnaire show some conflict with what emerges from the present enquiry. In particular,

— in Austria, P-B FSD can be applied to a few types of buildings / facilities;

— Germany indicates that P-B FSD can apply only to industrial plants;

— Hungary excludes high-rise and super high-rise buildings from P-B FSD applicability;

— Austria, France, Hungary, the Netherlands, Spain and Sweden exclude residential buildings from P-B FSD applicability; Austria, France, Germany, Hungary, the Netherlands, Spain and Sweden exclude schools.

4.4 Process for FSE design approval and qualification framework

4.4.1 Fire safety project approval, liability and regulatory review of FSE approach

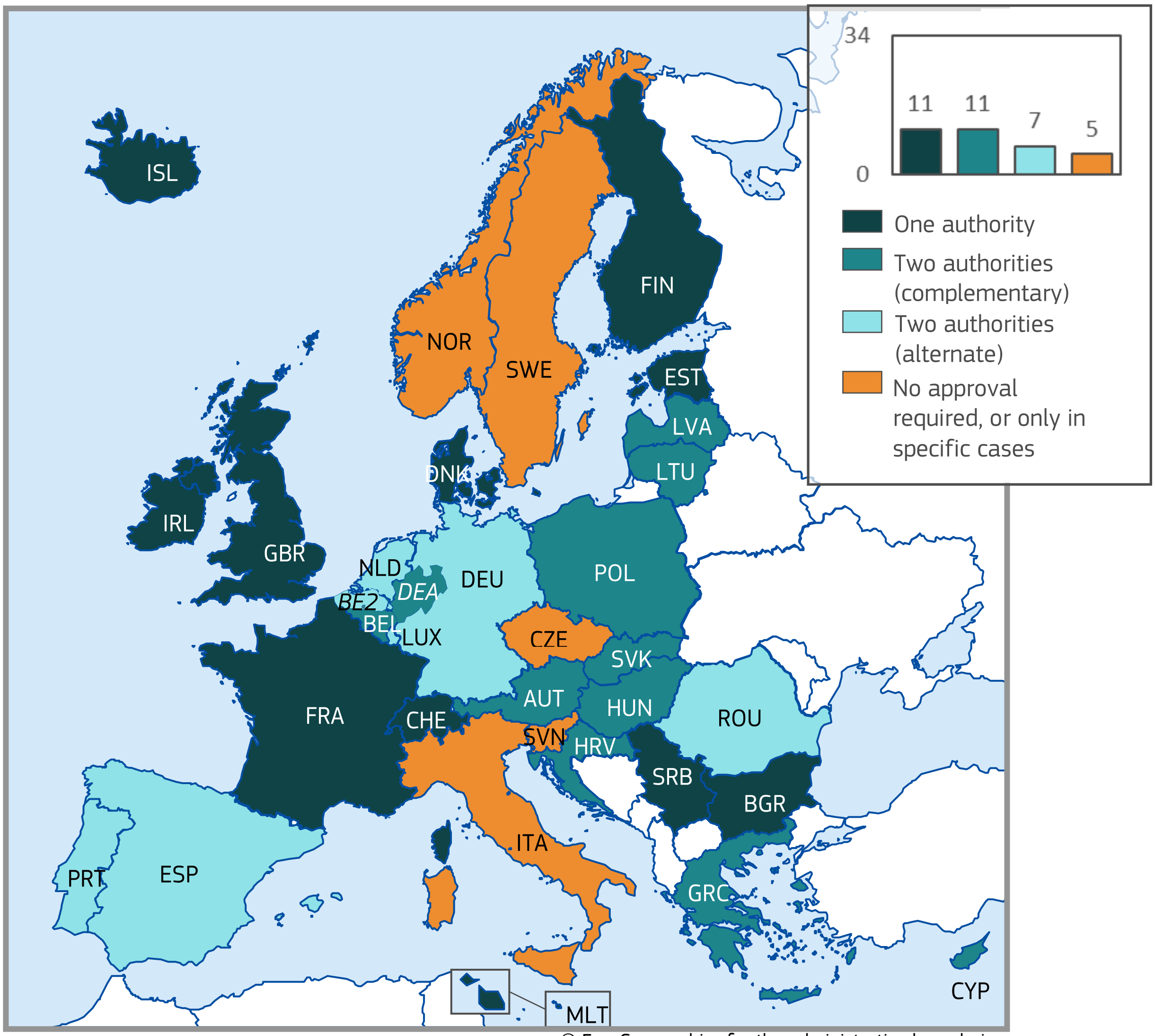
Q3. Who issues the approval of a construction work project from the fire safety design perspective?

Q4. Who is liable for fire safety design of construction works and design compliance to the regulation?

Q10. Which body/bodies perform a regulatory review of the FSE approach in projects?

All the 34 responding countries/regions have answered about the process for the fire safety design approval, and the related qualification framework for practitioners and reviewing/approving authorities (Figure 21).

Figure 21. Authorities approving a project from the fire safety perspective – all countries / regions (Q3)



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The histogram in Figure 22 details the possible roles of the local authority (LA), fire brigade (FB) and other(s) authorities in the approval process. The Venn's diagram in Figure 23 illustrates the different involvement of such authorities through the responding countries. In most countries / regions, a formal approval of at least one authority is required for the fire safety part of the construction project. In most cases, two authorities are required to approve the project, either in a complementary or (less frequently) alternate way; local authorities and the fire brigade are the most involved authorities in the approval process. In Czechia, Italy, Norway, Slovenia and Sweden no approval is normally required by the law, as reported by the fire regulators.

Figure 22. Roles of local authority (LA), fire brigade (FB) and others in the approval – all countries / regions (Q3)

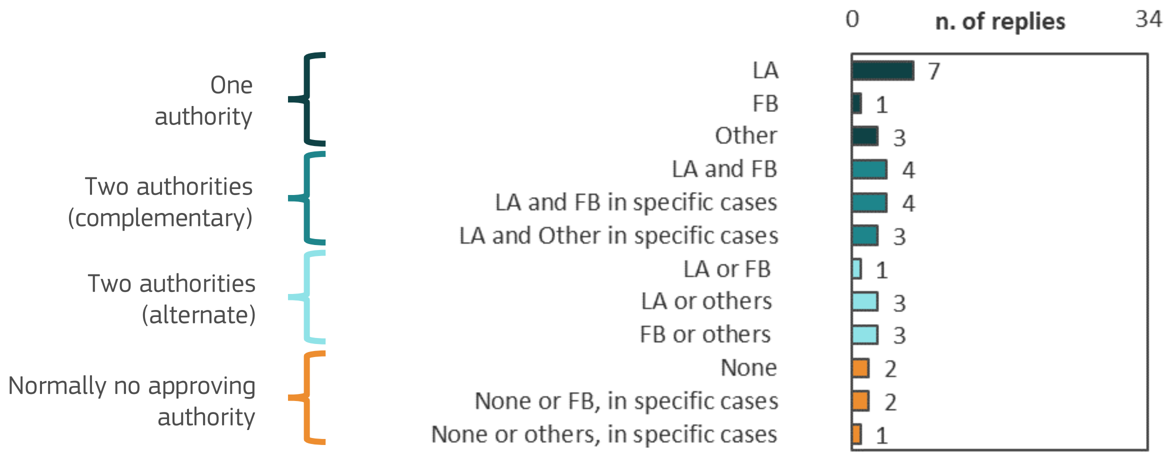
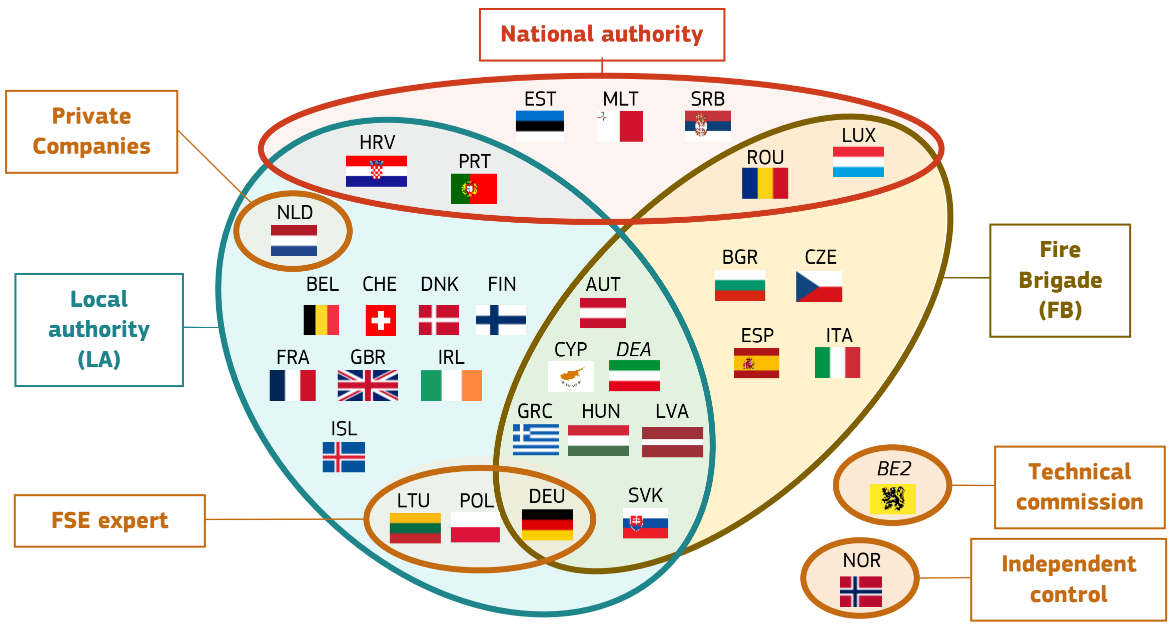
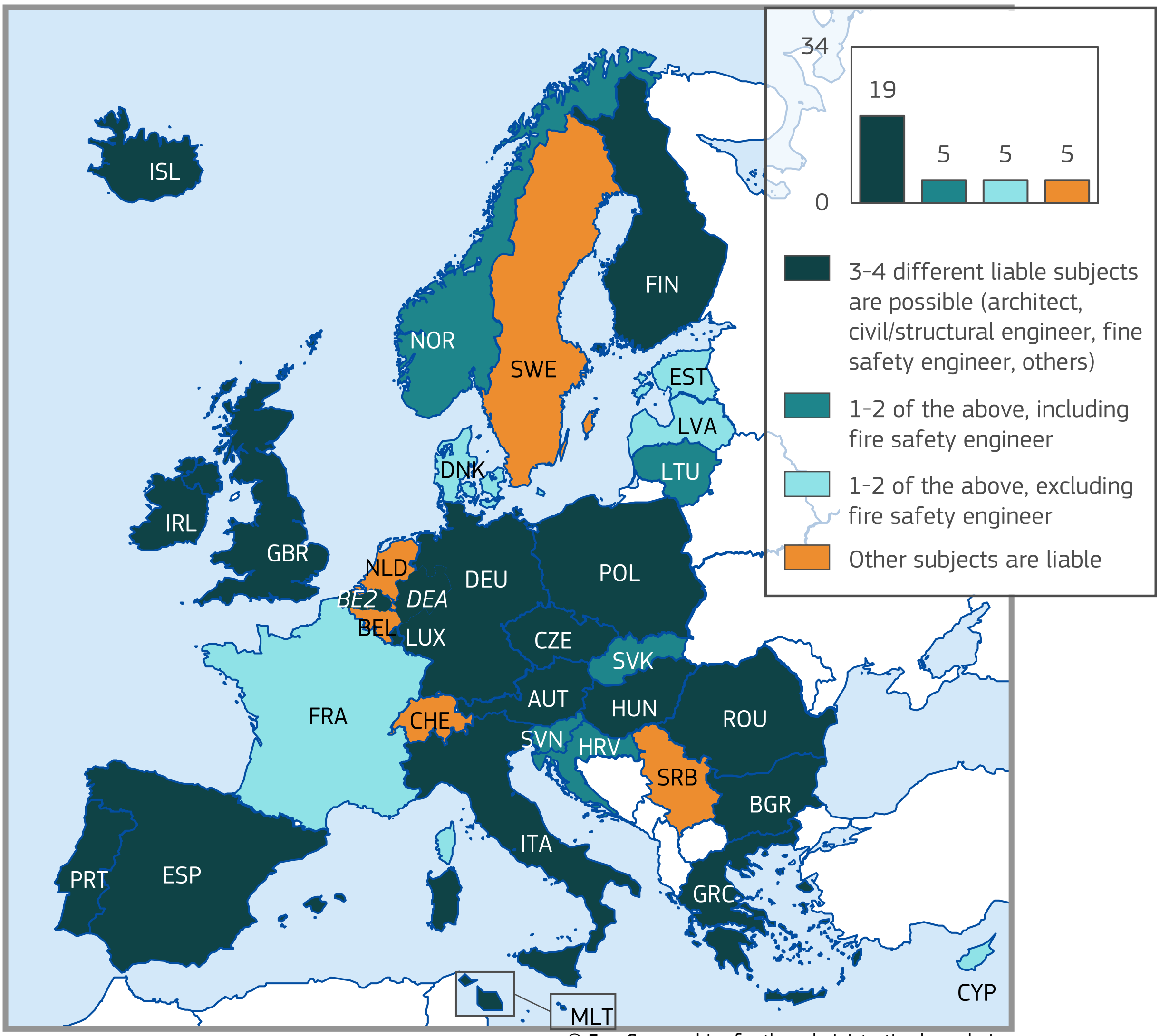


Figure 23. Involvement of local authority (LA), fire brigade (FB) and others in the approval – all countries / regions (Q3)



The liability for fire safety design, and its compliance to regulations (Q4), shows important differences through the responding countries / regions, as illustrated in Figure 24. Generally, if no specific fire safety designer is involved, the principal designer (architect or engineer) is responsible for the fire safety of the project and the constructed building. However, most countries indicate a fire safety designer as the responsible for fire design of the project, as well as for the fire safety of the constructed building. Different subjects – engineer, architect, or technician, depending on the type of project – can legally be the fire safety designer. On the other hand, in four countries (Switzerland, France, Netherlands and Sweden) liability remains with the builder or the contractor during the construction phase, and with the owner after the beginning of the building's service life.

Figure 24. Liability for the fire safety design and its compliance to regulations – all countries / regions (Q4)



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Country/ Region	CHE, FRA, NLD	GRC	HUN	SRB	ITA	SWE	BEL
Other liable subjects	Contractor (in the building phase) or owner (during the service life)	Mechanical engineer	Approving authority (>300 m³)	Qualified technical engineer	Qualified industrial technicians	Builder	No liability is defined a priori

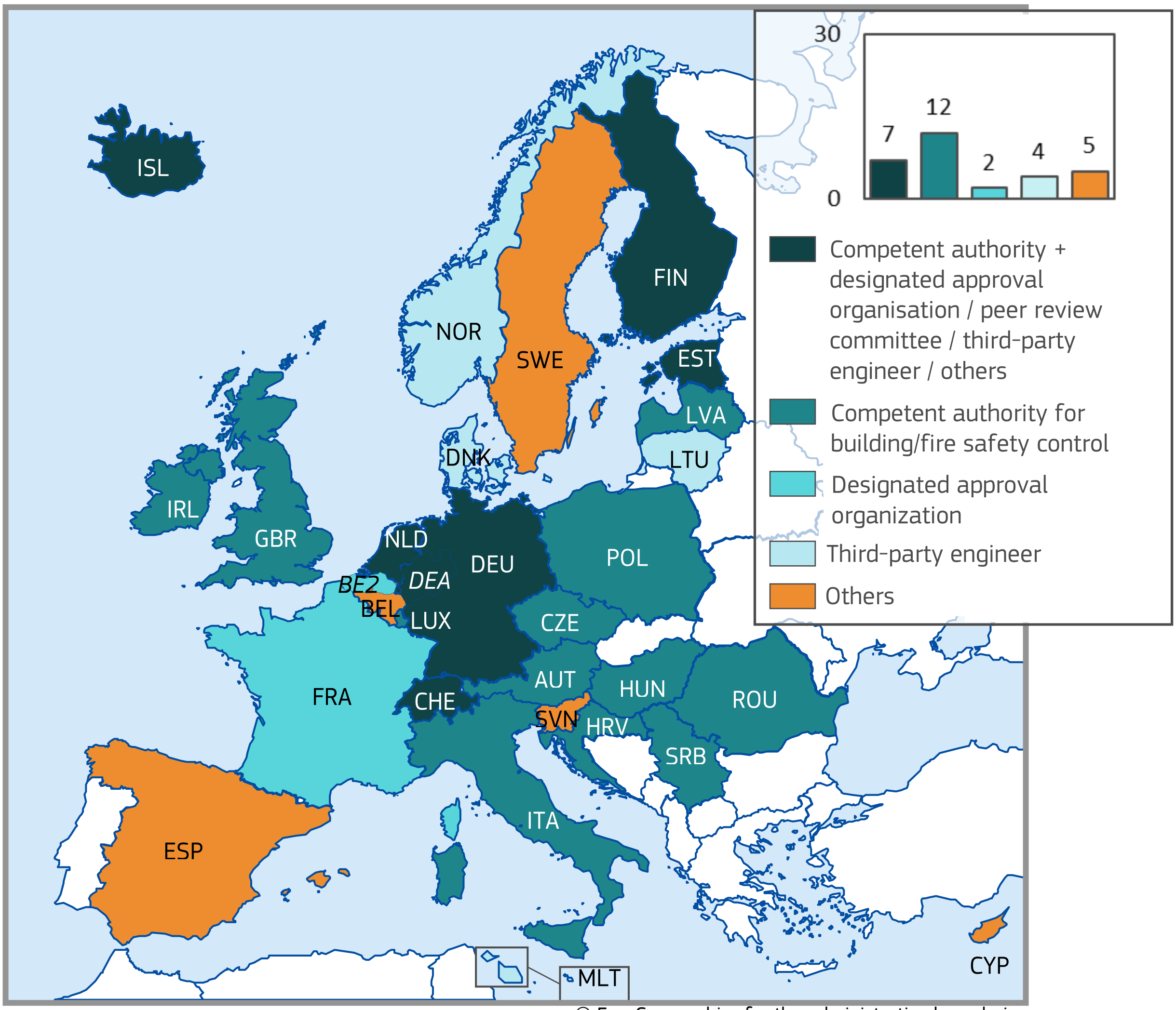
Box 5. MBA enquiry: the responsibility of architects and the involvement of external experts during the design phase of construction projects

Within the MBA enquiry, a specific part covers the responsibility of the architects, namely the questions "To what extent are architects responsible for the fire safety of the buildings they design?" and "Which other parties – besides the architect – has any responsibility for the fire safety of the final buildings?". Poland and Spain are the only countries where most architects consider themselves fully responsible for fire safety (62 and 66% respectively). In Belgium, France, Germany, The Netherlands and the United Kingdom the majority of architects consider fire safety a shared responsibility; in detail, the co-responsible parties are mostly the main contractor (Belgium, The Netherlands, United Kingdom), the building control authority (France, United Kingdom), and the fire safety engineer (Germany, The Netherlands, United Kingdom). On the other hand, most Italian architects (63%) do not consider themselves responsible for fire safety at all; the same holds the 15% of German architects and the 14% of Dutch architects. In the other Countries, this figure drops to 4% or less. Italy, Germany and The Netherlands indicate the fire safety engineer as the main co-responsible (with architect) of fire safety. The size of the design office and the type of activity (new build or restoration) make no significant difference.

Such information should be considered together with the answers of the architects about the involvement of external expertise in their projects. Generally, German architects are the most inclined to involve external expertise, while Polish and Spanish are the least. The most targeted experts are structural engineers (65%), followed by energy experts / engineers (45%), fire safety experts (36%) and finally sustainability experts (23%). Larger offices are more inclined to involve external experts. In detail, the involvement of fire safety experts can vary from 25% of projects (Poland) to 69% (Germany). Fire safety experts are more frequently involved in non-residential buildings, while other experts are equally involved in housing and non-housing projects. Finally, fire experts are more often involved in new build projects than in restoration. The latter is a very important point to be taken into consideration, because restoration work yards generally have high levels of fire risk. This is due to high levels of fire vulnerability, in reason of amounts of combustible materials – both embedded in the structure as construction materials (wood, straw) and present as furniture or works of art (tapestry, pictures). Moreover, preservation requirements often prevent the full application of legal provisions concerning fire risk limitation measures for work yards.

Figure 25 illustrates the body or bodies performing regulatory review of the FSE approach in construction projects (Q10).

Figure 25. Body performing regulatory review of FSE approach in projects – FSE-allowing countries / regions (Q10)



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Country	NLD, BEL	CHE	CYP	FIN	ESP	SWE	SVN
Other bodies	Advisory committee in case of conflict	Third-party engineer on behalf of the fire protection authorities	Dept. of Fire Prevention at National Fire Service	Third body at local authority's request	None, the designer is the only responsible	None, the builder is the only responsible	None, there's no regulation

It is shown that the body performing the regulatory review of fire design projects with FSE approach is generally the competent authority (in 19 out of 30 cases). In Cyprus, the National fire service is the competent body on the FSE approach. In other countries (Finland, Estonia, Germany, the Netherlands, Luxembourg, Switzerland) other bodies support the competent authority in the review, i.e. a designated approval organisation, peer review committee of third party engineer. No review is performed in Spain, Sweden, Slovenia, as these countries have specified by responding “Other”; in Belgium, a committee is appealed to, but only in case of a conflict.

Box 6. ISO enquiry: bodies performing regulatory review – other sources of peer review

In the seven European Countries answering the ISO questionnaire, the competent authority is always involved in the regulatory review of P-B FSD, except for Sweden. The overall results of ISO Enquiry demonstrate that the regulatory review is mostly public, either in a direct (i.e. performed by the competent authority itself) or indirect way (by third-party engineer nominated / approved by the competent authority). The answers of Austria (competent authority), Germany, The Netherlands (competent authority and/or third-party engineer) and Sweden (third-party engineer and/or others) confirm the outcomes of the present enquiry. On the other hand, France, Hungary and Spain specify different reviewing bodies from what they have done in the present enquiry.

4.4.2 Qualification for reviewers and practitioners

Q11. What professional qualification is required for the regulatory reviewers of the FSE approach in projects?

Q12. What professional qualification is required to engage in FSE approach practices?

The responding fire regulators have provided information on the professional qualification required for the regulatory reviewers of the FSE approach in construction projects, but also on the qualification necessary to engage in FSE approach practices. The data collected are illustrated in Figure 26 and provide a comparison of such framework in these two aspects.

Figure 26. Required qualification(s) to review (■) / engage (□) in FSE projects – FSE-allowing countries / regions (Q11 and Q12)

Country	AUT	BEL	*BE2*	CHE	CYP	CZE	DEU	*DEA*	DNK	ESP	EST	FIN	FRA	GBR	HRV	HUN	IRL	ISL	ITA	LTU	LUX	LVA	MLT	NLD	NOR	POL	ROU	SRB	SVN	SWE	total
Certification/license issued by the government or by a body designated by the government				□	□		■ □	■ □	■ □		■ □		■		□			■ □	■ □	■ □	■						□	■ □			10 ■ 12 □
Certification/license issued by recognised professional society or nominated body			■			□						□											■ □		■		■ □				4 ■ 4 □
Set of minimum educational/ professional experience acknowledged by government	□							■ □			■	□				■ □	■	■		□	□	■ □	■ □		□		■ □				8 ■ 10 □
Others				■											■ □									■ □					■ □		4 ■ 3 □
Qualification not explicitly defined	■	■ □	□	■	■	■	□			■ □		■	□	■ □	■		□							■ □		■ □				■ □	12 ■ 10 □

A qualification for reviewers in FSE project is not explicitly defined in 12 out of 30 countries / regions that allow for the application of the FSE approach in construction projects. Moreover, a professional qualification allowing to be engaged in FSE projects is not defined for practitioners, in several countries / regions. However, a certification / license is the most frequent requirement for professionals involved in FSE projects (in 10 out of 30 responding countries/regions). Frequently, different qualifications are required in combination, with some conflicting requirements between reviewers and practitioners. In 20 countries / regions, the same requirements apply to both reviewers and practitioners, with additional qualification necessary for the reviewers (region of North Rhine – Westphalia, Estonia, Iceland) or the practitioners (Lithuania, Romania). Different requirements apply to the two categories in the region of Flanders and the following countries: Austria, Cyprus, Czechia, Finland, France, Ireland, Luxemburg, Switzerland and, partially, Croatia.

Finally, other possible requirements than the available options have been reported as qualifications, namely:

- in Croatia, the only requirement for reviewers is a MSc diploma in Engineering field;
- in the Netherlands, non-mandatory membership of trade associations can be a qualification for both reviewers and practitioners;
- in Slovenia, no review is performed;
- in Switzerland, local fire protection authorities can appoint an expert for regulatory review.

Box 7. ISO enquiry: qualifications required to practitioners / regulatory reviewers of P-B FSD projects

The overall results of the ISO enquiry enlighten a similar situation to the present enquiry, namely:

- nearly half the responding Countries have no explicitly defined qualification for regulatory reviewers;
- the most frequent qualification is the government-issued license or certification in a relevant category;
- half the Countries have no explicitly defined qualification for FSE practitioners; the most frequent qualification is the government-issued license or certification in a relevant category;

In detail, for the European Countries of interest,

- the ISO enquiry provides confirmation to the answers of Austria, France, Spain, The Netherlands and Sweden, as far as they concern the reviewers' qualifications; Germany and Hungary have given different answers from those reported in the present enquiry;
- the ISO enquiry confirms only the answers of The Netherlands and Sweden about the practitioners' qualifications.

4.4.3 Specification of fire scenarios, design fires and fire safety criteria

Q13. Who/what specifies the fire scenarios in the project design with FSE approach?

Q14. How are the design fires specified in the project design with FSE approach?

Q15. How are the safety criteria determined in the project design with FSE approach?

The fire regulators of the 30 FSE-allowing countries/regions have indicated the source for the specification of the fire scenarios when the FSE approach is applied, as presented in Figure 27.

Figure 27. Sources of specification of fire scenarios – FSE-allowing Countries (Q13)

Country	AUT	BEL	*BE2*	CHE	CYP	CZE	DEU	*DEA*	DNK	ESP	EST	FIN	FRA	GBR	HRV	HUN	IRL	ISL	ITA	LTU	LUX	LVA	MLT	NLD	NOR	POL	ROU	SRB	SVN	SWE	total
National or regional regulations												■							■	■							■	■		■	6
Building/fire officials	■					■		■				■		■	■	■					■						■				9
Approval organisation or similar													■											■							2
Fire consultant or similar	■	■	■			■			■	■	■	■		■	■		■	■				■	■	■	■	■				■	18
Others				■	■		■	■				■	■		■	■		■							■				■		11

Through all the responding countries / regions, the importance of the fire consultant (fire engineer / expert) in the first step of fire design is evident as well as, other options than those available are often indicated. On the other hand, the role of national or regional regulations in place for the specification of the fire scenarios appears to be very limited. The breakdown per country / region shows a wide variability in the fire scenario specification. In detail, other subjects entitled to / involved in the specification of fire scenarios are reported as follows:

- in Cyprus, the architect / engineer can specify the fire scenario, if no fire consultant is appointed;
- in Croatia, the fire safety engineer proposes the fire scenario to the building control authority;
- in Switzerland, Germany, Finland and Hungary fire scenarios are ideally specified by the fire consultant, local authority and third body reviewers (if present) all together;
- in France, the local authority (not specified) is involved;
- in Iceland, national regulations refer to various national and international documents;
- in Norway, mandatory scenarios are specified in a national standard.
- finally, Slovenia specifies the fire engineer as "other" specifier of fire scenarios; this can possibly be the same as the fire consultant.

Box 8. ISO enquiry: specification of fire scenarios

From the ISO enquiry, a different picture emerges about the specification of fire scenarios. In fact, the regulations in place (national to local) have a prevalent role in more than half of the interviewed Countries; in half of the Countries, fire scenario are prescribed by expert judgements, both of building / fire officials and approval organisations.

The ISO results can partially confirm the outcomes of the present enquiry (Austria, Spain, Sweden).

The sources for the specification of design fires and safety criteria (Q14 and Q15, respectively) are presented together and compared in Figure 28. The replies to the two questions provide the same options as the possible sources for the specification of the design fires and safety criteria for FSE projects.

Figure 28. Sources of specification of design fires (■) and safety criteria (□), breakdown per Country / Region – FSE-allowing Countries / Regions (Q14 and Q15)

Country	AUT	BEL	*BE2*	CHE	CYP	CZE	DEU	*DEA*	DNK	ESP	EST	FIN	FRA	GBR	HRV	HUN	IRL	ISL	ITA	LTU	LUX	LVA	MLT	NLD	NOR	POL	ROU	SRB	SVN	SWE	total
The procedure is prescribed in a regulation					■ □		■	□			■ □	□				□					■			□		□	■ □	■ □		■ □	7 ■ 10 □
By reference to the national documents describing the guideline/recommendation on the procedure									■ □		■ □	□	■ □				□			□	□			□	■ □		■ □				5 ■ 10 □
By the engineer, with reference to internationally recognised documents in relevant area with approval of competent authorities	■		■ □	■ □	■ □			■		■ □	■ □	■ □	■ □	■ □			■ □	■ □	■ □	■	□	■ □	■ □	■ □	■ □	■ □	■	■ □			21 ■ 18 □
By the engineer, at their discretion, with approval of competent authorities	■ □	■ □		■ □		■ □	■ □	■ □				■ □	■ □	■ □	■ □	■	■ □	■ □			■ □	■		■ □		■ □					17 ■ 15 □
By discretion of the peer-review committee		■ □																	□												1 ■ 2 □
By discretion of the building/fire officials in charge		■ □										■ □	□												■						3 ■ 3 □
Others				■ □								■ □							■ □										■ □		4 ■ 4 □

In most countries / regions, both the design fires and safety criteria rely on the engineer (they can be defined or selected, depending on the regulatory framework); only a few countries / regions have prescribed rules for such determination procedures. The fire safety professionals' FSE education and training with the availability of internationally recognised documents in the field are thus of crucial importance.

In general terms, most countries seem to agree about the importance of the different sources for the identification of the design fire and safety criteria.

The breakdown per country / region shows a balanced picture, in which both the design fires and fire safety criteria are in most cases specified by the same subjects. Generally, many different sources seem to be involved in parallel. Some atypical procedures (different from the given options) are also in place in some countries, namely:

— in Switzerland, the fire design and safety criteria can be established only in accordance with the fire safety authority;

— in Finland, also third-body reviewer is involved;

— in Italy, the design fire is approved by peer review, while the fire safety criteria are determined on the grounds of national guidelines and internationally recognised documents in the relevant field;

— in Slovenia, the fire engineer specifies the design fire, while there are no safety criteria.

Box 9. ISO enquiry: specification of design fires and fire safety criteria

The overall results of the ISO enquiry confirm the prevalent reliance on the engineer, with the approval of the competent authority and the possible reference to internationally recognised documents in the relevant area.

The feedback of seven European Countries which responded to the ISO enquiry is in line with the general trend. Some differences can be found, with respect to the present enquiry, for the responses of Hungary and France.

4.5 Education, training and research needs for FSE

4.5.1 Educational framework

Q19. Which official educational bodies offer FSE education and training to students?

Q20. Do you see a need for FSE post-secondary education?

Q21. Do you see a need for FSE Continuing Professional Development courses?

Q22. Should FSE be part of the training for firefighters and/or other emergency responders?

The last part of the enquiry was dedicated to issues related to the FSE educational framework. Figure 29 presents the information collected by the responding countries/regions on the official educational bodies offering FSE related education and training (Q19), whereas the responding regulators views on the need for additional FSE-related post-secondary education (Q20) is illustrated in Figure 30.

Figure 29. Offered FSE education and training – all the responding countries / regions (Q19)

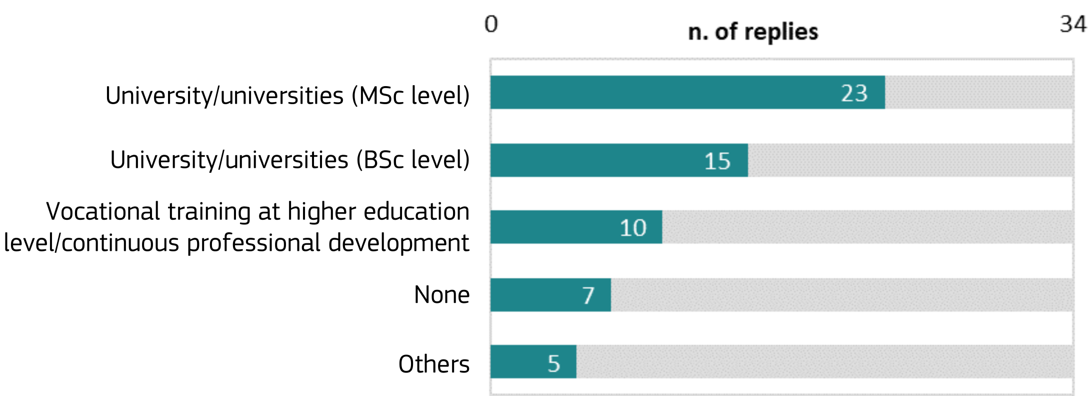
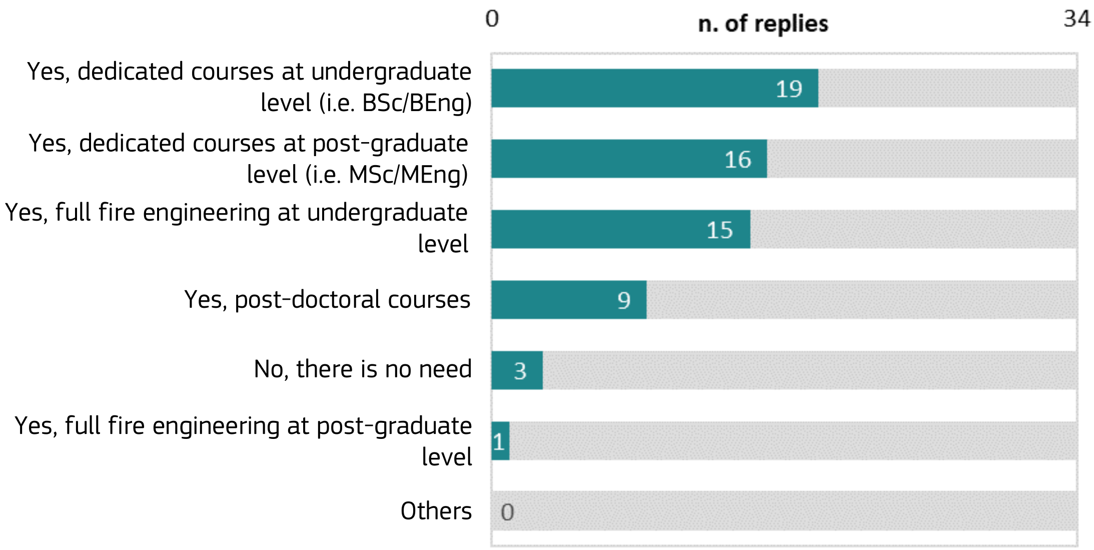


Figure 30. Needs for additional FSE education and training to professionals – all responding countries/regions (Q20)

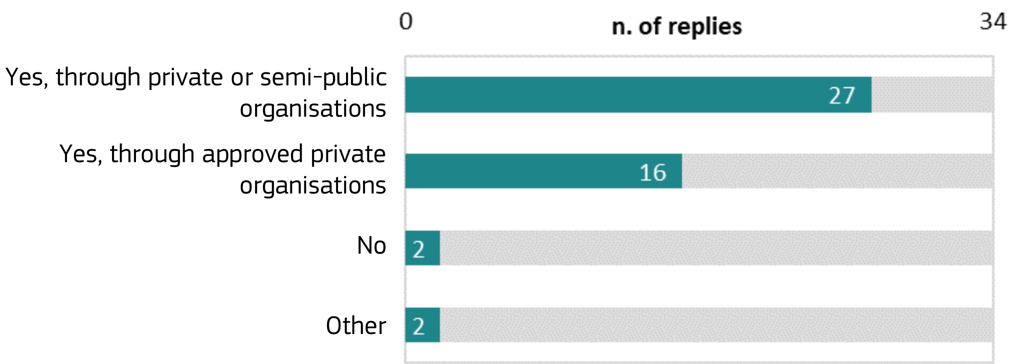


Comparing the replies on the currently available FSE-related education (Figure 29) and the needs for additional training acknowledged by the responders (Figure 30), it seems that educational course at the MSc level are, and/or are wished to be, the key sources for FSE education and training for students. Moreover, several fire regulators have noted the need for full fire engineering courses even at undergraduate level.

Other sources for FSE education illustrated by the responding countries are national and international fire safety related bodies, e.g. dedicated research centres and the national Fire and Rescue Service. No official FSE education and training is available in some countries (Bulgaria, Cyprus, Lithuania, Luxembourg, Portugal, Serbia and Slovenia). Finally, three countries (Bulgaria, Estonia and Serbia) see no need for post-secondary FSE education.

The information on the needs for education and training for professionals and for firefighters, according to the responders' opinions is presented in Figure 31 (Q21) and Figure 32 (Q22).

Figure 31. Perceived need for FSE education and training to professionals – all responding countries/regions (Q21)



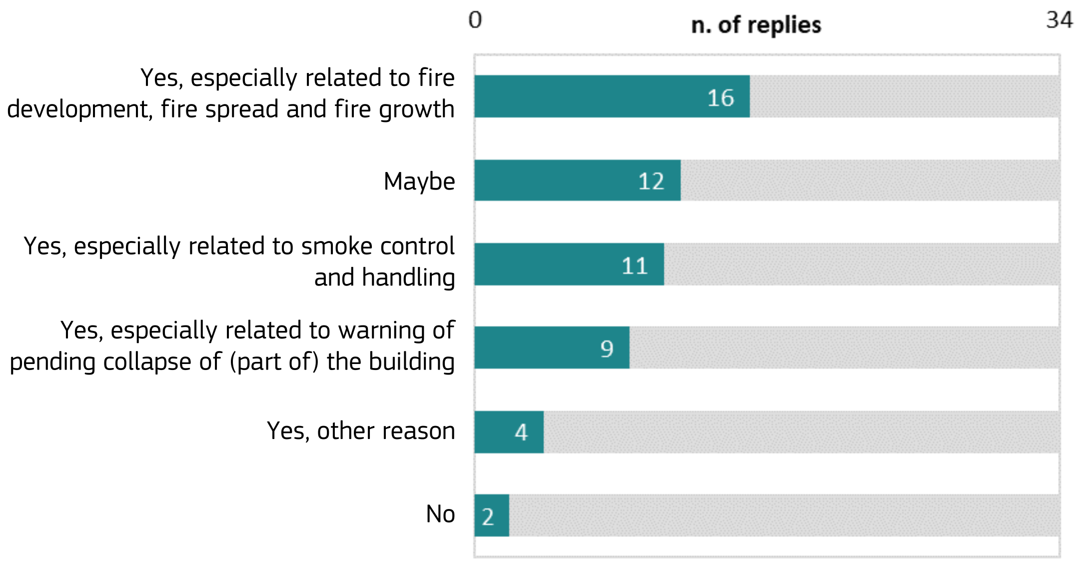
Most of the responders indicate private and semi-public organisations as the preferred providers for continuing professional development courses (Figure 31). Only Bulgaria and Estonia see no need for professionals' education and training on FSE, similarly to the answers presented in Figure 30.

FSE-related training to firefighters and other emergency responders is recognised according to more than half of the responders. In particular, the fire regulators have commented that such training should focus on issues like fire development, spread and growth. Some countries have also pointed out other topics on which such training can focus, in particular:

- focus on FSE approach for high-rise buildings (Cyprus);
- for firefighters aiming to authority positions (Finland).

In the case of FSE-related training needs for firefighters and emergency responders, it is only two countries (Switzerland and Hungary) that see no need for such training.

Figure 32. Perceived need for FSE education and training to firefighters – all responding countries / regions (Q22)



Box 10. BeneFEU / CEN TC127 enquiry: education and training

The results of BeneFEU / CEN TC127 enquiry confirm the importance of MSc level courses in providing FSE education to students.

However, only the 50% of all the responding countries provide educational FSE support for professionals. Generally, more courses are dedicated to regulation enforcers and design practitioners than to regulators.

4.5.2 Standardisation and research

Q17. Which topics should be further developed by the standardisation organisations (e. g. CEN, ISO, National Standardisation Bodies, etc.) to support the FSE approach practices in your country/region?

Q23. Which areas of FSE should be subject for research?

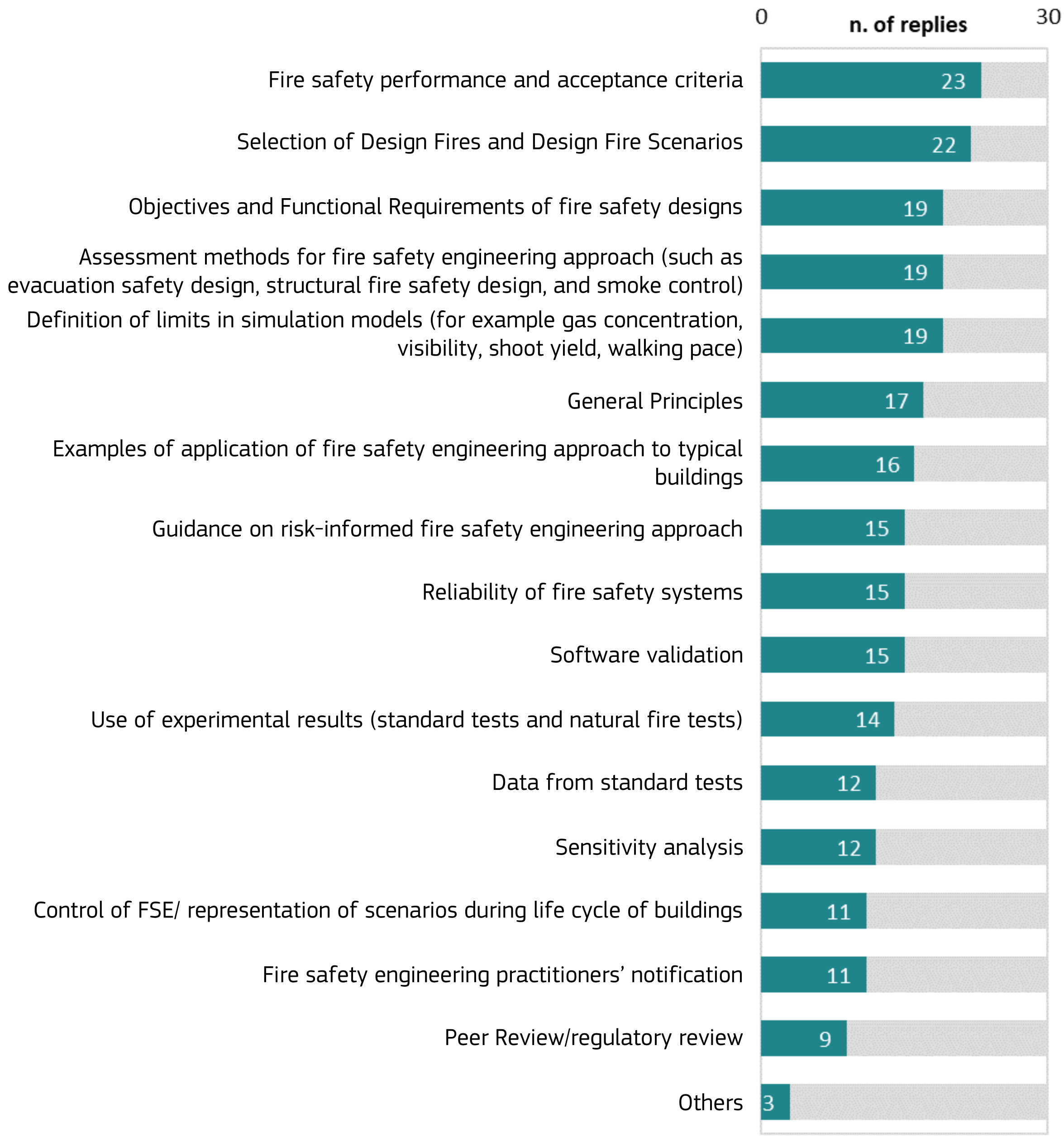
According to the responders' opinions, the most important topics for standardisation to be further developed (Q17) are the selection of design fires and design fire scenarios, and fire safety performance and acceptance criteria (Figure 33). The figure presents the views of the fire regulators of the countries that allow for the use of FSE approach in construction projects.

The relevance given by responders to such options is in fair agreement with the answers to Q13, Q14 and Q15, which demonstrate that the specification of fire scenarios, as well as the selection of design fires and safety criteria, mostly relies on expert judgement. Standardised FSE assessment methods, definition of limits in simulation models, and objectives and functional requirements of fire safety designs, are also indicated as important topics for standardisation.

Other needs (specified as "Other" option) noted by the responders are the following:

- Guidance on building management and systems maintenance to ensure that the FSE approach is operational as per the design principles during the life cycle of the building (Cyprus);
- Common requirements on the use and approval of simulators (smoke and heat, evacuation, etc.) (Hungary);
- Information and possibility to choose limited parameters in the standards (Lithuania).

Figure 33. Topics to be developed by standardisation organisations – FSE-allowing Countries / Regions (Q17)



Box 11. ISO enquiry: which topics should be developed by ISO TC92/SC4 documents to benefit the P-B FSD practices

According to the responses to the ISO questionnaire, the topics of interest for standardisation are:

— Selection of design fires and design fire scenarios;

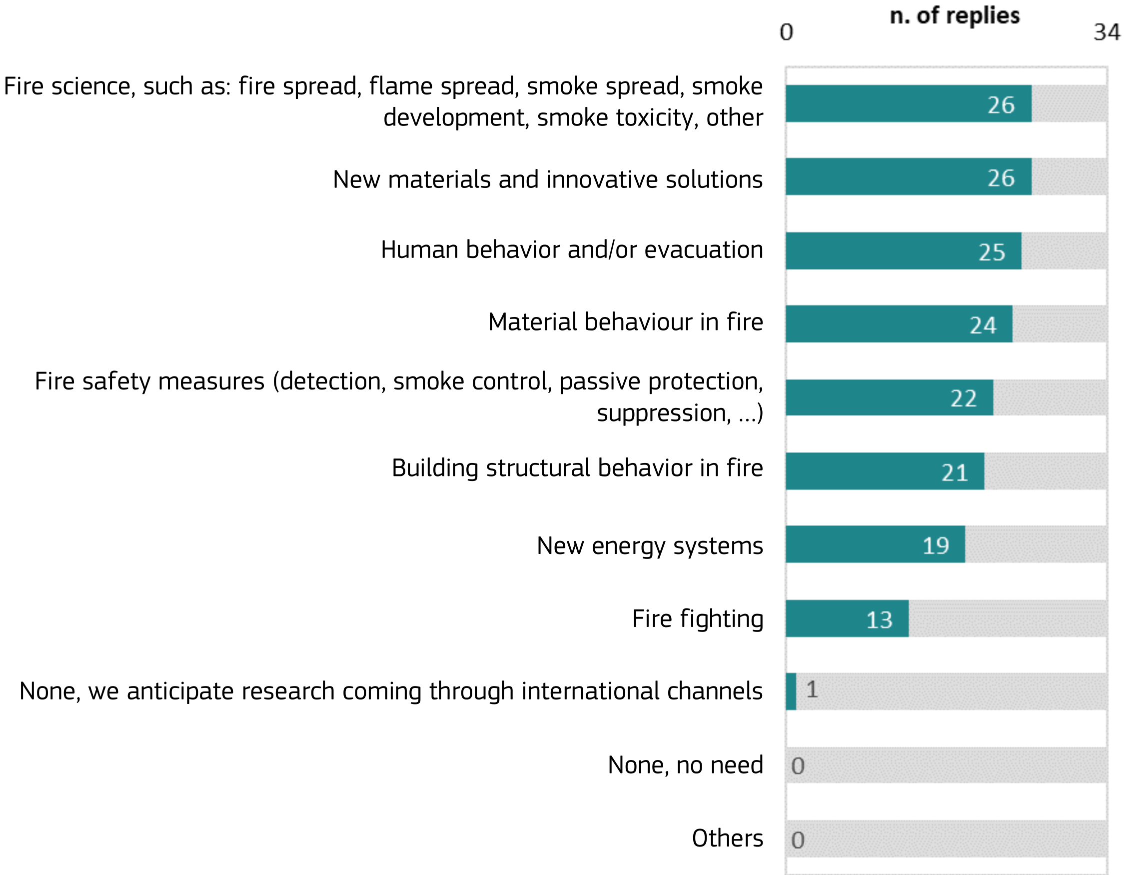
— Determination of fire safety criteria;

— Representative fire safety criteria and limits of application.

Within the ISO enquiry, all the European Countries agree about the importance of such topics.

The research needs identified by all responding countries / regions (FSE-allowing and not) are illustrated in Figure 34. It is noted that according to the responders' opinions, there are many areas of research in need of development to improve the implementation of FSE approach.

Figure 34. Research needs for FSE – all responding Countries / Regions (Q23)



It seems that the fire safety design in innovative buildings might be the ideal target for the use of FSE based design methods (new materials and innovative solutions). Moreover, it is evident that the design procedures should be based on scientifically obtained data and models (i.e. fire science, such as fire spread, flame spread, smoke spread, smoke developments, smoke toxicity, other) and also focus on the users' communities (Human behaviour and/or evacuation).

Box 12. BeneFEU / CEN TC127 enquiry: research needs

The BeneFEU / CEN TC127 enquiry details the identified needs of research and development.

— Demographics data. The use of buildings is changing with the aging of population and the access of disabled people. The design of a building should account for this, especially in relationship with fire scenarios and evacuation routes and dynamics.

— Fire hazard of new, sustainable buildings. New building construction responds to new environmental criteria, and may lead to new fire hazards, which current regulations do not take into consideration.

— Models for fire department response. Prescriptive regulations include measures to assist and to protect firefighters; however, models to account for this in FSE applications are lacking.

— Standardised approach for material properties.

— Adequacy of passive fire-resistive construction. Active and passive fire protection are generally adopted together, to obtain a desirable redundancy; but the passive measures are generally treated within prescriptive approach.

4.6 Additional comments of the responders

Q24. Open comments: Opinions/comments/questions on any current and future topics in your country/region, or on European level, concerning FSE practice; feedback on fire safety engineering studies.

All the additional comments provided by the responders are noted below.

- Discussion about FSE among stakeholders is in progress in Austria; changes in regulations are currently being introduced in France and Sweden.
- Belgium especially remarks the issues of liability of the designer / engineer and wishes for the introduction of an ethical framework above the engineering skills. Cyprus as well is concerned with the definition of the responsible engineers for the application of FSE approach.
- Cyprus also wishes for the introduction of specific guidance at European level, covering all the aspects of FSE approaches; according to Finland, European approaches concerning acceptance criteria should account for nationally-defined safety levels. Serbia suggests that common European regulations in the field of fire protection of gas boiler rooms, especially in high-rise housing, commercial and public buildings, would be useful.
- Bulgaria specifies that fire safety requirements must be the same and applied in the same way throughout the country. At present, laws regulate mandatory requirements for ensuring the fire safety of buildings, concerning the safety of people, the safety of rescue teams and the ways to limit the spread of fire, all applied jointly.
- Hungary describes the process of development of its national regulations (Fire Protection Technical Guidelines, issued by the National General Directorate for Disaster Management). It is remarked that consultations between Fire Safety Engineers and the fire authority can be difficult, because of possible push from the investor or the government to accelerate the construction of a building. The main difficulties in implementing FSE approach in Hungary are basically due to the lack of expertise both in creating and evaluating fire scenarios and models, the lack of supporting data and approved calculation methods, and generally to the fact that the reliability of results mostly depends on the qualification and expertise of the engineer.
- The importance of appropriate FSE education and training for professionals and approving authorities is also remarked and detailed by Cyprus; in particular, more teaching should cover Finite Element Modelling for structural members, Computational Fluid Dynamics for smoke behaviour analysis and smoke evacuation, and human behaviour analysis regarding the effect of age, disability and cultural differences in evacuation processes. FSE skills should cover not only the design phase, but the whole service life of an FSE-designed building. From this point of view, the responsibilities of the insurance companies are underlined.
- Netherlands suggests to consider bio-based constructions, car parks, electric vehicles and façades in FSE approach.
- Finally, Sweden suggests checking the definition of deemed-to-satisfy solution across the different countries / regions.

4.7 Comparative analyses for country and region responses

In two cases throughout the outcomes of the Questionnaire, the responses of a Country can be compared to those of its Region, i. e. Belgium to the Flanders, and Germany to North Rhine-Westphalia.

The first BeneFEU report of 2002 (Joyeux 2002) helps enlightening the relationships of each responding Country with its Regions in the field of fire design regulations. In particular, National and Regional regulating systems coexist in both Belgium and Germany;

— in Belgium, the main national regulation is a federal law; each region has its own sub regulation, which is complementary to the federal law.

— in Germany, the national regulation is the Building Regulations of the Länder (= Regions), which is a Model Building Code and may be overruled by the legislation of the individual Land.

4.7.1 Belgium and the Flanders

The current regulations were enforced in 1995 at national level and in 2011 in the region; however, the regional system remains fully prescriptive as for the technical details (Q1 and Q2). Belgium and the Flanders Region have given the same or mainly similar answers about:

- Nature of technical detail in fire design (Q2)
- Liable subjects for fire design (Q4)
- FSE allowance (Q5)
- Reasons for applying FSE approach to fire design (Q8)
- Regulatory framework allowing for FSE-based fire design (Q9)
- Required qualification for FSE practitioners (Q12)
- Specifier of fire scenarios in FSE projects (Q13)
- Need for FSE training and education (Q19 to Q23).

Minor differences between country and region appear in the following specifications:

- The main approving body is the Fire Brigade, but the Country and the Region indicate different other involved authorities (Q3).
- At the national level, the FSE approach is applicable to any type of construction for which prescriptive solutions are not available; on the other hand, the Flanders' response specifies that it applies only to health care facilities, housing for elderly people and hospitals (Q6).
- The Country and the Region refer to different reviewing bodies (a National Committee for peer review – as "Other" answer – and a Designated Approval Organisation) (Q10)

Finally, the most important differences between the national and regional responses are summarised as follows:

- The Technical Areas mainly involved in FSE are different for the Country (Smoke Compartment Systems, Structural Fire Safety and Prevention of Fire Spread) and the Region (Fire Detection, Early Suppression, Evacuation Routes) (Q7).
- While at the national level the qualification of reviewers is not specified, the Region prescribes that they must hold a proper certification (Q11).
- In the specification of the design fires as well as of the safety criteria, the Country points out a discretion-based system which may include different specifiers. On the other hand, the Region commits the specification to the engineer, with reference to internationally recognised documents and approval of competent authorities (Q14 and Q15).
- The available assessment methods are prevalently designated by building/fire regulations at the national level, while they are approved by government/designated bodies at the regional level (Q16).

According to the information provided by the BeneFEU enquiry, the minor and major differences should be understood as Region's complementary tools and procedures to the national regulations.

4.7.2 Germany and North Rhine-Westphalia

The current regulations in Germany and its Region North Rhine-Westphalia are recent and were enforced in the same period (2018-2019). The two systems are deemed prevalently performance-based, although the Region exhibits a higher percentage of prescriptive solutions in the considered Technical Areas (Q1 and Q2). Germany and North Rhine-Westphalia have given the same or very similar answers about:

- Liable subjects for fire design (Q4)
- FSE allowance (Q5)
- Types of constructions to which FSE design applies (Q6)
- Technical areas to which FSE design applies (Q7)
- Regulatory framework allowing for FSE-based fire design (Q9)

— FSE design projects reviewing body (Q10)

— Need for FSE training and education (Q19 to Q23).

Minor differences between country and region appear in the following specifications:

— The main approving body is the Local Authority, but the Country and the Region indicate different other authorities involved in the approval process (Q3)

— The required professional qualification is the same for both FSE reviewers and practitioners; the certification/license in relevant category issued by the government is a national requirement, while the Region also requires a set of minimum educational or professional experience acknowledged by the government (Q11 and Q12)

— At both national and regional level, the engineer can specify both design fires and safety criteria at their discretion, subjected to the approval of the competent authorities; however, the region also allows other sources of specification (Q14 and Q15)

Finally, the most important differences between the national and regional responses are summarised as follows:

— According to the region responder's opinion, the reasons for applying FSE approach are cost reduction and enhancement of the fire safety performance of the building, while the country does not give such reasons (Q8)

— In the country's reply, the fire scenarios are specified by agreement of building authority, third-party fire safety review engineer and fire safety design engineer; the region only mentions building/fire officials as the specifiers of fire scenarios (Q13).

— For the country, the available assessment methods in FSE field are prevalently those described in standards, referenced in the building/fire regulations; on the other hand, the region mainly leans on scientific literature (Q16).

According to the information provided by the BeneFEU enquiry, the minor and major differences should be understood as Region's alternative tools and procedures to the national regulations.

5 Conclusions, recommendations and further work

5.1 Conclusions from the enquiry

5.1.1 Status of implementation of FSE

As for the status of implementation of FSE approach in the responding countries / regions (27 EU MS, three EFTA MS and two CEN countries, as well as two regions), it can be concluded based on the enquiry that the FSE approach currently is not fully implemented in the national regulatory frameworks, even in case of recently issued or updated national regulations.

However, only four countries (Portugal, Greece, Bulgaria and Slovakia) have responded that FSE approach is not allowed in fire safety design; this fact seems to be the result of practical lack of tools, education and experience in FSE-related issues rather than any legal restrictions.

To address the technical details or technical areas within the FSE approach (fire detection, early suppression / suppression systems, evacuation routes, smoke control systems, structural fire safety, fire compartmentation, smoke compartmentation, prevention of fire spread to neighbouring buildings, material / system selection for façades, material / system selection for other relevant areas, firefighting and building installations), prescriptive methods are largely prevalent in practice throughout the countries responding the enquiry, even if FSE approach is allowed.

Through the different technical areas, the shares of applicability of the different design approaches are basically the same: about 50% are prescriptive, 20-25% deemed-to-satisfy and 25-30% performance-based. In principle, the need to implement a performance-based approach in the future is widely acknowledged in the countries.

The main reason to adopt FSE approach in fire design is the need for innovative in the built environment (i.e. to implement new technologies and design innovative spaces). Moreover, FSE is frequently allowed in cases that prescriptive design approaches for fire design are not available, especially for strategic buildings (hospitals, airports, museums, concert halls, sports hall), or in projects beyond certain limits of height, area and/or complexity (e. g. high- and super high-rise buildings). The FSE-based approach is in general applied to almost all technical areas, with the frequent exception of residential buildings.

Approximately 60% of the responding countries allow for only one approach for each technical area, enlightening mainly restricted choices for fire designers; about 30% of the countries allow at least for a choice between two approaches. The availability of calculation methods seems conditioned by the availability of international and national standard and codes, which are the main sources for methods.

The comparison of the enquiry results with other studies showed partial confirmation for the results of the present enquiry. In particular, the ISO enquiry – concerning the specific countries covered also by the present enquiry – indicates the lack of regulations for certain types or aspects of buildings as the main reason for adopting FSE; the wide adoption of FSE, extended to any type of structure; the shared character of liability for fire design in construction projects; the lack of predefined qualifications for FSE reviewers / practitioners; finally, the crucial role of the engineer in specifying design fires and safety criteria. The technical areas mostly covered by performance-based design solutions are the same in the ISO enquiry as well as in the BeneFEU study. On the other hand, the ISO enquiry reveals a higher relevance of academic sources for the technical detail necessary with the assessment methods; some differences can be noticed in the specification of the FSE approach reviewing body; finally, the ISO enquiry indicates the prevalence of regulations in place as sources of specification of fire scenarios, while the JRC enquiry has highlighted the role of the fire consultant. The MBA enquiry noted a limited involvement of fire design experts in restoration projects in the built environment.

5.1.2 Education and training needs

The results of the enquiry point out that the non-allowance for FSE approach application is mainly due to the lack of expertise of involved professionals, and insufficient infrastructure (legal, insurance, professional certification etc.) supporting the application of FSE approach in practice.

Aside from this clear conclusion, the role of technical and scientific education on FSE-related topics is crucial in all countries, because it is closely connected to the qualification framework for reviewers and practitioners, the specification of fire scenarios, design fires and safety criteria, and finally the liability of fire safety designers / consultants for design projects.

In fact, the enquiry has highlighted a very diverse qualification framework through the countries / regions, where the certifications issued by public bodies and the official acknowledgement of professional experience have an certain importance. The fact that about one third of the responding countries / regions states that qualifications are not explicitly defined basically increases the importance of professionals' / reviewers' education.

Finally, qualified professionals, i.e. FSE-educated engineers, are key actors as revealed by the involvement of fire safety experts as liable subjects for the fire part of construction projects, as well as in designing the actions, conditions and safety objectives of the FSE project. Such experts may have very different educational degrees depending on the type of project, underlining the importance of universities as well as that of high schools and public-private bodies offering professional-oriented teaching.

5.1.3 Standardisation and research needs

In the countries that apply FSE approach in building fire design, the need for standardisation is particularly high in the selection of design fires and fire scenarios as well as in the fire safety performance and acceptance criteria. In fact, such responsibilities currently rely on expert judgement, as shown by the responses about the specifiers of fire scenarios, design fires and fire safety criteria. The development of standards in such fields would increase the uniformity and objectivity in the processes of design and evaluation of FSE projects.

Further, the objectives and functional requirements of fire safety design, the assessment methods for FSE approach (such as evacuation safety design, structural fire safety design, and smoke control) and the definition of limits in simulation models (e. g. gas concentration, visibility, shoot yield, walking pace) are indicated by the responders as topics of interest for standardisation. This indeed confirms the need of support especially for designers in the use of advanced calculation methods.

Finally, there is agreement about the importance of research for the future development of FSE-based approach. As the responses of all countries / regions indicate, research should deepen the knowledge in fire science and material behaviour in fire as well as human behaviour and/or evacuation, and fulfil the need for innovative materials and solutions for fire design. This points out that the fire safety design of innovative buildings – especially featuring innovative materials or technological solutions – is seen as the main task of FSE; it must rely on scientifically obtained data and models from physics (of fire, materials etc.) as well as from human sciences.

5.2 Recommendations and future work

The following recommendations propose the next steps that can be promoted towards the aim of harmonisation of FSE implementation in the national regulatory systems.

Further research, focused on the reasons for non-allowance and the practical non-application, should better clarify and describe the obstacles to the acceptance of FSE approach in fire design. In particular, the difference between formal (i.e. at the code level) and practical non-allowance of design according to FSE approach should be substantiated. Then, it would also be opportune to focus on the other Technical Areas (i.e. areas mentioned by some of the responders, different than those accounted for in the questionnaire), to clarify what they are and why they are applied prescriptive, deemed-to-satisfy or performance-based approach.

A detailed study on FSE education both at university and professional level is recommended, to clarify the comparison between the paths to educate FSE engineers / experts / consultants and the tasks such professionals / officials are called to fulfil.

A focused investigation on the aspects that show the most varied features among the EU/EFTA MS and other CEN countries involved in the presented enquiry – mostly the qualification frameworks for reviewers / practitioners and design review and approval processes – is recommended. A deeper clarification of what each country means as "fire safety expert", "fire safety consultant", "fire safety engineer" – especially in terms of required qualification – seems opportune.

The objective of next efforts should be the identification of good practice examples in building fire design and construction across the targeted countries. In detail, the societal and economic effects (advantages and disadvantages) of typical or atypical practices, procedures and professional / official figures detected by the present JRC enquiry are to be observed in detail. This holds particularly in reference to the specific legal, social and physical context of the countries. The data provided by the 2001 BeneFEU report (with possible updates) could be a good basis to contextualise fire design codes and provisions in each country. The problems or issues touched or not touched by current practices (e. g. the liability for fire design; construction cost; duration of the design, approval and construction process) should be identified, possibly with reflection on case studies.

References

Athanasopoulou, A., Dimova, S., Sousa, M. L., Iannaccone, S., Progress report on the work on development of a fire engineering approach to be incorporated in fire safety regulations of the EU member states (Tasks 4.1, 4.2 and 4.3) during Year 2 (01.07.2019 – 30.06.2020), JRC Technical Report (EU restricted), 2020

Caird R. G., 'Fire safety engineering: role in performance-based codes', in: *Proceedings of 3rd Asia-Oceania Symposium on Fire Science and Technology*, Singapore, 10-12th June 1998, edited by Ch. Ching and S. Sugahara, Asia-Oceania Association for Fire Science and Technology, Singapore, 1998

De Hults, Q., *Architects survey on fire safety competency*, Modern Building Alliance, 2019

European Committee for Standardisation, Fire Safety Engineering in Europe - Review of national requirements and application, CEN/TR 17524: 2020

International Standard Organisation, Fire safety engineering – Survey of performance-based fire safety design practices in different countries, SC4 N1290 ISODTR 20413, 2019

Joyeux, D., BeneFEU - Benefits of fire Safety Engineering in the EU, The potential benefits of Fire Safety Engineering in the European Union, Final Report to DG Enterprise, 19 July 2002

Joyeux, D., Benefits of Fire Safety engineering in the EU - Updating the BeneFEU program, CEN TC127/WG8 N0136 Rev N0126, 2018.

List of abbreviations and definitions

FSE	Fire Safety Engineering
DTSS	Deemed-to-satisfy Solution
MS	Member State
PBS	Performance-based Solution
PS	Prescriptive Solution

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Annexes

Annex A. JRC fire safety expert network

Name	Role and affiliation	Country
Bin Zhao	Chairman, CEN/TC250 “Structural Eurocodes” Horizontal Group Fire	France
Debbie Smith	Chairperson, CEN/TC127 “Fire Safety in buildings”; Managing Director BRE Global Ltd - retired	U.K.
Kees Both	Manager, Standards and Regulations, ETEX BP Innovation & Technology Centre at ETEX; President, SFPE - Society of Fire Protection Engineers, Europe	Netherlands
Patrick van Hees	Professor, Lund University, Head of Office at Division of Fire Safety Engineering	Sweden
Fabienne Robert	Deputy Head, CERIB Fire Testing Centre	France
Francisco Miranda Perales	European Parliament	EU
Bart Merci	Professor, Ghent University, Department of Fluid Mechanics, Heat and Combustion	Belgium
Armelle Muller	Director Centre National de Prévention et de Protection, France (CNPP)	France
Benoît Dôme	International Federation for the Safety of Electricity Users (FISUEL)	Belgium
Francesca Sciarretta	Joint Research Centre, Safety and Security of Buildings Unit	EC – DG JRC
Krzysztof Biskup	Vice-chair, European Fire Safety Alliance (EuroFSA)	Poland
Daniel Joyeux	Chairman, Effectis Management Board; Convenor, CEN TC 127 WG8	France
Nick Malakatas	Chairman, CEN/TC250 "Structural Eurocodes" SC1 "Actions on Structures"	Greece
Nicola Tondini	Assistant Professor, University of Trento, Department of Civil, Environmental and Mechanical Engineering	Italy
Stephan Wevers	President Federation of European Fire Officer Associations	Netherlands
Andreas Rausch	Vienna Fire Brigade and Rescue Service, Federation of European Fire Officer Associations	Austria
Marco Andreini	Occupational Health & Safety and Environmental Protection Unit, CERN - European OrganisationOrganisation for Nuclear Research	Switzerland
Artur Pinto	Joint Research Centre, Safety and Security of Buildings Unit	EC – DG JRC

Silvia Dimova	Joint Research Centre, Safety and Security of Buildings Unit	EC – DG JRC
Adamantia Athanasopoulou	Joint Research Centre, Safety and Security of Buildings Unit	EC – DG JRC
Luisa Sousa	Joint Research Centre, Safety and Security of Buildings Unit	EC – DG JRC
Torbjörn Dyngeland	Joint Research Centre, Safety and Security of Buildings Unit	EC – DG JRC
Heikki Väänänen	Policy Officer, Sustainable Construction Unit, DG GROW, European Commission	EC - DG GROW
Dimitrios Athanasiou	Policy Officer, Buildings and Products Unit, DG ENER, European Commission	EC - DG ENER
Perrine Ethuin	formely, Modern Building Alliance	Belgium
Yannick Le Tallec	Deputy Manager, Certification, Effectis; former Technical Secretariat, FIEP	France
Quentin de Hults	Director, Green & Healthy Buildings, European Copper Institute	Belgium
Michael Strömgren	Chief Innovation Officer, Briab	Sweden
Samaras Panagiotis	Athens International Airport S.A.; Modern Building Alliance (MBA)	Greece
Adam Krasuski	Institute of Safety Engineering, The Main School of Fire Service	Poland

Annex B. Questionnaire

1. Responders Information (mandatory)
   - Name:
   - Affiliation:
   - Occupation:
   - Country/Region:
   - Contact email:
   - Contact address:
2. GENERAL INFORMATION ON EXISTING FIRE REGULATION

(Q1a) Please provide the title(s) of your current national/regional (if relevant) fire regulation(s) for construction works.

(Q1b) Please provide the year in which your current national/regional fire regulation was enforced.

(Q2) What is the nature and level of the technical detail in your fire regulation, considering the following technical details? (Check all that apply.)

Technical area	Requirements					
	Prescriptive solutions		Performance based solutions		Deemed-to-satisfy solutions	
	yes	no	yes	no	yes	no
Fire detection						
Early suppression/ suppression systems						
Evacuation routes						
Smoke control systems						
Structural fire safety						
Fire compartmentation						
Smoke compartmentation						
Prevention of fire spread to neighbouring building						
Material selection for façades						
Material selection for all other relevant areas excluding facades (e.g. interior finishing, cables, internal insulation, furniture, etc.)						
Firefighting (fire brigade access and intervention)						
Building installations (for example, electricity, gas. lifts)						
Other(s) (please specify):						

If Other(s), please provide the details (nature and level of technical area(s)).: ______________________

(Q3) Who issues the approval of a construction work project from the fire safety design perspective? (Check all appropriate answers).

Local authority ☐YES ☐NO

Fire brigade ☐YES ☐NO

Other – please specify which one(s): ____

(Q4) Who is liable for the fire safety design of construction works and the design compliance to the regulation?

Architect ☐YES ☐NO

Fire safety engineer ☐YES ☐NO

Civil / Structural engineer ☐YES ☐NO

Other – please specify which one(s): ____

Please comment on any variation of the liability and regulation compliance for the fire safety design according to the construction work type or situation: ____

3. ALLOWANCE OF FIRE SAFETY ENGINEERING (FSE) APPROACH

(Q5) Is FSE approach allowed for construction works in your country/state/region?

☐YES → Please go to Part 4 and answer Questions 6 – 17

☐NO → Please go to Part 5 and answer Question 18

4. STATUS OF IMPLEMENTATION OF FIRE SAFETY ENGINEERING APPROACH (In case your answer to Q5 is YES)

(Q6) What are the types of construction works to which FSE approach is applied? (Please check all appropriate answers.)

☐ Residential buildings and houses

☐ Health care buildings and hospitals

☐ Office buildings

☐ Schools, restaurants

☐ Churches, theatres, cinemas

☐ Museums, exhibition centres

☐ Sports facilities

☐ Concert halls, sports halls

☐ Retails shops

☐ Department stores

☐ Areas for storage use

☐ High-rise Buildings (50 – 200m high)

☐ Super high-rise Buildings (over 200m high)

☐ Airport terminal buildings

☐ Train stations, subway stations

☐ Tunnels

☐ Heritage buildings

☐ Others – please specify: ____

Please specify any additional information relevant to the definition of some types of construction works, e.g." FSE is applied for multi-residential buildings above 3 levels", etc.: ______________________

(Q7) Which fire safety technical areas are included in fire safety engineering approach applications? (Please check all appropriate answers.)

☐ Fire detection

☐ Early suppression/ suppression systems

☐ Evacuation routes

☐ Smoke control systems

☐ Structural fire safety

☐ Fire compartmentation

☐ Smoke compartmentation

☐ Prevention of fire spread to neighboring building

☐ Material selection façades

☐ Material selection for all other relevant areas excluding façades (e.g. interior finishing, cables, internal insulation, furniture, etc.)

☐ Firefighting (fire brigade access and intervention)

☐ Building installations (for example, electricity, gas, lift)

☐ Other – please specify: ____

(Q8) What are the main reasons to apply fire safety engineering approach? (Please check all appropriate answers.)

☐ The construction / fire regulations are performance-based

☐ The type/category of the structure or some element/part of the building is not addressed by the existing prescriptive regulations

☐ Cost reduction for the building construction/running/maintenance

☐ Enhancing fire safety performance of the building

☐ Implementation of new fire safety technologies

☐ Designing attractive/innovative building space

☐ Other reasons – please specify: ____

Please provide more details for the answer(s): ____

If Other reason(s), please provide the details: ____

(Q9) What is the regulatory framework that allows for the application of fire safety engineering approach?

☐ The building regulatory system is performance-based (i.e., fire safety engineering approach is permitted by the fire regulation)

☐ National or regional regulations exist for the approval of fire safety engineering approach

☐ A clause to approve specific/unique fire safety designs, which are not compliant with prescribed requirements, exists in applicable building / fire regulations

☐ Other – please specify: ____

If Other(s), please provide the details: ____

(Q10) Which body/bodies perform a regulatory-review of the fire safety engineering approach in projects? (Please check all appropriate answers.)

☐ Competent authority for building/fire safety control

☐ Designated approval organisationorganisation

☐ Committee for peer-review of the fire safety engineering approach

☐ Third-party engineer

☐ Others – please specify: ____

If Other(s), please provide the details: ____

(Q11) What professional qualification is required for the regulatory-reviewers of the fire safety engineering approach in projects?

☐ Holder of certification/license in relevant category issued by the government or by a body designated by government

☐ Holder of certification by recognized professional society / nominated body

☐ Set of minimum educational/professional experience acknowledged by government (e.g. graduate of recognized engineering program and certain number of years of professional practice

☐ Qualification is not explicitly defined

☐ Others – please specify: ____

Please provide more details for the answer(s): ____

If Other(s), please provide the details: ____

(Q12) What qualification is required to engage in FSE approach practices?

☐ Holder of certification/license in relevant category issued by the government or by a body designated by government

☐ Holder of certification by recognized professional society / nominated body

☐ Set of minimum educational/professional experience acknowledged by government (e.g. graduate of recognized engineering program and certain number of years of professional practice

☐ Qualification is not explicitly defined

☐ Others – please specify: ____

Please provide more details for the answer(s): ____

If Other(s), please provide the details: ____

(Q13) Who/what specifies the fire scenarios in the project design with FSE approach?

☐ National or regional regulations

☐ Building/fire officials

☐ Approval organisationorganisation, or similar

☐ Fire consultant

☐ Other – please specify: ____

If Other(s), please provide the details: ____

(Q14) How are the design fires specified in the project design with FSE approach?

☐ The procedure is prescribed in a regulation

☐ By reference to the national documents describing the guideline/recommendation on the procedure

☐ By the engineer with reference to internationally recognized documents in relevant area (e. g, ISO documents, Society of Fire Protection Engineers Guide to Performance Based Fire Protection Design, International Fire Engineering Guidelines, etc.) with approval of competent authorities

☐ By the engineer, at their discretion, with approval of competent authorities

☐ By discretion of the peer-review committee

☐ By discretion of building/fire officials in charge

☐ Others – please specify: ____

Please provide more details for the answer(s): ____

If Other(s), please provide the details: ____

(Q15) How are the safety criteria determined in the project design with FSE approach?

☐ The procedure is prescribed in a regulation

☐ By reference to the national documents describing the guideline/recommendation on the procedure

☐ By the engineer with reference to internationally recognized documents in relevant area (e. g, ISO documents, Society of Fire Protection Engineers Guide to Performance Based Fire Protection Design, International Fire Engineering Guidelines, etc.) with approval of competent authorities

☐ By the engineer, at their discretion, with approval of competent authorities

☐ By discretion of the peer-review committee

☐ By discretion of building/fire officials in charge

☐ Others – please specify: ____

Please provide more details for the answer(s): ____

If Other(s), please provide the details: ____

(Q16) What assessment methods for FSE are used for the prediction of fire, smoke, structural response, evacuation, etc.? (Please check all appropriate answers.)

Technical area	**yes**	**no**	**methods (see numbering below)**
Fire detection			
Early suppression/ suppression systems			
Evacuation routes			
Smoke control systems			
Structural fire safety			
Fire compartmentation			
Smoke compartmentation			
Prevention of fire spread to neighbouring building			
Material selection for façades			
Material selection for all other relevant areas excluding facades (e.g. interior finishing, cables, internal insulation, furniture, etc.)			
Firefighting (fire brigade access and intervention)			
Building installations (for example, electricity, gas. lifts)			
Other(s) (please specify):			

Method numbering

i. The methods designated by building/fire regulations

ii. Methods described in standards referenced in the building/fire regulations (e.g., Eurocodes, ISO - please provide details/example if possible)

iii. The methods approved by government/designated bodies.

iv. The methods described in the documents issued by academic/professional society

v. The methods described in peer-reviewed papers in journals/conference proceedings.

vi. The methods accepted by building/fire officials in charge

vii. Others – please specify: ____

If Other(s), please provide the details: ____

Please list the documents in which the methods used are described: ________________________________

(Q17) Which topics should be further developed by the standardisation organisationorganisations (e.g. CEN, ISO, National Standardisation Bodies, etc.) to support the fire safety engineering approach practices in your country/region? (Please check all appropriate answers.)?

☐ General Principles

☐ Objectives and Functional Requirements of fire safety designs

☐ Selection of Design Fires and Design Fire Scenarios

☐ Fire safety performance and acceptance criteria

☐ Assessment methods for fire safety engineering approach (such as evacuation safety design, structural fire safety design, and smoke control)

☐ Data from standard tests

☐ Control of FSE/ representation of scenarios during life cycle of buildings

☐ Guidance on risk-informed fire safety engineering approach

☐ Examples of application of fire safety engineering approach to typical buildings

☐ Reliability of fire safety systems

☐ Software validation

☐ Peer Review/regulatory review

☐ Sensitivity analysis

☐ Use of experimental results (standard tests and natural fire tests)

☐ Definition of limits in simulation models (for example gas concentration, visibility, shoot yield, walking pace)

☐ Fire safety engineering practitioners' notification

☐ Others – please specify: ____

If Other(s), please provide the details: ____

Please let us know your opinions/comments/questions on any topics concerning FSE approach: ____ ___________

5. REASONS FOR NOT APPLYING FIRE SAFETY ENGINEERING APPROACH (In case your answer to Q5 is NO)

(Q18) What are the main reasons that FSE approach is not being used in your country/region? (Please check all appropriate answers.)?

☐ The existing fire safety regulation is sufficient for any construction project

☐ Fire safety engineering is not possible to be applied due to the present legal situation

☐ Authority having jurisdiction is not positive to introduction of fire safety engineering approach

☐ There are no construction projects that need fire safety engineering approach application

☐ There are no engineer/designers who have professional expertise to deal with Fire Safety Engineering approach

☐ The approval authorities are not qualified to review / approve fire safety engineering approach

☐ The enforcement authorities are not prepared to assess / inspect / enforce appropriate design and construction to performance-based methods

☐ There are insufficient infrastructure components (e.g., legal system, insurance systems, professional certification systems, educational programs, etc.)

☐ Data / information to support Fire Safety Engineering is too poor

☐ Other reasons – please specify: ____

If Other reason(s), please provide the details: ____

6. FIRE SAFETY ENGINEERING TRAINING, EDUCATION AND RESEARCH

(Q19) What official educational bodies offer FSE education and training to students? (Please check all appropriate answers.)

☐ None

☐ Vocational training at higher education level/continuous professional development

☐ University/universities (BSc level)

☐ University/universities (MSc level)

☐ Others – please specify: ____

If Other(s), please provide the details: ____

(Q20) Do you see a need for FSE post-secondary education? (Please check all appropriate answers.)

☐ No, there is no need

☐ Yes, post-doctoral courses

☐ Yes, dedicated courses at undergraduate level (i.e. BSc/BEng)

☐ Yes, dedicated courses at post-graduate level (i.e. MSc/MEng)

☐ Yes, full fire engineering at undergraduate level

☐ Yes, full fire engineering at post-graduate level

☐ Others – please specify: ____

If Other(s), please provide the details: ____

(Q21) Do you see a need for FSE Continuing Professional Development courses? (Please check all appropriate answers.)

☐ No

☐ Yes, through private or semi-public organisation

☐ Yes, through approved private organisations

☐ Others – please specify: ____

If Other(s), please provide the details: ____

(Q22) Should FSE be part of the training for fire fighters and/or other emergency responders? (Please check all appropriate answers.)

☐ No

☐ Maybe

☐ Yes, especially related to fire development, fire spread and fire growth

☐ Yes, especially related to warning of pending collapse of (part of) the building

☐ Yes, especially related to smoke control and handling

☐ Others – please specify: ____

If Other reason(s), please provide the details: ____

(Q23) Which areas of FSE should be subject for research? (Please check all appropriate answers.)

appropriate answers.)

☐ None, no need

☐ None, we anticipate research coming through international channels

☐ Human behavior and/or evacuation

☐ Fire science, such as: fire spread, flame spread, smoke spread, smoke development, smoke toxicity, other

☐ Material behaviour in fire

☐ Building structural behavior in fire

☐ Fire safety measures (detection, smoke control, passive protection, suppression, …)

☐ Fire fighting

☐ New materials and innovative solutions

☐ New energy systems

☐ Others – please specify: ____

Please provide more details for the answer(s): ____

If Other(s), please provide the details: ____

7. OPEN SPACE FOR COMMENTS AND RECOMMENDATIONS

- Please let us know below your opinions/comments/questions on any current and future topics in your country/region, or on European level, concerning fire safety engineering practice.
- Please share any feedback on fire safety engineering studies, any point of attention or specific difficulty detected during the fire safety engineering process would be highly appreciated.

Annex C. Regulations in place for building fire design in the responding countries / states / regions

Country / state / region	ID	FSE allowed (answer to Q5)	Regulation of reference (answer to Q1)	Year of introduction or latest update
Austria	AUT	yes	*OIB Guideline 2, 2.1, 2.2 and 2.3*	2019
Belgium	BEL	yes	*Besluit van de Vlaamse Regering 09/12/2011 tot vaststelling van de specifieke*	1995
Belgium / Flanders	*FLA*	yes	*Koninklijk besluit van 7 juli 1994 tot vaststelling van de basisnormen voor de preventie van brand en ontploffing waaraan de gebouwen moeten voldoen*	2011
Bulgaria	BGR	no	*Regulation N Iz-1971 of 2009 on construction and technical rules and standards to ensure fire safety*	2010
Switzerland	CHE	yes	*VKF-Brandschutzvorschriften (Swiss fire safety code, binding for the whole of Switzerland)*	2015
Cyprus	CYP	yes	*Cyprus Building Code: Part IV - Fire Safety Code*	2020
Czechia	CZE	yes	*1) Act No. 133/1985 Coll., on fire protection, as amended; 2) Decree (Regulation) No. 23/2008 Coll., on the technical requirements for the fire protection of buildings, as amended; 3) Czech standards for designing of Fire safety of buildings, i. e. ČSN 73 0802 - ČSN 73 0875, … (more than 15 standards)*	2020
Denmark	DNK	yes	*Bygningsreglementet*	2018
Germany	DEU	yes	*Model Building Code ('Muster-Bauordnung' - abbreviated as MBO)*	2019
Germany / North Rhine – Westfalia	*NRW*	yes	*"Landesbauordnung 2018 (BauO NRW 2018) and "Sonderbauverordnung (SBauVO)"*	2019
Spain	ESP	yes	*Documento basico de seguridad en caso de incendio / Código técnico de la edificación*	2006
Estonia	EST	yes	*Fire safety requirements for buildings and requirements for firefighting water supply*	2017
Finland	FIN	yes	*Ympäristöministeriön asetus rakennusten paloturvallisuudesta (Ministry of the Environment Decree on the fire safety of buildings)*	2018
France	FRA	yes	*Decree on fire safety regulations concerning the residential building*	1986
			Code de la construction et de l'habitation - (Building and Housing Code)	2004

United Kingdom / England	GBR	yes	*The Building Act 1984; The Building Regulations 2010*	1985
Greece	GRC	no	*The main regulation is President's decree 41/2018 "Fire safety regulation for buildings". There are several fire provisions for buildings prior to 1988 (Decisions by the Fire Brigade Headquarters) that are considered as "existing buildings", and other fire provisions for specific installations (p. d., Ministerial decisions, etc).*	2018
Croatia	HRV	yes	*1. Fire safety Act (Official Gazette 92/10) and 2. Ordinance on fire resistance and other requirements that buildings have to meet in case of fire (Official Gazette 29/13, 87/15)*	2015
Hungary	HUN	yes	*Decree 54/2014. (XII.05.) BM of the Minister of the Interior on the National Fire Protection Regulations*	2015
Ireland	IRL	yes	*Building Regulations*	1992
Iceland	ISL	yes	*Byggingarreglugerð 112/2012 (Construction regulation)*	2012
Italy	ITA	yes	*Ministerial Decree 03/08/2015 as modified by the Ministerial Decree 18/10/2019 "Italian Fire Prevention Code".*	2019
Lithuania	LTU	yes	*Key Requirements of Fire Prevention approved by 7 December 2010 Order No 1-338*	2010
Luxembourg	LUX	yes	*ITM SST series 1500*	2017
			Eurocodes and national annexes	2012
Latvia	LVA	yes	*LBN 201-15 Fire Safety of Structures*	2015
Malta	MLT	yes	*No regulations are in place to date, however Civil Protection conditions relevant fire safety standards on Planning Authority applications for construction works*	-
The Netherlands	NLD	yes	*BB20212 BBL*	2021
Norway	NOR	yes	*Regulations on technical requirements for construction works ("Byggteknisk forskrift - TEK17")*	2017
Poland	POL	yes	*1. Regulation of the Minister of Infrastructure of April 12, 2002 on the technical conditions to be met by buildings and their location. 2. Regulation of the Minister of Interior and Administration of June 7, 2010 on fire protection of buildings, other construction facilities and areas.3. Regulation of the Minister of the Interior and Administration of July 24, 2009 on firefighting water supply and fire roads. 4. Regulation of the Minister of Infrastructure of June 17, 2011 on*	2019

			the technical conditions to be met by subway structures and their location.	
Portugal	PRT	no	*Lei n.º 123/2019 de 18 de outubro - 3ª alteração do Decreto-Lei n.º 220/2008 de 12 de novembro.*	2008
Romania	ROU	yes	*P118/99*	1999
Serbia	SRB	yes	*Law on Fire Protection; Rulebook on technical norms for fire protection of residential and commercial buildings and public buildings; Rulebook on technical norms for protection of catering facilities against fire; Rulebook on technical norms for protection of high buildings against fire; other regulations prescribing fire protection requirements for buildings, parts of buildings, equipment, installations and devices*	2019
Slovakia	SVK	no	*Ministry of Interior's regulation no. 94/2004 on technical requirements on fire safety of building construction and use*	2019
Slovenia	SVN	yes	*Guidelines on fire safety in buildings*	2020
Sweden	SWE	yes	*Boverket´s building regulations – mandatory provisions and general recommendations, BBR*	2012

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