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FIRE RESILIENCE AND BUILDINGS' SUSTAINABILITY IN RENOVATION WAVE

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ABSTRACT

Resilience represents a comprehensive concept that goes beyond physical resistance to hazards. It encompasses the ability of communities to withstand and recover from a variety of challenges, while preserving and restoring the essential functions necessary for sustainable living.

A sustainable building has been defined as a building with high efficiency in the use of energy, water and materials, and reduced impacts on the health and the environment through better siting, design, construction, operation, maintenance and removal throughout its life cycle.

Designing sustainable buildings requires considering a wide range of aspects that affect society, the environment and the economy. This resonates well with the concept of fire resilience, as fire can have a dramatic impact on all three dimensions of sustainability. Fire resilience is considered as the ability of a system, community or society to adapt, transform and recover from a fire timely and efficiently.

The paper explores the relationship of fire resilience and buildings' sustainability within the scope of Renovation Wave. Conducted research indicates that fire resilience is one of the crucial aspect of overall building sustainability, yet it is often neglected or inadequately addressed in existing sustainable building rating schemes. In order to create safer and more sustainable built environment, there is a need to adopt a holistic approach to building sustainability through integration of fire resilience from initial building design and into building policies and regulation. Energy renovation is a good starting point to tackle both the energy efficiency requirements and the fire safety challenges. By taking a holistic approach that considers both energy efficiency and fire safety, we can create buildings that are truly sustainable, safe and resilient, positively impacting society and the environment.

Keywords: Renovation Wave, Buildings Renovation; Energy efficiency; Fire Resilience; Sustainability;

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1. INTRODUCTION

As the largest energy consumer in the European Union (EU) and one of the largest CO_2 emitters, the built environment has a significant impact on many sectors of the economy and quality of life [1].

The building sector plays a central role in the EU's energy-saving policies and is recognized as a key sector for achieving the energy and climate goals for 2030 and transition to clean energy [2]. It is also crucial for meeting the long-term objectives aimed at achieving a highly energy-efficient and decarbonized building sector by 2050 [3]. Improving the energy efficiency of building stock would cut emissions, tackle energy poverty, reduce people's vulnerability to energy prices and support the economic recovery and job creation [4].

Energy-efficient buildings should be healthy, affordable, safe and sustainable [5]. The COVID-19 pandemic has brought to the forefront the significance of living in healthy and safe buildings. As people spent more time indoors, the quality of their living environment became increasingly important.

A sustainable building has been defined as a building with high efficiency in the use of energy, water and materials, and reduced impacts on the health and the environment through better siting, design, construction, operation, maintenance and removal throughout its life cycle [6]. Sustainable buildings play a significant role in enhancing resilience on multiple levels.

Resilience represents a comprehensive concept that goes beyond physical resistance to hazards. It encompasses the ability of communities to withstand and recover from a variety of challenges, while preserving and restoring the essential functions necessary for sustainable living.

Designing sustainable buildings requires considering a wide range of aspects that affect society, the environment and the economy. This resonates well with the concept of fire resilience, as fire can have a dramatic impact on all three dimensions of sustainability. Fire resilience is considered as the ability of a system, community or society to adapt, transform and recover from a fire timely and efficiently [7].

The increase in building fire events over the last decade indicates that existing fire safety regulations are lagging behind new technologies, materials and innovative construction and design, increase the inherent fire risk and compromising the safety of building users. Improving a buildings' energy performance through renovation can make a building more sustainable but can also increase the fire load of the building and change the way the building responds to a fire, unless non-combustible materials are used [8]. When enhancing energy-efficiency, building's fire safety should not be impaired.

The paper explores the relationship of fire resilience and buildings' sustainability within the scope of the initiative *A Renovation Wave for Europe* [9]. Energy renovation is a good starting point to tackle both the energy efficiency requirements and the fire safety challenges. By taking a holistic approach that considers both energy efficiency and fire safety, we can create buildings that are truly sustainable, safe and resilient, positively impacting society and the environment.

2. THE ROLE OF BUILDING RENOVATION

Europe has set itself the goal of improving energy efficiency by at least 32.5% and reducing greenhouse gas (GHG) emissions by at least 55 % below 1990 levels by 2030, with underlying objective to become a climate-neutral and sustainable continent by 2050 [10].

The renovation of building stock by improving the energy performance of existing buildings is a crucial factor in achieving set goals and creating a sustainable built environment, as building are significant contributors to energy consumption, greenhouse gas emissions and resource use.

Building sector accounts for 40% of energy consumed in Europe and for 36% of CO_2 emissions [11], which makes it the largest consumer of energy, but also a sector with significant potential for reducing energy demand.

A large share of today's EU building stock was built without any energy performance requirement. One third (35%) of the EU building stock is over 50 years old, more than 40% of the building stock was built

before 1960 and 90% before 1990. Almost 75% of it is energy inefficient according to current building standards and 85-95% of the buildings that exist today will still be standing in 2050 (Figure 1) [9, 12].

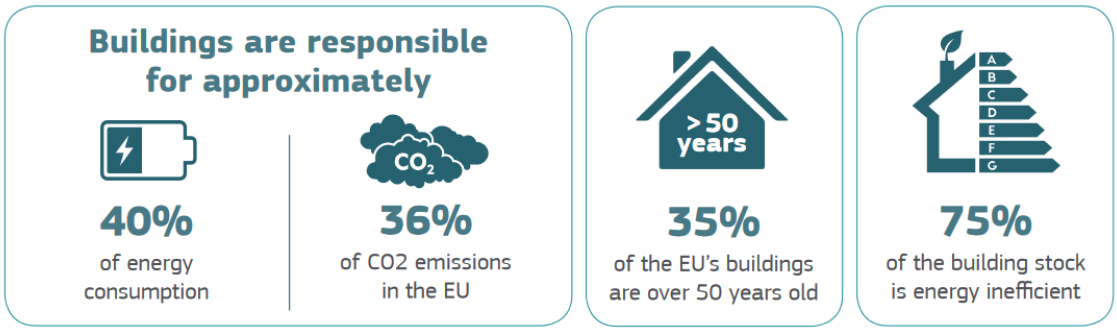


Fig. 1. The building sector in Europe – facts and figures [13]

The Directive on Energy Performance of Buildings (EPBD) [3] is the cornerstone of European legislation for transforming the building sector. In order to achieve the set climate and energy goals, Member States (MS) are required to adopt long-term renovation strategies and increase the renovation rate, as well as to establish minimum requirements for energy performance for both new buildings and existing buildings that are subject to major renovation, and for the replacement or retrofit of building elements like heating and cooling systems, roofs and walls. Directive also obligates all MS to ensure that from 2021 onwards, all new buildings are "nearly zero-energy buildings".

The European Green Deal [14], strategy introduced by the European Commission (EC) in 2019, identified building renovations as a key tool to reduce emissions and provide a healthy and affordable living and working environment for all. Increasing renovation rates to almost 3 % and renovating 210 million existing buildings could create up to 2 million jobs in the construction sector, which accounts for about 9 % of the EU's GDP and is an important part of the recovery strategy after the COVID-19 crisis, and could contribute to a clean economy [5].

At the same time, energy efficiency renovation presents a valuable opportunity to upgrade the fire safety of buildings, and this aspect should not be overlooked. In Europe, over 5,000 fires incidents occur daily. Annually, 70,000 people require hospitalization due to severe fire-related injuries, and 4,000 people die in fires, while 90% of all fire victims are killed by fires in buildings. Emissions of smoke, toxic gases, and other particles negatively impact our environment and health. In 2012, fire-related air pollution in the EU resulted in 403,000 deaths. Fires also affect communities, businesses, families, and workers, leading to high costs for medical treatment and counseling, long-term care needs, displacement from homes or jobs, and more. In the most advanced countries, the total economic losses associated with fires amount to 1% of European GDP (Figure 2) [15-17] .



Fig. 2. Fire safety in Europe – facts and figures

EU acknowledges the importance of addressing the fire safety during renovation. Fire safety aspects should be considered during the design, selection of materials, construction, renovation and operation of buildings in order to improve prevention, detection, early suppression, evacuation, compartmentation, structural resistance and fire-fighting, as well as the relevant competencies of involved professionals [5], and MS should be able to use their long-term renovation strategies to address fire safety issues which

affect energy efficiency renovations and the lifetime of buildings [3]. By integrating fire safety measures into renovation projects, buildings can become more resilient to fire incidents.

Despite the potential benefits, only 0.4-1.2% of the building stock is renovated each year. At the current pace, the decarbonisation of the building sector would require centuries[9].

3. RENOVATION WAVE

In 2020, the EC released *A Renovation Wave for Europe* [9] - a strategic document accompanied by an action plan, aimed to accelerate the renovation of existing buildings across the EU and make them more energy-efficient, sustainable, and resilient. The Renovation Wave aims at adopting a holistic perspective on EU buildings policy, going beyond solely the EPBD measures [18].

Initiative strives to address the challenges of climate change, reduce greenhouse gas emissions, and enhance the sustainability of the built environment. It provides concrete actions and guidelines for increasing building renovations and encourages MS to develop renovation strategies and take measures to improve the energy efficiency of buildings.

The objective is to at least double the annual energy renovation rate of both residential and non-residential buildings by 2030 and to foster deep energy renovations. Mobilizing forces at all levels towards these goals will result in 35 million building units renovated by 2030.

The initiative prioritize action in three areas:

- tackling energy poverty and worst-performing buildings,
- renovating public buildings, such as administrative, educational and healthcare facilities and
- decarbonizing heating and cooling.

These areas should be considered as a priority for policy and financing, because they offer huge potential for increasing renovation rates, while delivering large energy savings and healthier and more comfortable buildings for citizens.

To address untapped energy efficiency potential in the building sector and increase the building renovation rate, the EC proposes introducing mandatory *Minimum Energy Performance Standards* (MEPS) [19] in the building sector as part of its Renovation Wave strategy.

In 2021, the EC proposed a revision of the EPBD [20]. The proposal introduces EU–level MEPS for the worst-performing buildings (building classified in energy performance classes E, F or G) and leaves MS the scope to set their own standards in addition. MEPS require selected existing buildings to meet a required minimum level of energy performance by a future date or trigger point in the building lifecycle (sale or rent). In particular, public and non-residential buildings will have to be renovated and improved to at least energy performance class E at the latest by 2027, and to at least class D by 2030. Residential buildings should be renovated to at least class E by 2030, and to at least class D by 2033. The focus on the very lowest performing classes of the building stock ensures that efforts focus on buildings with the highest potential for decarbonisation, energy poverty alleviation and extended social and economic benefits. MS shall also, as part of the national building renovation plans, establish specific timelines for achieving higher energy performance classes by 2040 and 2050, in line with their pathway for transforming the national building stock into zero-emission buildings. The proposal also introduces “renovation passport” - a document that provides a tailored roadmap for the deep renovation of a specific building in a maximum number of steps that will transform the building into a zero emission building by 2050 at the latest.

In the context of fire safety, recast EPBD states that MS shall ensure that new buildings adhere to fire safety standards as well as address the compliance of buildings undergoing major renovation to fire safety standards. The renovation passport shall comprise wider benefits related to fire safety, inter alia. MS shall put in place inspection schemes including digital tools to certify that the delivered construction and renovation works meet the designed energy performance and are compliant with fire safety requirements as laid down in by the building codes or equivalent regulations.

As a member of the *Energy Community*, the Republic of Serbia (RS) is obligated to implement EU directives related to energy efficiency and energy performance of buildings into the national legislation. In 2022, the Government of RS has adopted a *Long-term strategy for inciting investments in the renewal of the national buildings fund until 2050* [21]. The main goal of the strategy is to define building renovation measures, based on the established building stock characteristics, defined model buildings and performed cost-optimal analyzes. Five possible scenarios of renewal have been prepared. The first, the main scenario, entails unsubsidized renewal and construction according to the current regulations, while the last, most advanced one, entails the building renovation to the level of nearly zero-energy buildings. In the context of fire safety it is stated that renovation measures must ensure equivalent or superior fire safety for occupants than the existing buildings.

4. FIRE RESILIENCE AND SUSTAINABILITY OF BUILDINGS

The focus on sustainability in the built environment emerged about 40 years ago, while the concept of resiliency of infrastructure and the built environment has existed for much longer, but 're-emerged' over the past twenty years [22].

Fire resilience and sustainability share common goals of providing benefits to people and the environment. The effects of a building fire can be detrimental to the environment, public health, and overall sustainability goals, which implies that a building is not sustainable if it is not fire resilient. Building fires can release harmful effluents and by-products that pollute the surrounding environment - the air, the soil and the groundwater. The emissions from building fires can pose serious health risks to people. Building fires can disrupt community life and economic consequences can be severe, as building structure is damaged and property is lost.

Buildings can be designed to be both sustainable and to be resilient to natural and manmade disasters – including fire – as well as to long-term changes resulting from climate change. With respect to fire as a hazard, this type of thinking can result in *Sustainable And Fire Resilient* (SAFR) buildings/structures (Figure 3) [22].

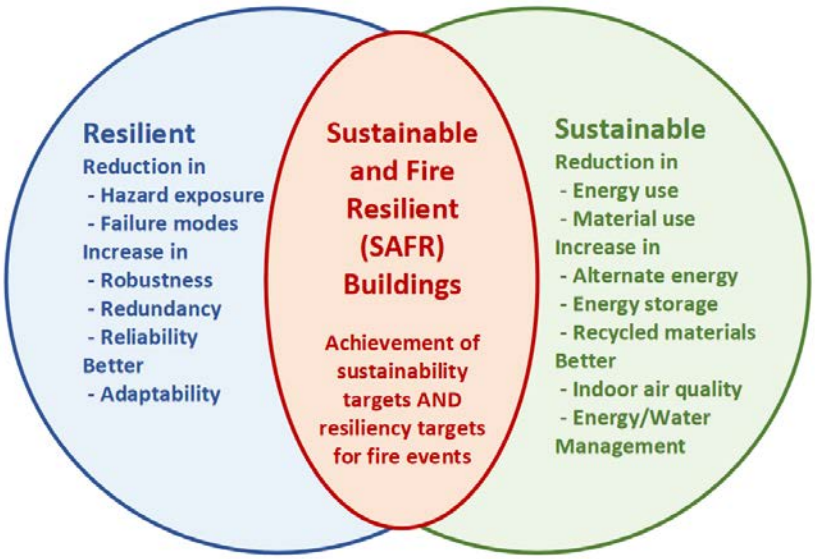


Fig. 3. Sustainable And Fire Resilient (SAFR) buildings concept [22]

Increased focus on energy conservation, sustainable development and sustainable construction over the past few decades triggered development of a wide range of regulations, codes, standards and guidelines for energy and sustainability performance of buildings, as well as the non-regulatory sustainable building rating schemes [22].

Existing sustainable building rating schemes assess various aspects of a building's environmental impact, energy efficiency, water conservation, indoor air quality, materials used, and overall sustainability performance. So far, fire resilience is not a part of any of existing sustainable building

rating schemes. These tool are built upon assumption that fire safety is adequately covered in building regulations, which is not a case as fire safety building regulations mostly focus on the safety of occupants during a fire (in terms of safe evacuation) and neglect building fire resilience [15]. Although existing sustainable building rating schemes do not explicitly include fire resistance, some schemes, such as *BREEAM*, *LEED* and *Green Homes* include criteria linked to fire safety. However, most remain voluntary or the requirements focus mostly on compliance with existing regulation when compliance is mandatory.

In 2020, the EC committed itself to come forward with a *Strategy for a Sustainable Built Environment* [23] and underlined that it would use *Level(s)*, which is the European framework for sustainable buildings, to integrate life cycle assessment in public procurement and the EU sustainable finance framework. However, a building's fire safety and fire resilience are not currently considered in Level(s).

In order to bridge a gap between fire resilience and sustainability of buildings, the *European Fire Safety Community* launched a project *A Fire Safety Rating Scheme For Buildings* [24]. The aim of the project is to develop a fire safety assessment for buildings with the ambition to create a relative scoring system to inform consumers on the level of fire safety of a building based on a holistic evaluation of buildings through a series of key requirements. One of the projects objectives is also to develop and offer to green buildings rating scheme stakeholders a ready-made fire safety module for existing rating schemes.

The entry of new policy objectives around sustainability has simultaneously created a wide range of fire resilience challenges, from regulatory development to enforcement, to design, to operational safety, with potentially the most significant issues around existing building stock. Research [22] has found that challenges exist in incorporating sustainability and resiliency objectives into building regulations. There are no easy solutions for developing building regulatory systems and design approaches that are holistic and balancing of multiple objectives, such as sustainability and resiliency, since while the problems are easy to recognize, the solutions are difficult to agree and implement. These challenges exist in part because sustainability and fire resilience are not yet being viewed as having the same level of importance. Unfortunately, the lack of holistically reflecting the desired performance of buildings from a sustainable and fire resilient perspective was observed with the Grenfell Tower fire in London in 2017, in which over 70 people lost their lives [25].

In order to create safer and more sustainable built environment, there is a need to adopt a holistic approach to building sustainability through integration of fire resilience from initial building design and into building policies and regulation.

5. CONCLUSION

The renovation of existing buildings aligns with the overall EU’s objectives of decarbonization, energy efficiency and sustainability, and can significantly contribute to combating climate change and creating a more resilient and sustainable built environment for present and future generations.

Sustainable building design should go beyond mere energy efficiency and environmental protection and encompass fire safety and fire resilience as integral components. With the introduction of new sustainable materials and technologies in the renovation process, it is essential to evaluate the fire risks associated with these new elements, especially concerning flammability and toxicity [26]. Within the emergence of new tools such as the MEPS, it is crucial to factor in fire-safety. Sustainable buildings must be fire safe and fire resilient, thus energy-efficient renovations must integrate fire-safety.

When looking at sustainability concepts and policy measures, there is no clear link to fire safety. Additionally, despite being one of the crucial aspect of overall building sustainability, fire resilience it is often neglected or inadequately addressed in existing sustainable building rating schemes.

Conducted research highlights the need to recognize fire resilience as an integral component of building sustainability, as both share common goals and directly impact the protection of human lives, property, and the environment.

It is necessary to embed fire resilience into various aspects of building regulations, policies, strategies and sustainable building rating schemes and reporting frameworks, including:

- Renovation Wave, by encouraging the insertion of fire safety and fire resilience in national long-term renovation strategies.
- EPBD implementation at the national level, by ensuring EU countries follow the revised EPBD recommendations on fire safety during energy efficiency renovations.
- Strategy for a Sustainable Built Environment, by including fire resilience in buildings lifecycle assessment and by upgrading Level(s) to factor in fire resilience.

By taking these measures, the EU can advance towards a more holistic and resilient approach to sustainable building practices, considering the entire lifecycle of a building and promoting fire resilience as an integral component of sustainability.

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REFERENCES

[1] European Commission (2020). A new Circular Economy Action Plan For a cleaner and more competitive Europe. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions COM/2020/98. Brussels, Belgium.

[2] European Commission (2019). Commission Recommendation (EU) 2019/786 of 8 May 2019 on building renovation. Official Journal of the European Union.

[3] European Union (2018) Directive (EU) 2018/844 of the European Parliament and of the Council of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency. Official Journal of the European Union.

[4] European Commission (2021). Questions and Answers on the revision of the Energy Performance of Buildings Directive. Brussels, Belgium.

[5] European Parliament (2020). Maximising the energy efficiency potential of the EU building stock. European Parliament resolution of 17 September 2020 on maximising the energy efficiency potential of the EU building stock (2020/2070(INI)).

[6] Fire Safe Europe - FSEU (2020). Of the Importance of Fire Resilience for Buildings’ Sustainability.

[7] Fire Safe Europe - FSEU (2020). Integrating Fire Safety for a Deep and Sustainable Renovation Wave. Position Paper.

[8] Kelly Spillane D. (2021). Fire resilience – One more reason to ride the renovation wave.

[9] European Commission (2020) A Renovation Wave for Europe - greening our buildings, creating jobs, improving lives. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. COM/2020/662. Brussels, Belgium.

[10] European Union (2023). Directive of the European Parliament and of the Council on energy efficiency and amending Regulation (EU) 2023/955 (recast). Brussels, Belgium.

[11] European Commission, Directorate-General for Energy (2019). Clean energy for all Europeans. Publications Office. ISBN: 978-92-79-99835-5. DOI: 10.2833/9937

[12] Filippidou F., Jimenez Navarro J.P. (2019). Achieving the cost-effective energy transformation of Europe’s buildings. Publications Office of the European Union, Luxembourg. ISBN 978-92-76-12394-1. DOI:10.2760/278207.

[13] European Commission (2019). Factsheet: Energy Performance in Buildings Directive.

[14] European Commission (2019). The European Green Deal. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. COM/2019/640. Brussels, Belgium.

[15] Andolfatto J. (2020). Above and beyond. Article in Fire Protection Association.

[16] Dyrbøl S. (2020). A sustainable building starts with a fire safe building.

[17] Fire Safe Europe (2023). Fire Safety: Know The Facts.

[18] Buildings Performance Institute Europe – BPIE (2021). The Renovation Wave Strategy & Action Plan: Designed for Success or Doomed to Fail? Review and Gap Analysis of the Renovation Wave.

[19] Kamenders K., Stivriņš R., Žogla G. (2022). Minimum Energy Performance Standards (MEPS) in the Residential Sector. Final study report for The European Economic and Social Committee (EESC). ISBN 978-92-830-5747-5.

[20] European Parliament (2023). Energy performance of buildings (recast). Amendments adopted by the European Parliament on 14 March 2023 on the proposal for a directive of the European Parliament and of the Council on the energy performance of buildings (recast). COM/2021/0802 – C9-0469/2021 – 2021/0426(COD).

[21] Vlada Republike Srbije (2022). Dugoročna strategija za podsticanje ulaganja u obnovu nacionalnog fonda zgrada Republike Srbije do 2050. godine, Službeni glasnik RS, br. 27/2022. Beograd, Srbija.

[22] Meacham B.J., McNamee M. (2020). Fire Safety Challenges of 'Green' Buildings and Attributes. Fire Protection Research Foundation. Quincy, MA, USA.

[23] Ragonnaud G. for European Parliament (2022). Strategy for a Sustainable Built Environment.

[24] The European Fire Safety Community (2020). The Fire Safety Rating Scheme project.

[25] Rawlison K. (2017). The victims of the Grenfell Tower fire. Guardian Today.

[26] Fire Safe Europe - FSEU (2020). Boosting sustainable buildings through fire safety. Position paper.