FRISSBE
fire-safe sustainable built environment

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ACRONYMS AND ABBREVIATIONS

Acronym / Abbreviation	Description
COBISS	Co-operative Online Bibliographic System & Services
ERA Chair holder	Prof. Grunde Jomaas
GA	Grant Agreement
OA	Open Access
R&D	Research and Development
SCI	Science Citation Index
SFPE	Society of Fire Protection Engineers
SICRIS	Slovenian Current Research Information System
WP	Work Package
ZAG	Zavod za gradbeništvo Slovenije (Slovenian National Building and Civil Engineering Institute)

1. INTRODUCTION

The FRISSBE project aims to achieve research at a high level of excellence in the field of fire-safe sustainable environments, which is in accordance with the Grant Agreement. This involves research and innovation, including collaborations internally, with industry, and with external research institutions. FRISSBE's goal is to disseminate the project's results to the previously defined target audiences in the *Detailed Dissemination and Communication Plan (D5.4*). The primary channels for disseminating FRISSBE's research outputs are scientific and professional publications. Therefore, the number of scientific and professional articles and conference contributions, as well as their impact (e.g., citations), are key performance indicators of the success of the FRISSBE research concept and its scientific excellence.

The Grant Agreement for the FRISSBE project set the goal of publishing in highly ranked SCI journals, measuring success by having at least 40 academic peer-reviewed articles (referred to as scientific publications in this report) accepted and 15 professional articles published. *The Detailed Dissemination and Communication Plan (D5.4)* further specifies that the number of publications shall be distributed among staff at different research levels (ERA Chair holder, senior researchers, postdoctoral researchers, PhD students). Whenever possible, scientific articles have been published as open access with the FRISSBE acknowledgement. Additionally, conference contributions are an important tool to share research findings and increases awareness about FRISSBE through active participation in scientific and professional events and have therefore also been included.

In this report (Deliverable D3.5), the success of the scientific and professional dissemination activities is evaluated by analysing submitted publications. The focus is on the achievement of previously defined goals in terms of quantity, quality, collaborations, and scientific impact for publications at scientific, professional and conference level throughout the FRISSBE project.

2. PUBLICATION GOALS AND ACHIEVEMENTS

The FRISSBE members whose scientific publications are included in the following analysis comprise the ERA Chair Holder (Grunde Jomaas), the current Head of the FRISSBE Department (Aleš Jug), and members of the Fire Research and Innovation Unit (560) who are at different research career levels.

The metrics for assessing the researchers in Slovenia are registered in the Slovenian Current Research Information System (SICRIS) through the Co-operative Online Bibliographic System & Services (COBISS). Hence, the academic and professional publications resulting from the project are visible on the profile of the FRISSBE researchers. In addition, all researchers are expected to keep their Google Scholar profiles up to date by regularly adding newly published work if this is not done automatically. As defined in the GA, ZAG follows an Open Access approach to publications, ensuring that all peer-reviewed scientific outputs are accessible online free of charge. This includes the majority of publications from the FRISSBE project, which are categorised as Gold Open Access, where ZAG has allocated part of the funding to cover publishing costs, and Green Open Access for self-archived publications available via the Digital Repository of Slovenian Research Organisations (DiRROS). Publications are also updated on the FRISSBE website to ensure the dissemination and visibility of the project's scientific output. The full list of publications submitted and published by FRISSBE members at the time of deliverable submission is provided in the following sections.

Over the course of the FRISSBE project, a total of 152 publications were recorded. The main categories are peer-reviewed scientific journal publications, professional articles and conference contributions. Further outputs, categorised as 'Others' within this document, include white papers, books and book chapters, and newsletters, totalling 21 publications. At the time of the current report, which was published a couple of months before the end of the FRISSBE project, 56 Scientific journal publications, 44 professional articles and 31 conference contributions were recorded. As shown in Figure 1, the publication output has a clear increase since the beginning of the FRISSBE project, demonstrating growth and continuous involvement of FRISSBE researchers in both scientific research and professional dissemination activities.

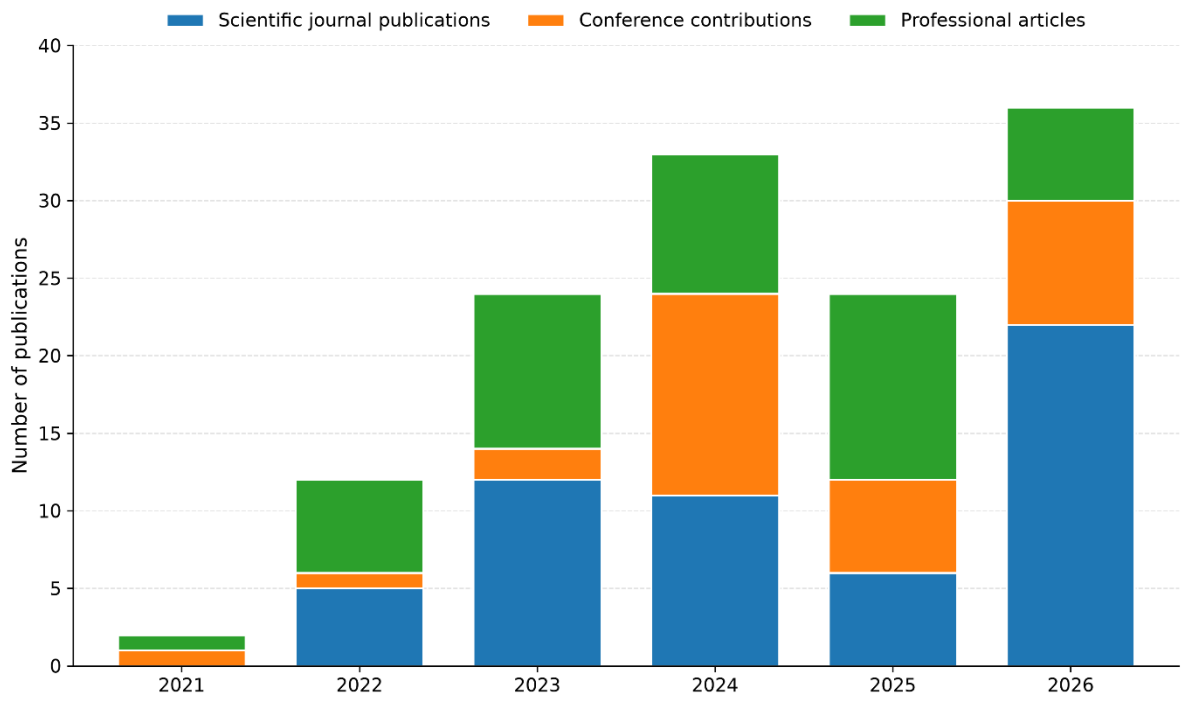


Figure 1 Scientific, conference and professional publications (2021-2026)

Table 1 and Figure 2 presents the yearly number of scientific and professional publications as well as the expected goals presented in the GA. The distribution provides an overview of the involvement of researchers at different career stages. It should be noted that the categories are not exclusive, as a single publication may include authors from several researcher levels. The number of scientific and professional publications exceeded the expected goals for the ERA Chair holder, Senior researchers, and PhD students. In particular, the ERA Chair holder and Senior researchers consistently produced high-level scientific and professional publications, publishing more than four and three times the initial target respectively. As the PhD students and their research matured towards the end of the FRISSBE project, an increasing number of research results emerged, resulting in a significant number of publications in high-quality scientific and professional journals. The publication output exceeded the initial targets set for the PhD students, with three more scientific publications and ten more professional publications than originally expected. The initial target of 12 scientific journal publications for postdoctoral researchers could not be met, as there was initially a lack of staff at this research level. Two postdoctoral research positions were filled in January and May 2025, resulting in professional publications and involvement in scientific journal publications in 2026. In addition, ongoing research activities involving the postdoctoral researchers are expected to result in further scientific publications beyond the reporting period. It should also be

noted that one of the senior researchers was initially hired as a post-doc and that the project has elaborated on the challenges associated with hiring post-docs, which resulted in hiring additional senior researchers in their place, in previous reports.

Table 1 Yearly number of scientific and professional publications in regard to the expected goals presented in the Grant Agreement.*

FRISSBE responsible	Scientific journal publications						Professional articles						
	Total Goal/ Achieved	2022	2023	2024	2025	2026	Total Goal/ Achieved	2021	2022	2023	2024	2025	2026
ERA chair holder	**6*/19**	5	4	1	1	8	**4*/23**	1	6	2	8	2	5
Senior researchers	**16*/38**	2	8	10	6	12	**2*/20**	0	0	7	3	6	4
Post-doctoral researchers	**12*/0**	0	0	0	0	0	**6*/4**	0	0	0	0	1	3
PhD students	**6*/9**	0	0	0	1	8	**3*/13**	0	0	3	4	4	2
Total number of publications	**40*/56**	5	12	11	6	22	**15*/44**	1	6	10	9	12	6

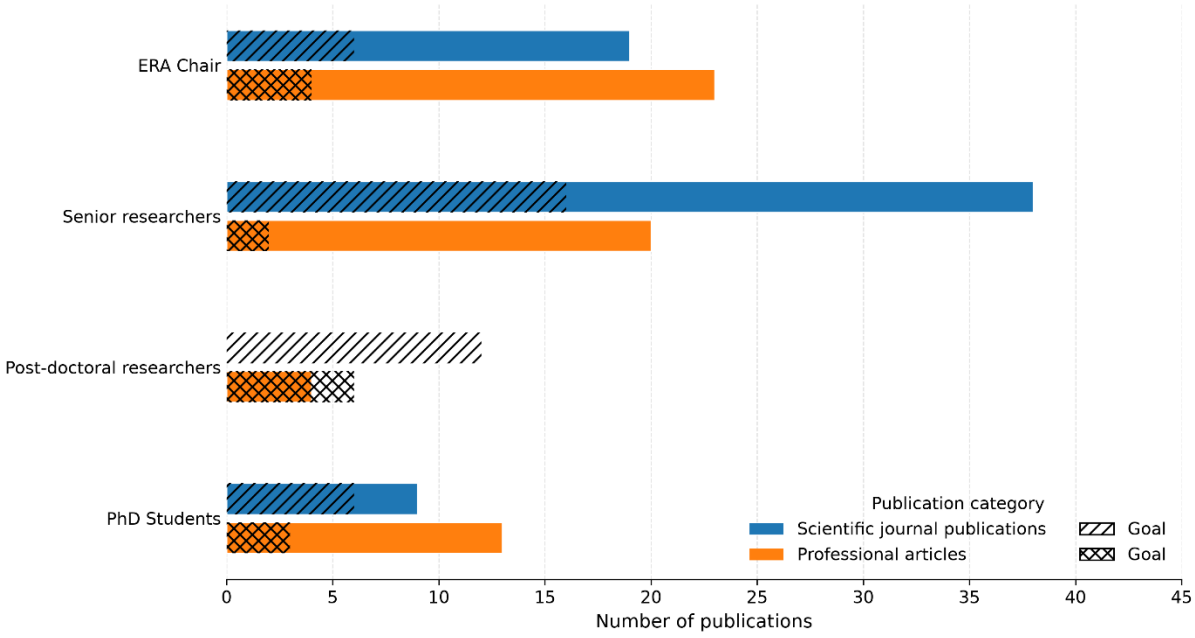


Figure 2. Overview of goal and achieved number of publications for each group in the period of the FRISSBE project.

2.1. Authorship distribution

Both independent and joint research activities have been resulting in a significant number of scientific and professional publications with FRISSBE members as either lead author or co-authorship. The distribution of authorship demonstrates a balance between scientific leadership and collaborative research within FRISSBE. Overall, 24 % of the scientific publications are led by FRISSBE researchers, demonstrating

FRISSBE's scientific independence and its capacity to initiate, coordinate and disseminate research activities.

The distribution of lead authorship across the different researcher levels, illustrated in Figure 3, further highlights the complementary roles of researchers within FRISSBE. The ERA Chair holder has a predominantly coordinating role, while senior researchers contribute through both active research and scientific leadership. PhD students play a strong role in conducting research, reflected in a substantial share of first-author publications at their career stage.

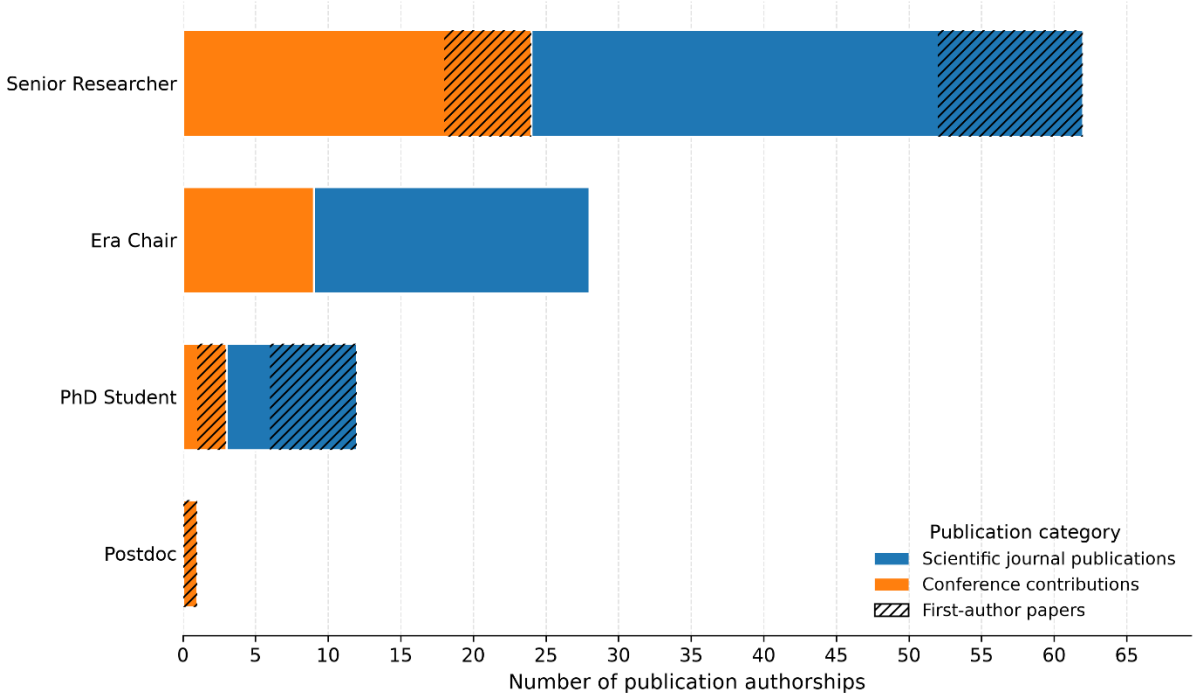


Figure 3 Distribution of first authorship by career level.

3. SCIENTIFIC JOURNAL PUBLICATIONS

Scientific journal publications (SJP) are one of the primary research outputs of the FRISSBE project and serve as the main measure of scientific excellence and research impact in research in general, along with citations. They demonstrate scientific innovation and disseminate research results, presenting ZAG/FRISSBE as a reliable coordinator and partner in research projects, and creating further research opportunities. Below, a list of abstracts of peer-reviewed scientific journal publications is presented. The publications are classified according to their open access status (Gold, Green, Non-open access) and evaluated accordingly. In addition, the pursuit of high scientific quality is assessed in terms of journal quality and research impact.

3.1. List and abstracts of the scientific journal publications

Table 2 Overview of published scientific journal publications during the FRISSBE project.

2022_SJP1 (Green OA)	Rojas-Alva, U., & Jomaas, G. (2022). A historical overview of experimental solid combustion research in microgravity. *Acta Astronautica*, *194*, 363–375. https://doi.org/10.1016/j.actaastro.2022.01.037 http://hdl.handle.net/20.500.12556/DiRROS-17261
Abstract	Studying solid combustion phenomena in microgravity environments can be complex, and this is furthered by many limitations and constraints in the available microgravity research platforms. Consequently, fire safety in spacecraft is also a complex subject. The main limitations found in the field are related to the microgravity quality, the duration of microgravity conditions, the rig capabilities in volume and size, time scales, length scales and the diagnostic systems, and these are therefore the focus in the current investigation. The laboratory capacity of ground-based platforms has remained somewhat stalled since 1990s, some drop towers have recently been upgraded to extend their performance. New space-based platforms have been or are being established and could extend the windows-of-opportunity to perform research. In addition, a discussion is provided on the implications of the fact that the phenomena studied in the experimental investigations and the type of material employed covers both programmatic and scientific needs. It is found that a handful of materials are most widely studied to quantify and characterise some of the phenomena, while some materials have been employed even in single experimental efforts. The current literature review provides a very comprehensive overview of previous experimental studies and the experimental methodologies utilised. Thus, this study can become an aid to planning for future studies.
2022_SJP2 (Green OA)	Rojas-Alva, U., Møller-Poulsen, F., Man, S.-L., Creamer, C., Hanna, D., & Jomaas, G. (2022). Flame spread behaviour of Polydimethylsiloxane (PDMS) membranes in 1 g and μg environments. *Combustion and Flame*, *240*, 112009. https://doi.org/10.1016/j.combustflame.2022.112009 http://hdl.handle.net/20.500.12556/DiRROS-17258
Abstract	Diffusion flame behaviour and silica ash (SiO2) production were experimentally studied for various Polydimethylsiloxane (PDMS) membrane thicknesses (0.125 mm to 1.0 mm) in normal gravity and during microgravity flight experiments. The flames were established on vertical samples (300 mm in length) and subjected to either opposed or concurrent forced flows (both laminar and turbulent), assimilating the NASA Test 1 that is in use for spacecraft material selection. The opposed flame spread rate was observed to be steady and could be estimated using classical theory. Under concurrent flow, the flame spread rate was only steady for very high forced flows. The opposed flame-spread rate ranged from 0.5 to 1.5 mm/s, while the concurrent case ranged between 0.1 and 12 mm/s. The transport of silica ash (SiO2) was found to affect the heat balance of the concurrent flame spread in a manner that resulted in unsteady flame spread. For opposed flame spread, on the other hand, the transport of silica ash showed to be irrelevant. The extinction behaviour for the concurrent flame spread was heavily dominated by the transport of silica-ash, while for opposed flames, extinction was due to kinetics (at high forced flows). In microgravity environments, the transport and deposition of silica ash is anticipated to dominate flame spread and near-limit as well. These results suggest that silica-based products might be less flammable in microgravity than other similar materials such as common thermoplastics (PP or PE) used as wire jackets.
2022_SJP3 (Green OA)	Alimzhanova, M., Spearpoint, M., & Jomaas, G. (2022). Fire safety assessment of sprinkler systems for car parks using the J-value methodology. *Fire Safety Journal*, *129*, 103565. https://doi.org/10.1016/j.firesaf.2022.103565 http://hdl.handle.net/20.500.12556/DiRROS-17673
Abstract	A J-value assessment was carried out to quantify the costs and benefits of sprinkler system installation in car parks, both with respect to life safety and property protection. Nine scenarios were established based on collected input data. All car park types were considered for the USA, England, Scotland, Wales and the UK nations collectively, while separate considerations were made for multi-storey car parks (MSCPs) in the UK and for MSCPs, underground and other parking types in England. Even when assuming 100% sprinkler effectiveness, the J-values for the nine scenarios were all larger than unity (ranging from 5 to 555), thus indicating that the installation of sprinklers is not a cost-effective investment for car parks from a societal point of view. The analysis showed that different car park types

	must be treated separately, due to specifics of structure and fire statistics. The lowest J-values were obtained for MSCPs and underground car parks. Sprinkler installation mainly provides property protection benefits, because of property loss savings substantially outweigh those associated with life safety. Even though sprinklers were not cost-effective for car parks in the current analysis, the scarcity of data and new emerging technologies suggests that further investigation is needed.
2022_SJP4 (Gold OA)	Kristensen, J. S., Jacobs, B., & Jomaas, G. (2022). Experimental Study of the Fire Dynamics in a Semi-enclosure Formed by Photovoltaic (PV) Installations on Flat Roof Constructions. *Fire Technology*, *58*(4), 2017–2054. https://doi.org/10.1007/s10694-022-01228-z
Abstract	Flame spread experiments upon a BROOF(t4) compliant flat roof mock-up located below a vertical barrier were carried out for variations in gap height, inclination, subjacent insulation material, and the barrier type (stainless-steel board or photovoltaic (PV) module). A binary flame spread scenario was identified, where reradiation from the flame facilitated self-sustained flame spread if the gap height to the horizontal panel was below 10 cm for the stainless-steel board and 11 cm for PV modules. These were defined as the critical gap heights. Inclination of the PV modules increased the critical gap height and caused a 25% faster flame spread rate (FSR) than the FSR below horizontal modules with the same gap height at the location of ignition. The faster FSR for inclined modules caused a 40% reduction of the maximum temperature measured at a depth of 70 mm in the insulation materials (242°C). Based on temperatures measured in the insulation materials, the 60 mm polyisocyanurate (PIR) insulation performed slightly better than the 50 mm mineral wool insulation. However, it is expected that the mineral wool would outperform the PIR insulation if tested with the same thickness, as it insulates significantly better at high temperatures. Finally, no sustained flame spread was observed on the back side polymer sheet of the PV modules, but one of the three PV module brands produced burning droplets. Based on the experiments, it can be concluded that the current standards are inadequate as the introduction of a PV system on a compliant roof construction enables flame spread.
2022_SJP5 (Green OA)	Liu, Z.-G., Li, X.-Y., & Jomaas, G. (2022). Effects of governmental data governance on urban fire risk: A city-wide analysis in China. *International Journal of Disaster Risk Reduction*, *78*, 103138. https://doi.org/10.1016/j.ijdrr.2022.103138 http://hdl.handle.net/20.500.12556/DiRROS-17674
Abstract	The effects of data governance (as a means to maximize big data value creation in fire risk management) performance on fire risk was analyzed based on multi-source statistical data of 105 cities in China from 2016 to 2018. Specifically, data governance was first quantified with ten detailed indicators, which were then selected for explaining urban fire risk through correlation analysis. Next, the sample cities were clustered in terms of major socio-economic characteristics, and then the effects of data governance were examined by constructing multivariate regression models for each city cluster with ordinary least squares (OLS). The results showed that the constructed regression models produced good interpretation of fire risk in different types of cities, with coefficient of determination (R2) in each model exceeding 0.65. Among the indicators, the development of infrastructures (e.g. data collection devices and data analysis platforms), the level of data use, and the updating of fire risk related data were proved to produce significant effects on the reduction of fire frequency and fire consequence. Moreover, the organizational maturity of data governance was proved to be helpful in reducing fire frequency. For the cities with large population, the cross-department sharing of high-value data was found to be another important determinant of urban fire frequency. In comparison with existing statistical models which interpreted fire risk with general social factors (with the highest R2 = 0.60), these new regression models presented a better statistical performance (with the average R2 = 0.72). These findings are expected to provide decision support for the local governments of China and other jurisdictions to facilitate big data projects in improving fire risk management.
2023_SJP6 (Green OA)	Olson, S. L., Ruff, G. A., Ferkul, P. V., Owens, J. C., Easton, J., Liao, Y.-T., T'ien, J. S., Toth, B., Jomaas, G., Fernandez-Pello, C., Legros, G., Guibaud, A., Fujita, O., Smirnov, N., & Urban, D. L. (2023). The effect of duct size, sample size, and fuel composition on concurrent flame spread over large cellulose samples in microgravity. *Combustion and Flame*, *248*, 112559. https://doi.org/10.1016/j.combustflame.2022.112559 http://hdl.handle.net/20.500.12556/DiRROS-17650
Abstract	Concurrent flame spread data for thermally-thin charring solid fuels are presented from Saffire and BASS experiments performed in habitable spacecraft for three duct sizes, five sample sizes, two

	materials, and two atmospheres. The flame spread rates and flame lengths were strongly affected by duct size even for the relatively large ducts (> 30 cm tall). A transient excess pyrolysis length (i.e., flame length overshoot) was observed for the cotton fabric that burned away, which indicates that the transient excess pyrolysis length phenomenon is caused by more than just the flame moving into the developing boundary layer thickness as was the case with the SIBAL sample. A burnout time, defined as the pyrolysis length divided by the flame spread rate, normalized the pyrolysis length histories into a single curve with a steady burnout time of 22 s for the SIBAL fabric. The transient excess pyrolysis length is hypothesized to be a post-ignition flame growth transient for the essentially two-dimensional flames where the burnout time becomes very long until the preheat and pyrolysis lengths develop. The three-dimensional flames over narrow samples have lateral thermal expansion and lateral oxygen diffusion which allows them to transition to a steady state length without the transient excess pyrolysis length. Surface temperature profiles, nondimensionalized by the pyrolysis length, indicate that the temperature profiles exhibit the same shape across the pyrolysis zone. A surface energy balance calculation in the preheat region revealed that the heat flux increased rapidly at the pyrolysis front to near the critical heat flux for ignition. An estimate of the acceleration of the inviscid core flow in the duct due to thermal expansion and developing boundary layers on the duct walls and the SIBAL sample surface seems to explain the observed spread rate trends across three duct sizes and multiple sample sizes.
2023_SJP7 (Green OA)	Zhao, J., Li, X., Hu, Z., Kang, R., & Jomaas, G. (2023). Experimental study of the burning behavior and key parameters of gasoline pool fires with different ullage heights. *Fire Safety Journal*, *140*, 103912. https://doi.org/10.1016/j.firesaf.2023.103912 http://hdl.handle.net/20.500.12556/DiRROS-17651
Abstract	Pool fires with different ullage heights are a common type of fire accident. A series of gasoline pool fire experiments with two sizes (D = 40 cm, 60 cm) and six ullage heights (h = 0, 0.2D, 0.4D, 0.6D, 0.8D, 1.0D) are conducted. The burning process, axial temperature profile, radiative heat feedback, and burning rate are measured and analyzed. The result shows that the fuel vapor layer and the down-reaching flame layer are distinguished based on the axial temperature profile for the steady burning stage. Meanwhile, the down-reaching flame length (L_{down}) increases more profoundly for large tank diameters under the same ullage height. Subsequently, the dimensionless down-reaching flame length ($L_{down}^* = L_{down}/D$) increases exponentially with the dimensionless ullage heights ($h^* = h/D$). Finally, based on the classical burning rate model for the low ullage height and the heat transfer process from the flame to the fuel surface, a correlation with different ullage heights is established to calculate the burning rate, which is then validated against the experimental data in the paper and literature values. The results are of importance to understand the burning rate and the radiative heat feedback to the fuel surface for pool fires with different ullage heights.
2023_SJP8 (Gold OA)	Marrot, L., Zouari, M., Schwarzkopf, M., & DeVallance, D. B. (2023). Sustainable biocarbon/tung oil coatings with hydrophobic and UV-shielding properties for outdoor wood substrates. *Progress in Organic Coatings*, *177*, 107428. https://doi.org/10.1016/j.porgcoat.2023.107428
Abstract	With wood regaining substantial interest as a construction material due to sustainability concerns and aesthetics trends, efficient and safe protection methods are needed to prevent the discouloration and the loss of mechanical properties of this renewable and UV-sensitive material. In this study, sustainable coatings comprising 0 to 20 wt % biocarbon (BC) dispersed in tung oil were developed for wood protection. BC particles were added as ultraviolet (UV) absorbers and were produced by various carbonization routes. The BC powders were characterized in terms of particle size and surface functional groups by Fourier-Transform infrared, and the UV and visible absorbance of dispersed BC powders in water solutions were related to these characteristics. Two wooden substrates (beech and oak) were coated with the developed coatings and the samples underwent six months of onsite weathering. While the total colour change of uncoated samples and tung oil-coated substrates without BC kept increasing over time and resulted in a clear alteration of the wood surface aesthetics, an increased BC content in the coatings led to enhanced colour stability, with alteration of the colour close to 2 for both wood species after six months of weathering for 10 and 20 wt% BC. Coating with tung oil made the wooden substrates, initially hydrophilic, become hydrophobic, and the further introduction of biocarbon increased hydrophobicity. However, the increase in BC content was not correlated with an increase in water repellence, the highest water contact angle being observed for 5 % BC, and no further improvement in hydrophobicity was observed with higher BC content. The weathering negatively affected the water repellence of all the samples (i.e., reference samples and coated samples with various BC content).

	However, the introduction of 20 % BC best protected the decrease in water repellence induced by the onsite weathering.
2023_SJP9 (Gold OA)	Manes, M., Sauca, A., El Houssami, M., Andersson, P., McIntyre, C., Campbell, R., Rush, D., Hofmann, A., Wagner, P., Sokolov, S., Leene, M., Kobes, M., Oberhagemann, D., Rupp, N., Jomaas, G., Grone, F., & Guillaume, E. (2023). Closing Data Gaps and Paving the Way for Pan-European Fire Safety Efforts: Part II—Terminology of Fire Statistical Variables. *Fire Technology*, *59*(4), 1969–2000. https://doi.org/10.1007/s10694-023-01408-5
Abstract	A well-defined terminology of fire-related variables is important for correct analyses and supporting knowledge-based decisions regarding the evaluation of building fires at the European level. After developing an overview of current practices for fire statistics in Part I, the terminology used and the data collected by the EU Member States and eight other countries regarding fire incidents, property damage and human losses were mapped to increase awareness of their practice and support a comprehensive assessment of several fire statistical datasets. A questionnaire was distributed to relevant authorities responsible for the collection, elaboration/analysis, and fire statistical data publications to define and select the essential variables for an appropriate fire assessment and fire incident description. Based on the results of the questionnaire able to identify the essential fire statistical variables and a detailed analysis of current definitions adopted in the fire statistics of the EU Member States and other countries, a common terminology is proposed to collect the necessary data in the EU Member States and obtain meaningful datasets based on standardised terms and definitions. The results will generate essential outputs to move towards harmonised fire statistics at the EU level and contribute to an appropriate analysis able to improve fire prevention and fire mitigation in building fires.
2023_SJP10 (Gold OA)	Manes, M., Houssami, M. E., Campbell, R., Sauca, A., Rush, D., Hofmann, A., Andersson, P., Wagner, P., Sokolov, S., Veeneklaas, J., Kobes, M., Oberhagemann, D., Rupp, N., Jomaas, G., Grone, F., Van Hees, P., & Guillaume, E. (2023). Closing Data Gaps and Paving the Way for Pan-European Fire Safety Efforts: Part I—Overview of Current Practices for Fire Statistics. *Fire Technology*, *59*(4), 1925–1968. https://doi.org/10.1007/s10694-023-01415-6
Abstract	The analysis of the current state of fire statistics and data collection in Europe and other countries is needed to increase awareness of how fire incidents affect buildings and to support pan-European fire prevention and fire mitigation measures. The terminology and data collected regarding fire incidents in buildings in the EU Member States were mapped to obtain meaningful datasets to determine common terminology, collection methodology, and data interpretation system. An extensive literature review showed that fire data collection systems have been instrumental in informing firefighting strategies, evidence-based planning, prevention, and educational programmes. Differences and similarities between fire data collection systems were also investigated. The amount and quality of the information in fire statistical recording systems appear to be influenced by the complexity and structure with which the data are collected. The analysis also examined the existing fire statistics in the EU Member States and a few other countries. Finally, a detailed investigation of the number of fires, fire deaths, and injuries from 2009 to 2018 in several countries was examined based on data from a report by CTIF. The trends showed differences attributable to the existing fire statistical practices in terms of terminology and data collection, and interpretation. Part II proposes a common terminology for selected fire statistical variables. The results provide relevant information regarding fire safety at the European level and should be used to guide the development of more uniform fire statistics across Europe.
2023_SJP11 (Green OA)	Gernay, T., Ni, S., Unobe, D., Lucherini, A., Chaudhary, R., & Van Coile, R. (2023). Cost–Benefit Analysis of Fire Protection in Buildings: Application of a Present Net Value Approach. *Fire Technology*, *59*(4), 2023–2053. https://doi.org/10.1007/s10694-023-01419-2 http://hdl.handle.net/20.500.12556/DiRROS-17371
Abstract	In fire safety engineering, cost–benefit analysis provides a systematic method to assess whether the projected benefits from a fire safety measure outweigh its costs. However, there remains a wide discrepancy between methods used in the field for cost–benefit analysis, as well as a lack of quantitative data on the costs and economic impact of fire protection in buildings. In a recent research project, a reference methodology was proposed based on Present Net Value evaluation and on a combination of specialized construction database, fire statistics, and numerical modeling for estimation of the cost components. This paper presents the application of the methodology to four case studies. The case studies allow describing the methodology, the collection of data, fire statistics, and loss estimation, as well as illustrating how the methodology can support decision-making when multiple alternatives are

	compared. Under the assumptions adopted for the single-family house and the residential timber building case studies, it is found that for every 1$ invested in sprinklers, $1.06 is saved. This benefit–cost ratio increases with increasing valuation of indirect losses and statistical value of life. Sensitivity analyses are provided to explore the robustness of the investment recommendations. The results of evaluations, adapted from the presented case studies with project-specific inputs, can support decision making for policy makers, insurance companies, and individual building owners.
2023_SJP12 (Green OA)	Lucherini, A., Hidalgo, J. P., Torero, J. L., & Maluk, C. (2023). Numerical heat transfer model for swelling intumescent coatings during heating. *International Journal of Thermal Sciences*, *184*, 107922. https://doi.org/10.1016/j.ijthermalsci.2022.107922 http://hdl.handle.net/20.500.12556/DiRROS-17648
Abstract	This research study presents a heat transfer model aimed at estimating the thermal and physical response of intumescent coatings. The numerical model is inspired by the outcomes of an experimental study focused on analysing the insulating effectiveness of a commercial intumescent coating for a range of heating conditions and initial coating thickness. The model solves the one-dimensional heat conduction problem using the finitedifference Crank-Nicolson method, and it assumes that the effectiveness of intumescent coatings is mainly dependent on their ability to develop swelled porous char. The coating swelling is implemented in the model by adopting an approach based on expanding the mesh representing the physical domain in proximity to the substrate-coating interface. The model described herein offers researchers and engineers a tool to estimate the heat transfer of swelling intumescent coatings (i.e. in-depth thermal gradient). Outcomes of the analysis shown herein demonstrate that the heat conduction within intumescent coatings is governed by the physical coating swelling and the thermal conditions at the coating-substrate interface. The numerical model shows that its accuracy is highly influenced by the coating thickness ahead of the reaction zone. Consequently, the coating swelling rate plays a key role, while the thermo-physical properties of the intumescent coating have a secondary effect. According to its assumptions, the model defines a quasi-steady-state thermal problem: it is more accurate for conditions close to steady-state (e.g. high heat fluxes), but it loses accuracy for cases characterised by transient phenomena (e.g. phases prior to the onset of swelling and low heat fluxes).
2023_SJP13 (Gold OA)	Zouari, M., Stanciu, S. G., Jakes, J., Marrot, L., Fiorentis, E., Stanciu, G. A., & DeVallance, D. B. (2023). Investigations on the topography and micro-mechanical properties of polyvinyl alcohol thin-film composites reinforced with hardwood biocarbon particles. *Journal of Materials Research and Technology*, *27*, 5533–5540. https://doi.org/10.1016/j.jmrt.2023.10.217
Abstract	In this study, we investigated the impact on surface topography and micro-mechanical properties of polyvinyl alcohol (PVA) thin films when loaded with hardwood-derived biocarbon particles (BCP). The PVA/BCP composites were prepared with the conventional film casting method, after varying BCP concentrations of 6, 8, 10, 12, and 20 wt% were added to the PVA solution. Atomic force microscopy (AFM) investigations and nanoindentation tests were performed. The average roughness of the thin films increased with the increase in BCP content. The alternation between dark and light patterns observed in the AFM images showed an irregular surface topography with alternating high peaks and deep valleys. The skewness and kurtosis parameters showed that the different dispersion degrees of the BCP within the PVA matrix influenced the composites' surface roughness. The micro-mechanical properties of the thin film composites depended on the BCP type and concentration. Films reinforced with red oak-derived BCP had higher hardness and Young's modulus compared to films reinforced with willow SV1 and yellow-poplar BCP, which was attributed to the high carbon content and low ash content of red oak BCP. We argue that these results may be extrapolated to other types of BCP-reinforced thin films and can significantly contribute to enabling more efficient methods and protocols for reinforcing polymers with hardwood biocarbon.
2023_SJP14 (Gold OA)	Zouari, M., Marrot, L., & DeVallance, D. B. (2023). Evaluation of properties and formaldehyde removal efficiency of biocarbon prepared at variable pyrolytic temperatures. *Frontiers in Environmental Science*, *11*, 1252926. https://doi.org/10.3389/fenvs.2023.1252926
Abstract	Biocarbon (BC) represents a potential material for application in air remediation. This study investigated the efficiency of BC particles in the removal of formaldehyde. BC samples were prepared from *Arundo donax* (AD) and olive stone (OS) feedstocks at variable pyrolysis temperatures (from 300°C to 800°C). The BC particles were characterized using proximate, Fourier transform infrared, water contact angle, particle size, and physisorption analyses. The formaldehyde removal capacity was tested using an

	electrochemical formaldehyde sensor in a batch experiment. The physicochemical and structural properties depended on the pyrolysis temperature at which the BC was produced. The increase in pyrolysis temperature increased the BC's pH, hydrophobicity, and porosity. All the samples achieved a formaldehyde removal capacity ranging between 26% and 64% for BC pyrolyzed at 300°C and 800°C, respectively. In BC pyrolyzed at temperatures under 500°C, the formaldehyde capture was governed by a partitioning mechanism through diffusion in the noncarbonized organic fraction. In comparison, formaldehyde capture was controlled by a physical adsorption mechanism through pore filling for BC pyrolyzed at 500°C or above. BC pyrolyzed at 800°C was more efficient for formaldehyde adsorption due to the well-developed microporous structure for both AD and OS. AD-derived BC prepared at 800 °C (AD-BC800) was selected for the re-usability test, using thermal regeneration to remove the adsorbed components. The regenerated sample maintained a comparable formaldehyde removal capacity up to four re-use cycles. Moreover, the comparison between non-activated and activated AD-BC800 revealed that physical activation significantly enhanced BC's adsorptive ability.
2023_SJP15 (Gold OA)	Seweryn, A., Lucherini, A., & Franssen, J.-M. (2024). An Experimental Apparatus for Bench-Scale Fire Testing Using Electrical Heating Pads. *Fire Technology*, *60*(4), 2427–2460. https://doi.org/10.1007/s10694-023-01514-4
Abstract	This research study concerns an experimental, budget-friendly, electricity-powered apparatus for bench-scale fire testing. The apparatus consists of various elements, of which the most important are ceramic heating pads, used to impose heat fluxes on exposed surfaces of specimens. The test method allows to control the heating pads' temperature and to adjust the distance between the heating pads and the specimen to obtain well-defined heat fluxes up to 50–60 kW/m^2. Higher heat fluxes and temperatures can be obtained by setting the heating pads in *full power mode*, with or without the use of a thermal shield, which can lead to heat fluxes up to 150 kW/m^2. The heating and thermal boundary conditions imposed by the apparatus are characterised and discussed, and the thickness of the convective boundary layer at the heating pads' surface is estimated significantly lower than in the case of gas-fired radiant panels. The performance of the apparatus is analysed for various conditions: controlling the temperature of the heating pads, in an open environment or with the presence of thermal shields, and in *full power mode*. A few examples of application of the apparatus to fire test typical construction materials (steel and glass) are also presented. These results emphasise the well-defined heating conditions in temperature-controlled mode. The study finally discusses the advantages and limitations of the apparatus, as well as many possibilities of future applications and improvement for future research studies.
2023_SJP16 (Gold OA)	Lucherini, A., & Torero, J. L. (2023). Defining the fire decay and the cooling phase of post-flashover compartment fires. *Fire Safety Journal*, *141*, 103965. https://doi.org/10.1016/j.firesaf.2023.103965
Abstract	The current research study discusses and characterises the fire decay and cooling phase of post-flashover compartment fires, as they are often mixed up despite their important heat transfer differences. The two phases are defined according to the fire heat release rate time-history. The fire decay represents the phase in which the fire heat release rate decreases from the ventilation- or fuel-limited steady-state value of the fully-developed phase to fire extinguishment. This phase is highly influenced by the fuel characteristics, ranging from fast decays for hydrocarbon and liquid fuels to slow decays for charring cellulosic fuels (wood). Once the fuel is consumed, the compartment volume enters the cooling phase, where the cooling in the gas-phase and solid-phase happens with significantly different modes and characteristic times. The thermal boundary conditions at the structural elements are then defined according to physical characteristics and dynamics within the compartment. The research study also underlines how the existing performance-based methodologies lack explicit definitions of the decay and cooling phases and the corresponding thermal boundary conditions for the design of fire-safe structural elements under realistic fire conditions.
2023_SJP17 (Green OA)	Van Coile, R., Lucherini, A., Chaudhary, R. K., Ni, S., Unobe, D., & Gernay, T. (2023). Cost-benefit analysis in fire safety engineering: State-of-the-art and reference methodology. *Safety Science*, *168*, 106326. https://doi.org/10.1016/j.ssci.2023.106326 http://hdl.handle.net/20.500.12556/DiRROS-17181
Abstract	Cost-effectiveness is a key consideration within fire safety engineering. Currently, different approaches are being applied in literature. These approaches differ in how cost-effectiveness is evaluated, which costs are considered, and how the preferred design solution is defined. Recognizing this issue, the Fire Protection Research Foundation enrolled an international team of researchers, supported by a broad

	stakeholder panel, to develop a reference methodology. In this paper, this reference methodology for cost-benefit analysis in fire safety engineering is presented following an extensive literature review. The methodology clarifies the minimum requirements for assessing cost-effectiveness, and highlights that only a present net value evaluation can be used to compare design alternatives. Commonly used cost-benefit ratios should only be used when deciding on the effectiveness of a single package of fire safety measures. An illustrative case study demonstrates the application of the methodology and shows how designs based on cost-benefit ratios can be sub-optimal when evaluating multiple possible fire safety measures.
2024_SJP18 (Gold OA)	Zouari, M., Hribernik, S., Marrot, L., Tzolov, M., & DeVallance, D. B. (2024). Manganese dioxide-coated biocarbon for integrated adsorption-photocatalytic degradation of formaldehyde in indoor conditions. *Heliyon*, *10*(9), e29993. https://doi.org/10.1016/j.heliyon.2024.e29993
Abstract	Formaldehyde is a common indoor air pollutant with hazardous effects on human health. This study investigated the efficiency of biocarbon (BC) functionalized with variable contents of MnO2 for formaldehyde removal in ambient conditions via integrated adsorption-photocatalytic degradation technology. The sample with the highest formaldehyde removal potential was used to prepare a functional coating made of acrylic binder mixed with 20 wt% of the particles and applied on beech (Fagus sylvatica L) substrate. SEM images showed that MnO2 was deposited around and inside the pores of the BC. EDX spectra indicated the presence of Mn peaks and increased content of oxygen in the doped BC compared to pure BC, which indicated the successful formation of MnO2. Raman spectra revealed that the disorder in the BC's structure increased with increasing MnO2 loadings. FTIR spectra of BC–MnO2 samples displayed additional peaks compared to the BC spectrum, which were attributed to MnO vibrations. Moreover, the deposition of increased MnO2 loadings decreased the porosity of the BC due to pores blockage. The BC sample containing 8 % Mn exhibited the highest formaldehyde removal efficiency in 8 h, which was 91 %. A synergetic effect between BC and MnO2 was observed. The formaldehyde removal efficiency and capacity of the coating reached 43 % and 6.1 mg/m2, respectively, suggesting that the developed coating can be potentially used to improve air quality in the built environment.
2024_SJP19 (Gold OA)	Zouari, M., Marrot, L., & DeVallance, D. B. (2024). Functional biocarbon-based coatings for wood protection and indoor air depollution. *Building and Environment*, *261*, 111716. https://doi.org/10.1016/j.buildenv.2024.111716
Abstract	Growing concerns about indoor air pollution heighten the need to develop depolluting materials to achieve a healthy built environment. This study developed functional coatings for wooden surfaces using 20 wt% photocatalytic biocarbon particles doped with manganese oxide (BC–MnO2) and two different coating materials (linseed oil and waterborne acrylic). The samples' surface hydrophobicity and color properties were tested before and after accelerated aging. The depolluting potential of the samples was evaluated by formaldehyde removal efficiency test in indoor conditions. Results showed that adding BC-MnO2 particles increased the hydrophobicity regardless of the coating material's type. After accelerated aging, the hydrophobicity of all samples increased, which was attributed to the curing of the oil and acrylic polymers and the increase in surface roughness eventually caused by surface damage. The color change (ΔE) was more intense in the case of uncoated wood and samples without BC-MnO2. However, the BC-MnO2-containing coatings were effective in color preservation (ΔE < 2), which was attributed to the anti-UV property of biocarbon. The BC-MnO2-containing coatings exhibited a promising formaldehyde removal efficiency of up to 24 % and 46 % for oil and acrylic samples, respectively. The combination of BC-MnO2 and acrylic material was more favourable to attracting the formaldehyde molecules, likely due to the similar polarity. The developed functional coatings exhibited an acceptable ability for wood protection and formaldehyde remediation and can be potentially used to enhance indoor air quality.
2024_SJP20 (Green OA)	Han, L., Schwarzkopf, M., Pečnik, J. G., Rojas-Alva, U., Lucherini, A., Kutnar, A., & Sandberg, D. (2024). Exploratory study on the bending performance of thermo-hydro-mechanically densified Scots pine (*Pinus sylvestris* L.) at elevated temperatures. *Wood Material Science & Engineering*, *19*(3), 829–832. https://doi.org/10.1080/17480272.2024.2350685 http://hdl.handle.net/20.500.12556/DiRROS-20894
Abstract	Thermo-hydro-mechanical (THM) densification is a well-known wood modification procedure for improving the mechanical properties of low-density wood species, but its performance at elevated temperatures is not well understood. The objective of this study was to determine the bending behaviour

	of densified Scots pine at elevated temperatures. A total of 48 specimens (200 mm (longitudinonal) × 20 mm (radial) × 20 mm (tangential)) were tested to investigate the bending performance under constant temperatures at 25, 50, 125 and 175°C, respectively. It was found that the modulus of rupture (MOR) and modulus of elasticity (MOE) of both un-densified and densified pine decreased with increasing temperature. However, the densified wood exhibited more brittle shear failure but retained higher MOR and MOE than the untreated specimens treated at the same temperature level. In general, the results demonstrate that densification can be a potentially effective method to retain the mechanical properties of wood at elevated temperatures, thereby having a potential maintain the load-bearing capacity during and after fire.
2024_SJP21 (Gold OA)	Zouari, M., Marrot, L., & DeVallance, D. B. (2024). Effect of demineralization and ball milling treatments on the properties of Arundo donax and olive stone-derived biochar. *International Journal of Environmental Science and Technology*, *21*(1), 101–114. https://doi.org/10.1007/s13762-023-04968-9
Abstract	The structural and physio-chemical properties of biochar are crucial to determining biochar's quality and the adequate application. Specifically, the large porosity of biochar has been known as a favorable feature, especially for environmental remediation. In this regard, physical and chemical modifications have been used to improve biochar's porosity which requires high-energy consumption and involves chemical agents. The objective of this study was to prepare biochar with developed porosity using mild treatments. Arundo donax and olive stone were demineralized by a water-washing method. Treated and non-treated biomasses were pyrolyzed, and part of the derived samples was subjected to wet ball milling. Samples were characterized with proximate, Fourier transform infrared, particle size, and physisorption analyses. The effect of demineralization depended on the biomass type, as ash reduction only influenced Arundo donax-derived biochar, which was attributed to the difference in initial ash content that was relatively low for olive stone. The carbonization yield decreased by 46% for the Arundo donax biomass after demineralization. Moreover, demineralization expanded the surface area and total pore volume of the Arundo donax biochar. The ball milling was effective in producing micro-sized biochar particles with a mean size ranging between 30 ± 2 μm and 42 ± 2 μm and between 13 ± 1 μm and 22 ± 2 μm for Arundo donax and olive stone without and with demineralization, respectively. Ball milling increased the surface area of non-demineralized Arundo donax by 47% and demineralized Arundo donax by 124%. Additionally, ball milling increased the surface area of non-demineralized olive stone by 65% and demineralized olive stone by 62%.
2024_SJP22 (Green OA)	Put, F., Lucherini, A., Merci, B., & Van Coile, R. (2024). Model uncertainty in a parametric fire curve approach: A stochastic correction factor for the compartment fire load density. *Fire Safety Journal*, *144*, 104113. https://doi.org/10.1016/j.firesaf.2024.104113 http://hdl.handle.net/20.500.12556/DiRROS-18677
Abstract	A commonly used approach to represent the thermal load in a compartment fire is the Eurocode Parametric Fire Curve (EPFC), which specifies gas temperatures (or rather adiabatic surface temperatures). Recognizing the significant deviations between real fires and the EPFC framework, the concept of model uncertainty is explored. This study does not aim to assess or improve the EPFC, but introduces a model uncertainty, allowing for reliability-based structural fire engineering (SFE). It presents a stochastic correction factor for the fire load density, based on the maximum temperature in steel sections. The focus is on the fire load density, but in general other parameters can be jointly taken into account as well. This correction factor considers protected and unprotected sections, incorporating variations in section factor and protection thickness. The findings reveal that the fire load density within the EPFC framework can be modified to better represent the severity of fire experiments. This approach ensures physical consistency of the obtained compartment gas temperatures, as opposed to alternative approaches for addressing the EPFC model uncertainty. While promising results are evident in this proof of concept, exploration for other types of structural elements and evaluation for structural systems is necessary before integration into design practices.
2024_SJP23 (Gold OA)	Lucherini, A., Jovanović, B., Torero, J. L., Van Coile, R., & Merci, B. (2024). Thermal characterisation of the cooling phase of post-flashover compartment fires. *International Journal of Thermal Sciences*, *199*, 108933. https://doi.org/10.1016/j.ijthermalsci.2024.108933
Abstract	The main characteristics of the cooling phase of post-flashover compartment fires are studied using a simplified first-principles heat transfer approach to establish key limitations of more traditional methodologies (e.g., Eurocode). To this purpose, the boundary conditions during cooling are analysed. To illustrate the importance of a first-principles approach, a detailed review of the literature is presented

	followed by the presentation of a simplified numerical model. The model is constructed to calculate first-order thermal conditions during the cooling phase. The model is not intended to provide a precise calculation method but rather baseline estimates that incorporate all key thermal inputs and outputs. First, the thermal boundary conditions in the heating phase are approximated with a single (gas) temperature and the Eurocode parametric fire curves, to provide a consistent initial condition for the cooling phase and to be able to compare the traditional approach to the firstprinciples approach. After fuel burnout, the compartment gases become optically thin and temperatures decay to ambient values, while the compartment solid elements slowly cool down. For simplicity, convective cooling of the compartment linings is estimated using a constant convective heat transfer coefficient and all linings surfaces are assumed to have the same temperature (no net radiative heat exchange). All structural elements are assumed to be thermally thick. While these simplifications introduce quantitative errors, they enable an analytical solution for transient heat conduction in a semi-infinite solid that captures all key heat transfer processes. Comparisons between the results obtained using both approaches highlight how, even when considering the same fire energy input, the thermal boundary conditions according to the Eurocode parametric fire curves lead to an increase energy accumulated in the solid after fuel burnout and a delay in the onset of cooling. This is not physically correct, and it may lead to misrepresentation of the impact of post-flashover fires on structural behaviour.
2024_SJP24 (Green OA)	Zhao, J., Zhang, Q., Hu, Z., Kang, R., Jomaas, G., & Yang, R. (2024). Thin-layer boilover of large-scale diesel pool fires at sub-atmospheric pressure. *Fuel*, *360*, 130482. https://doi.org/10.1016/j.fuel.2023.130482 http://hdl.handle.net/20.500.12556/DiRROS-17808
Abstract	As thin-layer burning of fuels on water are often followed by thin-layer boilover fires, particularly during the firefighting process, an experimental and numerical study was undertaken to address key aspects of such fires, especially in plateau areas (i.e., sub-atmospheric pressure). In the thin-layer boilover experiments at subatmospheric pressure (69 kPa), diesel was used as the fuel in five circular steel trays (ranging from 0.4 m to 1.2 m in diameter) and a square steel tray (side length of 2.5 m). The burning process, and especially the continuous boilover stage, was presented and the corresponding boilover intensity, time to boilover onset and boilover time interval were measured and analyzed. The results show that the flame height increased sharply at the initial boilover, while this increasing range gradually became weak for the subsequent boilovers. The initial boilover intensity showed a linear dependency on the fuel layer thickness at the time of boilover, and the slope of the boilover intensity line decreased with increasing pan area. Eventually, the effect of pan area on boilover intensity became limit. Moreover, a predictive model for the boilover intensity was established based on dimensionless analysis. The initial boilover onset time under the sub-atmospheric pressure was delayed compared with that under atmospheric pressure. The corresponding predictive correlation (for 69 kPa) with different diameter and fuel thickness was developed based on the one-dimension two-layer conduction model. In the end, the boilover time interval decreased with the boilover times, closing to uninterrupted boilover eventually. This work enriches the thin-layer boilover behavior experimental data at sub-atmospheric pressure and provides guidance for the fuel storage safety.
2024_SJP25 (Green OA)	Unobe, I. D., Lucherini, A., Ni, S., Gernay, T., Chaudhary, R., & Van Coile, R. (2024). State of the Art Methodologies for the Estimation of Fire Costs in Buildings to Support Cost–Benefit Analysis. *Fire Technology*, *60*(3), 2067–2100. https://doi.org/10.1007/s10694-024-01561-5 http://hdl.handle.net/20.500.12556/DiRROS-18733
Abstract	Fires can lead to costly building damage as well as loss of lives and injuries. Installed to protect buildings from fire, or to limit the damage from such outbreaks, fire protection measures are a common feature in buildings. However, these features come at a cost. Although quite ubiquitous in buildings, the value of these features to private individuals and to society is not fully understood. To understand their value, a cost benefit analysis detailing the costs and benefits of fire protection measures is needed. Carrying out such an analysis requires methods for computing both the cost of these fire protection measures, and losses from fires (including both direct and indirect losses). This study outlines methodologies for evaluating those costs and losses. An exhaustive collection of available data necessary for estimating both costs and losses is presented. Several limitations in current methodologies and data constraints were identified, with recommendations proposed to address these shortcomings. Relevant sections of a study by the authors that refines fire protection cost estimation at national and sub-national levels are emphasized, including updated building categories, guidance on computing multipliers, and detailed cost calculation methods for installation and maintenance costs. The calculation uses regularly updated U.S.

	Census Bureau construction data, ensuring timely multiplier updates. The insights and suggestions presented in this study will ultimately refine the process of selecting fire protection strategies that maximize the net benefit of fire protection measures for both private stakeholders and society at large.
2024_SJP26 (Green OA)	Lucherini, A., & De Silva, D. (2024). Modelling intumescent coatings for the fire protection of structural systems: A review. *Journal of Structural Fire Engineering*, *15*(4), 483–507. https://doi.org/10.1108/JSFE-10-2023-0038 http://hdl.handle.net/20.500.12556/DiRROS-18716
Abstract	Purpose. Intumescent coatings are nowadays a dominant passive system used to protect structural materials in case of fire. Due to their reactive swelling behaviour, intumescent coatings are particularly complex materials to be modelled and predicted, which can be extremely useful especially for performance-based fire safety designs. In addition, many parameters influence their performance, and this challenges the definition and quantification of their material properties. Several approaches and models of various complexities are proposed in the literature, and they are reviewed and analysed in a critical literature review. Design/methodology/approach. Analytical, finite-differences and finite-elements methods for modelling intumescent coatings are compared, followed by the definition and quantification of the main physical, thermal, and optical properties of intumescent coatings: swelled thickness, thermal conductivity and resistance, density, specific heat capacity, and emissivity/absorptivity. Findings. The study highlights the scarce consideration of key influencing factors on the material properties, and the tendency to simplify the problem into effective thermo-physical properties, such as effective thermal conductivity. As a conclusion, the literature review underlines the lack of homogenisation of modelling approaches and material properties, as well as the need for a universal modelling method that can generally simulate the performance of intumescent coatings, combine the large amount of published experimental data, and reliably produce fire-safe performance-based designs. Research limitations/implications. Due to their limited applicability, high complexity and little comparability, the presented literature review does not focus on analysing and comparing different multi-component models, constituted of many model-specific input parameters. On the contrary, the presented literature review compares various approaches, models and thermo-physical properties which primarily focuses on solving the heat transfer problem through swelling intumescent systems. Originality/value. The presented literature review analyses and discusses the various modelling approaches to describe and predict the behaviour of swelling intumescent coatings as fire protection for structural materials. Due to the vast variety of available commercial products and potential testing conditions, these data are rarely compared and combined to achieve an overall understanding on the response of intumescent coatings as fire protection measure. The study highlights the lack of information and homogenization of various modelling approaches, and it underlines the research needs about several aspects related to the intumescent coating behaviour modelling, also providing some useful suggestions for future studies.
2024_SJP27 (Green OA)	Put, F., Lucherini, A., Van Coile, R., & Merci, B. (2024). CFD-based analysis of deviations between thermocouple measurements and local gas temperatures during the cooling phase of compartment fires. *Fire Safety Journal*, *150*, 104276. https://doi.org/10.1016/j.firesaf.2024.104276 http://hdl.handle.net/20.500.12556/DiRROS-20704
Abstract	Data from thermocouple (TC) measurements play a pivotal role in fire safety science and engineering studies. It is well-known that there are deviations from the actual local gas temperature and many studies have led to the development of correction factors. The present study focuses on these deviations inside compartments through a systematic series of CFD simulations, performed with Fire Dynamics Simulator (FDS), version 6.8.0. A canonical cubic box is used as geometry. This allows for the demonstration of the impact of the presence of smoke, with variable optical thickness, on the TC data as retrieved from FDS. Significant differences are observed between TC measurements and local gas temperatures. Corrections as developed for TC measurements in open atmospheres cannot be readily applied in compartment configurations, where smoke properties change both spatially and temporally.
2024_SJP28* (Green OA)	Jovanović, B., Caspeele, R., Reynders, E., Lombaert, G., Put, F., Lucherini, A., & Van Coile, R. (2025). Experimental investigation on the effect of natural fire exposure on the post-fire behavior of reinforced concrete beams using electric radiant panel. *Structural Concrete*, *26*(3), 3629–3644. https://doi.org/10.1002/suco.202400550 http://hdl.handle.net/20.500.12556/DiRROS-20895

	*Available online: November 2024, Journal issue in which the paper is published is in 2025.
Abstract	In this study, the effects of natural fire exposure on the post-fire behavior of concrete beams are investigated. The study is based on laboratory tests where three reinforced concrete beams were subjected to fire exposure using an electric radiant panel. This panel enables a precise application of radiative heat exposure closely mimicking natural fire exposure in a safe manner. During the test, the deflections, deformations and temperature changes are measured for all three concrete beams. Additionally, finite element modeling (FEM) is applied to supplement these tests, demonstrating the performance of existing structural fire engineering calculation tools in evaluating the burnout performance of concrete beams. The results of the tests show that the electric radiant panel provide a novel approach for fire simulation which is effective in replicating natural fire conditions, by applying the heat flux as specified in the Eurocode Parametric Fire Curve in a highly controlled manner. The uniformity of the temperature field measured inside the beams and the consistent deformations observed during the heat exposure across all three tests underscores the accuracy of the fire simulation. Furthermore, post-fire assessments reveal that while the exposed beams suffered some reduction in load-bearing capacity, they retained a significant portion of their original strength that was consistent across all three beams. The numerical simulations conducted in this study demonstrate a high level of accuracy in predicting the behavior of the concrete beams during fire exposure. These simulations effectively mirrored the experimental results, validating that they are a valuable tool for assessing concrete structures' performance in fire scenarios.
2025_SJP29 (Gold OA)	Lucherini, A., Pitelková, D. Š., & Mózer, V. (2025). Estimating the effective char depth in structural timber elements exposed to natural fires, considering the heating and cooling phase. *Engineering Structures*, *323*, 119255. https://doi.org/10.1016/j.engstruct.2024.119255
Abstract	This research study investigates the effect of different heating and cooling regimes on the effective cross-section of timber elements exposed to natural fires. An advanced calculation method based on a 1D finite-difference heat transfer model and effective thermo-physical properties is adopted to analyse the heat penetration and the consequent reduction in mechanical properties. In particular, the research focuses on the evolution and penetration speed of the char depth (300 ◦C isotherm) and zero-strength layer (determined through in-depth temperatures and reduced mechanical properties). Results reveal how the char depth mainly develops during the heating phase, with non-negligible contributions from the cooling phase. In contrast, the zero-strength layer increases throughout the whole fire exposure, particularly during cooling and, possibly, after the end of the cooling phase. In general, the heating phase contributes about 2/3 to the total effective char depth, while the cooling phase about 1/3. The most challenging conditions were found for the fires of the longest durations (heating and overall), corresponding to low ventilation and high fuel load density conditions. The study emphasises the necessity of incorporating the cooling phase in performance-based methodologies for fire-safe timber structures to avoid under-estimating heat penetration effects.
2025_SJP30 (Gold OA)	Rus, N., Lucherini, A., Jomaas, G., & Derikvand, M. (2025). Fire safety of timber buildings – The case of photovoltaic systems. *BioResources*, *20*(2), 2468–2471. https://doi.org/10.15376/biores.20.2.2468-2471
Abstract	Photovoltaic (PV) systems play an important role in reducing society's dependence on carbon-based energy sources, and their coupling with timber buildings is an interesting and expected solution for meeting sustainability requirements in the modern built environment. However, both PV systems and timber structures have unique fire safety challenges, and their combination may introduce additional risks. Therefore, relevant fire hazards associated with each of the technologies and their pairing are discussed. The findings highlight the importance of revising fire testing standards and developing tailored safety measures to identify and manage these risks.
2025_SJP31 (Gold OA)	Pečnik, J. G., Marrot, L., Mikuljan, M., Langella, T., & Schwarzkopf, M. (2025). Preliminary assessment of alkali-resistant flax based meshes for reinforcing cementitious composites. *Sustainable Materials and Technologies*, *45*, e01541. https://doi.org/10.1016/j.susmat.2025.e01541
Abstract	The production of textile-reinforced concrete (TRC) requires less materials and energy in comparison with conventional concrete reinforced with steel rebars, which draws some solutions towards the production of net zero concrete that the Cement and Concrete Industry sector should reach by 2050. To go one step further, this study investigates the development of flax based meshes as basic components for a reinforcement grid in cementitious materials. Flax strands and hybrid strands (combination of flax

	strands and glass or basalt rovings) were impregnated with an epoxy resin to form meshes. The physical and mechanical properties of the flax based meshes were assessed and the alkaline resistance of these reinforcing materials was evaluated to determine their durability in a cementitious matrix. At isoweight of reinforcement, the flax-based meshes demonstrated the best performance in terms of specific modulus and specific strength compared to the hybrid meshes. The hybrid meshes from the control batch displayed specific properties in the same range, whether they were constituted of AR-glass or basalt. However, the use of alkali-resistant glass rovings strongly mitigated the degradation of the mechanical properties of the hybrids meshes by making them less affected by the alkaline environment, among all the reinforcement meshes. In contrast, hybrid meshes with basalt experienced an extensive reduction in tensile strength and strain after exposure to alkaline environment, due to the corrosion of the basalt fibres. Pullout tests revealed maximum bond strengths for the flax based meshes embedded in a high-performance concrete matrix.
2025_SJP32 (Green OA)	Put, F., Jovanović, B., Symoens, E., Lucherini, A., Merci, B., & Van Coile, R. (2025). High-Intensity Fast-Response Electric Radiant Panel (HIFREP) to Impose Fire Equivalent Heat Fluxes on Building Elements with Enhanced Thermal Boundary Conditions Accuracy. *Fire Technology*, *61*(5), 3849–3874. https://doi.org/10.1007/s10694-025-01758-2 http://hdl.handle.net/20.500.12556/DiRROS-22656
Abstract	Bench-scale fire testing has gained popularity as a highly controllable and cost-effective solution, overcoming many of the shortcomings of traditional large-scale fire resistance tests. Whereas gas-fired radiant panels have demonstrated significant success in this area, the present study introduces a novel High-Intensity Fast-Response Electric radiant Panel (HIFREP). Utilizing electrically operated radiation emitters, it provides more precise and quasi-instantaneous control over the thermal boundary conditions. HIFREP delivers high and stable heat fluxes up to 105 kW/m2, and, due to the low thermal inertia of the emitters, can rapidly adjust its output to changes in the input. In this regard, the time constant of the emitters has been found to be less than 1 s, both during heating and cooling. It eliminates gas combustion and hence avoids the need for extraction hoods when testing the fire performance of non-combustible materials, making it suitable for traditional structural testing laboratories. The presented High-Intensity Fast-Response Electric radiant Panel also provides a reliable tool for the validation of FEM simulation results by accurately replicating the thermal boundary conditions in structural fire engineering analyses
2025_SJP33 (Gold OA)	Song, L., Zhou, Z., Ju, X., Wang, B., Rojas-Alva, U., Zhou, X., & Yang, L. (2025). Experimental study on thermal runaway characteristics and fire hazards of lithium-ion batteries in semi-confined space of transportation. *Journal of Energy Storage*, *128*, 117220. https://doi.org/10.1016/j.est.2025.117220
Abstract	Fire incidents involving lithium-ion batteries during transportation have become increasingly frequent, causing significant property damage and posing serious health risks to individuals nearby. Despite growing concerns over these incidents, the effects of spatial confinement during transportation on battery thermal runaway and fire behavior remain insufficiently understood. In this study, considering that batteries during transportation are often in space-limited scenarios, a comparative experiment was conducted to investigate lithium iron phosphate batteries' thermal runaway characteristics and fire hazards in semi-confined space with top openings. The research demonstrates that semi-confined space accelerates the thermal runaway process and exacerbates the fire hazard. Furthermore, as the state of charge increases, the severity of thermal runaway and the associated fire hazard escalate. Notably, as the size of the top opening increases, the battery deflagration transitions from extinction to stable continuous combustion, with gas toxicity initially increasing and then decreasing. This paper emphasizes the critical role of semi-confined space in influencing the fire behavior of lithium-ion batteries. It underscores the importance of effective smoke venting designs to mitigate the risks of battery thermal runaway during transportation. These findings can provide valuable insights for formulating regulations on lithium-ion battery transportation and designing smoke venting systems for transportation containers.
2025_SJP34 (Gold OA)	Rojas-Alva, U., Mancini, L., Mauko Pranjić, A., Marini, E., & Bozzini, B. (2025). On thermal safety characteristics of rechargeable alkaline batteries based on zinc and manganese dioxide. *Process Safety and Environmental Protection*, *199*, 107175. https://doi.org/10.1016/j.psep.2025.107175
Abstract	As lithium-ion technology's exhibits inherent issues with safety due to thermal runaway, a sustainable and cheaper alternative has been proposed in this work: the rechargeable alkaline battery chemistry. However, so far, the postulated safety of the new battery chemistry has not been demonstrated adequately. Therefore, a safety study is being carried out for rechargeable alkaline battery cells. This Short Communication paper is the first report on the thermal safety of Zn-MnO2 CR2032 rechargeable

	alkaline battery coin cells. 100 % charged coin cells were tested under thermal abuse conditions in a gravity-convection furnace to quantify the temperature at which the cell would go into thermal runaway. Morphological characterisation of pristine and tested cells was performed via laboratory-based X-ray computed microtomography. The onset temperature to thermal runaway for the rechargeable alkaline battery cells was found to be in the range of 290–380 ◦C, much higher than that reported in the literature for lithium-ion cells (150–200 ◦C) of similar capacity and geometry. These results emphasise that rechargeable alkaline battery technology has improved thermal stability compared to lithium-ion technology. Lastly, morphological analyses highlighted the variations of cell geometry brought about by thermal testing.
2026_SJP35 (Gold OA)	Yu, W., Yang, L., Wang, X., Lai, D., Jomaas, G., Liew, K. M., & Ju, X. (2026). Experimental and numerical investigation of the fire behavior of double-glass building integrated photovoltaic modules with PVB interlayers. *Energy*, *342*, 139726. https://doi.org/10.1016/j.energy.2025.139726
Abstract	Amid rising global energy demands and environmental concerns, energy-efficient, or 'green', buildings are becoming mandatory in building regulations worldwide. In that context, building-integrated photovoltaics (BIPV), which merge photovoltaic (PV) modules with architectural design, are gaining widespread adoption. To assess fire safety aspects of BIPV, the fire performance of double-glass PV modules with polyvinyl butyral (PVB) encapsulation in BIPV façade systems was studied experimentally and numerically. More specifically, fire experiments were conducted under varying radiative heat fluxes to evaluate thermal degradation, fire behavior, and toxic gas emissions. Key parameters, including ignition time, heat release rate per unit area (HRRPUA), mass loss rate (MLR), and gas composition, were analyzed. The results confirm that a higher external heat flux markedly reduces ignition time while increasing HRRPUA and MLR for BIPV, which is in line with results for other materials. The primary toxic gases emitted during combustion were CO, CO2, H2, and SO2, with CO and CO2 emissions rising significantly at elevated heat fluxes. To complement the experimental results, a numerical model coupling transient heat conduction and pyrolysis kinetics was developed to predict the pre-ignition thermal response of the multilayer structure. The model employed layer discretization and temperaturedependent boundaries, demonstrating close agreement with experimental data. Therefore, it enabled systematic analyses of the sensitivity of PV module material flammability to incident radiative heat fluxes, material properties, and geometric configurations. This combined experimental and numerical approach offers a predictive framework for assessing fire risks and optimizing the fire safety design of BIPV systems.
2026_SJP36 (Green OA)	Put, F., Sørensen, M. B., Abbiati, G., Lucherini, A., Merci, B., & Van Coile, R. (2026). Optimal experimental design for the calibration of a high-temperature thermal strain model for concrete during cooling. *Construction and Building Materials*, *518*, 145731. https://doi.org/10.1016/j.conbuildmat.2026.145731 http://hdl.handle.net/20.500.12556/DiRROS-28808
Abstract	Performance-based structural fire design relies on models that capture material and structural behaviour during heating and cooling. Such models require experimental data, but experiments are often time- and resourceintensive. Optimal Experimental Design (OED) can reduce the number of tests needed by minimizing the variance of parameter estimates. This study demonstrates the use of OED, using D-optimality as the optimization criterion, for an experimental setup that measures the thermal elongation of concrete specimens. In these tests, cylindrical concrete specimens are slowly heated to a predefined maximum temperature while their elongation is being measured. The goal of the experimental campaign is to calibrate a model for the free thermal strain of concrete during cooling. The OED determines the optimal exposure that is expected to result in the lowest variance around the mean values of the parameter estimates. The results of the OED are compared with a baseline experimental design without optimization, showing that the advantages of OED become increasingly evident as the number of experimental runs grows and intuitive reasoning becomes less reliable. In addition, the approach is validated considering real experimental data.
2026_SJP37 (Green OA)	Put, F., Felicetti, R., Lucherini, A., Merci, B., & Van Coile, R. (2026). Updating of a deterministic model for the free thermal strain of concrete in fire during heating and cooling using novel experimental data and Bayesian inference. *Fire Safety Journal*, *161*, 104659. https://doi.org/10.1016/j.firesaf.2026.104659 http://hdl.handle.net/20.500.12556/DiRROS-28086
Abstract	With the rise of performance-based structural fire design, understanding the behaviour of materials during both the heating and cooling phases of a fire has become essential. Traditionally, research has

	focused on the heating phase, resulting in limited data on material properties during cooling, in particular for the free thermal strain of concrete. This gap is critical, as free thermal strain significantly influences load redistribution in reinforced concrete structures. Two experimental campaigns were conducted to expand the available data: one using the UGent HIFREP ('High Intensity Fast-Response Electric Radiant Panel') and the other employing an electric furnace. The first test campaign provided an extensive dataset on the residual thermal strain, whereas the timeconsuming furnace tests provided data for the entire fire event (heating and cooling). These datasets were used to update an existing model through Bayesian inference, coherently integrating the new information. The outcome is a comprehensive probabilistic model that accurately captures the free thermal strain behaviour of concrete throughout both heating and cooling, allowing for a full reliability-based evaluation of concrete structures in fire.
2026_SJP38 (Gold OA)	Veit, M., Johra, H., Rask, N., Roesgaard, S. M., & Jensen, R. L. (2026). Experimental investigations of internal macro-scale convection in the loose-fill wood fiber insulation layer of a full-scale wall element. *Energy and Buildings*, *350*, 116646. https://doi.org/10.1016/j.enbuild.2025.116646
Abstract	With increasing restrictions on the energy efficiency of buildings, thicker insulation layers are installed in new and refurbished buildings to reduce heat losses. Previous studies have indicated that internal macro-scale convection cells can occur in thick porous insulation layers, decreasing the thermal performance of the envelope component. The focus of previous studies has been on horizontal insulation layers, most often composed of glass wool. Therefore, there is a lack of empirical data for loose-fill insulation and, in particular, bio-based materials, which have the potential of being more sustainable than conventional ones. The present investigation of this paper looks at the possibility of internal macro-scale convection inside loose-fill wood fiber insulation in a fullscale vertical wall element, with the modified Rayleigh number in the current investigation being between 20 and 45 and exhibiting internal convection in all cases. The experimental results show good agreement in terms of heat flux and temperature distribution with numerical simulations where the macro-scale convection is modelled explicitly. It also indicates that internal macro-scale convection can be modelled with existing building physics simulation tools, such as COMSOL. Finally, the internal macro-scale convection increases the effective U-value by up to 90 % for the highest temperature difference in steady-state conditions. This effect appears to diminish under dynamic boundary conditions, with a calculated effective U-value being within the uncertainty of the steady-state case with the lowest temperature difference, indicating that it might be less influential under real conditions.
2026_SJP39 (Gold OA)	Song, L., Wang, Z., Zhu, Y., Zhou, Z., Wang, B., Wang, D., Rojas Alva, U., Yang, L., & Ju, X. (2026). A review of safety issues in lithium-ion battery transportation process: Research advances and challenges. *Journal of Loss Prevention in the Process Industries*, *100*, 105912. https://doi.org/10.1016/j.jlp.2026.105912
Abstract	The growing demand for lithium-ion battery transportation, coupled with inadequate regulatory frameworks, has led to frequent fire incidents during transit, resulting in substantial losses of life and property. These recurring accidents underscore the urgent need to enhance the safety of lithium-ion batteries throughout the transportation process. This review begins by identifying key factors affecting battery safety during transport, such as mechanical abuse, thermal abuse, air pressure variations, and salt concentration. It then synthesizes current technological advancements and real-world battery transportation scenarios to conduct a targeted analysis of the critical technical challenges constraining transportation safety limits—specifically, ventilation and heat dissipation strategies, thermal monitoring, and fire safety design—while systematically examining the limitations of existing research. Accordingly, the paper proposes actionable recommendations and technical measures to improve the safety of lithium-ion battery transportation. Additionally, it outlines existing international standards and testing protocols governing lithium-ion battery transport and highlights shortcomings in the current regulatory landscape. The insights presented herein could provide valuable guidance for optimizing safety protocols in the transportation of lithium-ion batteries.
2026_SJP40 (Gold OA)	Spyridakis, S., Wiesner, F., Lucherini, A., Wu, W., Maluk, C., & Orabi, A. (2026). Fire performance of thin intumescent coatings: Material characterisation and application to mass timber structures. *Fire Safety Journal*, *162*, 104711. https://doi.org/10.1016/j.firesaf.2026.104711
Abstract	This study investigates the thermal behaviour of two opaque and one transparent thin intumescent coating at material level (coating only) and system level (coating applied at real scale on timber), and their effects on timber in fire. Micro-scale tests were conducted to examine the underlying mechanisms of intumescence and degradation for each coating individually, while bench-scale tests demonstrated how these behaviours translate to larger scales. Critical temperature and heat flux thresholds were

	identified at which the coatings begin to insulate the timber through the formation of the intumescent char layer, as well as those marking degradation of the layer and the reduction of its insulating efficacy. The findings highlight that coating type and thickness, heating conditions and exposure duration influence mass retention, swelling pattern, and the integrity of the intumescent char layer. Overall, the transparent coating exhibited lower durability than the opaque ones. It was also shown that, due to the similar temperature ranges of timber pyrolysis and coating swelling, timber degradation occurs close to the coated surface during the transient swelling process, resulting in a heated region of 1520 mm with negligible mechanical properties by the end of swelling. Therefore, intumescent coatings provide insulation progressively rather than immediately.
2026_SJP41 (Gold OA)	Gupta, V., Senez, K., Pope, I., Wiesner, F., Lucherini, A., Lange, D., Torero, J. L., Weckman, E., & Hidalgo, J. P. (2026). Burning of liquid pools and wood cribs in large fully developed timber compartment fires. *Fire Safety Journal*, *162*, 104739. https://doi.org/10.1016/j.firesaf.2026.104739
Abstract	The contribution of exposed mass timber to compartment fire dynamics is often framed by prescribed fuel load density, implicitly assuming fuel-independent thermal feedback. This paper interrogates that assumption experimentally using full-scale cross-laminated timber (CLT) compartments with two exposed surfaces (ceiling and side wall) and a movable fuel; either a kerosene pool or a wood crib. High-resolution measurements of heat flux, in-depth timber temperatures, burning rates, opening flows, and gas species demonstrate that fuel chemistry and geometry strongly modulate oxidizer delivery and residence time, thereby governing radiative feedback, CLT burning rates, and external flaming. The pool fire exhibited pronounced radiative enhancement and transient oxidizer starvation near the timber until pool decay. In contrast, the crib burning rate was inhibited, while the CLT burned efficiently. Analysis of the Global Equivalence Ratio (GER) and air bypass ratio revealed significant excess oxygen in the outflow, indicating that entrained air did not permeate the crib but instead oxidized the CLT, leaving unreacted air due to short mixing timescales. Despite unchoked doorway conditions, the crib fire produced bypass ratios and external flaming fractions comparable to the pool fire. The work shows that fuel load and ventilation factors alone are insufficient to describe the mass timber compartment fire dynamics and the CLT performance (e.g. charring). The fuel chemistry, geometry, and placement interact significantly with the compartment geometry. Therefore, the role of the moveable fuel is fundamental, and care must be employed when extrapolating demonstrator experiment results to the fire safety design of mass timber buildings.
2026_SJP42 (Gold OA)	Igweh, E. J., Stoliarov, S. I., & Sunderland, P. B. (2026). Temperature and heat flux measurements from firebrand piles using color ratio pyrometry. *Fire Safety Journal*, *162*, 104712. https://doi.org/10.1016/j.firesaf.2026.104712
Abstract	Glowing firebrands are a key ignition source in Wildland–Urban Interface fires, yet their thermal characterization is challenging due to small size, irregular shape and sensitivity to environmental conditions. This study extends color ratio pyrometry from a single firebrand to firebrand piles to measure spatially resolved surface temperatures, heat flux to a remote location, and radiative loss fraction in a wind tunnel at 0.9–2.7 m/s. A Digital Single Lens Reflex camera, calibrated against a blackbody furnace, recorded temperatures at 1 Hz in the range 873–1473 K. Mean surface temperatures were measured with color ratio pyrometry and determined to be 1130–1260 K, with localized hot spots on the windward side of the pile. Radiant heat flux at a point 9.6 cm above the firebrand pile was computed using a pixel-wise view factor method with surface-specific emissivity and transmittance. This approach reproduced the temporal trends measured by a Schmidt–Boelter heat flux gauge, with peaks near 6 kW/m2. Including a correction for hot, non-glowing regions below 873 K improved agreement across all wind speeds, keeping the average error below 9%. The radiative loss fraction, measured via carbon oxide calorimetry, stabilized at 0.20–0.23 during the first 100 s of the glowing phase.
2026_SJP43 (Green OA)	Charlier, M., De Paula Filho, J. H. M., & Lucherini, A. (2026). Environmental Impact of Structural Fire Engineering for Sustainable Building Design: Current Practices and Future Directions. *Fire and Materials*, fam.70061. https://doi.org/10.1002/fam.70061 http://hdl.handle.net/20.500.12556/DiRROS-29409
Abstract	In the climate emergency context, it is necessary to consider the several existing structural fire engineering strategies through the lens of sustainability, hence assessing the environmental impact of the current structural fire engineering practices to minimise it, based on the project's specificities. However, it is equally necessary to raise awareness of how environmental targets may affect the structural performance of a building in the event of a fire. This paper offers an overview of the existing

	strategies and recent developments to decrease the embodied carbon and foster circularity for structural fire engineering. Low-carbon emission materials, optimisation strategies for structural systems and fire protection, and circularity principles like design for disassembly and reuse of structural elements are discussed. Finally, a case study of an office building is presented to analyse the embodied carbon of different equivalent design and structural fire engineering practices, indicating the potential for reducing the climate impact in a fire safety context.
2026_SJP44 (Green OA)	Ma, H., Kong, W., Jomaas, G., De Liso, B. A., Salzano, E., Huang, H., & Zhao, J. (2026). Evaporation and piloted ignition in porous media soaked with heptane. *Fire Safety Journal*, *162*, 104775. https://doi.org/10.1016/j.firesaf.2026.104775 http://hdl.handle.net/20.500.12556/DiRROS-33007
Abstract	In incidents involving liquid fuel spills, the application of porous media such as sand is widely regarded as an efficient and safe mitigation measure. However, the effectiveness of this approach in preventing ignition has not been thoroughly investigated. This study investigated the evaporation and piloted ignition behavior of quartz sand soaked in heptane (representative flammable liquid) under varying external heat fluxes (10–50 kW/m2) and fuel levels, using a cone calorimeter with electric spark igniter. A numerical model, complemented by theoretical ignition models, was developed to simulate the underlying processes. Results showed that the time required for flash ignition and sustained ignition decreased nonlinearly with increasing external heat flux and fuel level, with sustained ignition times ranging from 28 s to 3400 s. The critical mass flux (the minimum mass flux of fuel gases for which the flame is sustained for at least 5 s) required for sustained ignition remained consistent under different conditions and was accurately predicted by a gas-phase ignition model. By calibrating key parameters and boundary conditions, the numerical model effectively predicted both evaporation rates and temperature evolution. The integration of numerical and ignition models enabled the prediction of sustained ignition times with errors within 20%. The findings of this study provide data and a valuable tool for assessing the ignition behavior of fuel-soaked porous media.
2026_SJP45 (Green OA)	Yu, W., Yang, L., Chen, X., Wang, Z., Xu, J., Jomaas, G., & Ju, X. (2026). Effect of vertical cavity geometry on flame spread along insulated double-glass BIPV façades exposed to window spill fires. *Fire Safety Journal*, *162*, 104752. https://doi.org/10.1016/j.firesaf.2026.104752 http://hdl.handle.net/20.500.12556/DiRROS-33011
Abstract	The integration of insulated double-glass Building-Integrated Photovoltaics (BIPV) façades are increasingly applied in modern façades, but their fire behavior under window spill plume exposure remains insufficiently understood. An experimental study was therefore carried out to examine how cavity depth factors influence flame spread in insulated BIPV façade systems exposed to window spill plume. A 1/8 scale five-story building model was constructed with systematic variations in cavity gaps, including no cavity and four different cavity depths (δ) of 2 cm, 5 cm, 8 cm, and 10 cm. Propane burners produced controlled spill flames, with corresponding window overflow heat release rates of 5.5 kW, 8.5 kW, and 11.6 kW. Flame height, spread rate, and temperature profiles were recorded. The study focuses on how changes in cavity depth influence vertical flame propagation. At higher heat release rates, the spread rate decreases non-linearly with δ, while at lower rates a threshold exists below which flames cannot sustain spread. A temperature analysis confirms that cavity confinement amplifies convective and radiative feedback, accelerating flame growth. Importantly, the findings are interpreted in light of window spill plume and flame spread theories, providing a theoretical basis for understanding cavity-driven façade fire dynamics and supporting fire-safe design of BIPV façade systems.
2026_SJP46 (Gold OA)	Veit, M., Lucherini, A., Verstockt, S., & Merci, B. (2026). Video enhancement for increased spatio-temporal resolution in thermal videos: Demonstration on a pool fire. *Fire Safety Journal*, *163*, 104758. https://doi.org/10.1016/j.firesaf.2026.104758
Abstract	A spatio-temporal video enhancement of a small-scale pool fire is performed to address the typically low spatial resolution and frame rate of inexpensive infrared (IR) cameras. Improving image quality can increase the applicability of low-cost thermal cameras for certain research tasks and analyses. The spatial resolution and frame rate are doubled, from 310 × 250 pixels (px) to 620 × 500 px, and from 25 frames per second (fps) to 50 fps, as well as from 50 fps to 100 fps. Spatial resolution enhancement is achieved using super-resolution methods based on deep learning, employing several pre-trained models: Fast Super-Resolution CNN (FSRCNN), Efficient Sub-Pixel Convolutional Network (ESPCN), Enhanced Deep Super-Resolution (EDSR), Laplacian Pyramid Super-Resolution Network (LapSRN), and

	Real-ESRGAN. The footage consists of an n-heptane pool fire recorded using a mid-wave infrared (MWIR) FLIR X6981 HS InSb camera. EDSR provides the best performance for both purely resized images and images subjected to complex degradation. For temporal enhancement, a pre-trained frame interpolation model, FLAVR (FlowAgnostic Video Representation), is used. The resulting interpolated frames appear realistic and preserve the overall flow direction and shape of the flame. The interpolated frames are compared with ground-truth data to validate the accuracy of the temporal enhancement.
2026_SJP47 (Green OA)	Pope, I., Lucherini, A., Torero, J. L., Solarte, A., Soriguer, D., Gupta, V., Wiesner, F., Lange, D., & Hidalgo, J. P. (2026). Charring and in-depth thermal penetration within cross-laminated timber elements in large-scale compartment fires. *Fire Safety Journal*, *163*, 104817. https://doi.org/10.1016/j.firesaf.2026.104817 http://hdl.handle.net/20.500.12556/DiRROS-29407
Abstract	The fire performance of engineered timber structures is fundamentally controlled by the coupling between the indepth temperature evolution of the timber elements and the internal compartment fire dynamics. Charring and heating of the timber during and after a fire are known to significantly degrade the mechanical capacity of timber elements, while also influencing the intensity and duration of burning by generating additional fuel and potentially inducing bond line failures. A series of large-scale fire experiments in cross-laminated timber (CLT) compartments with varying configurations of exposed timber surfaces and movable fuel loads has been performed to investigate these interrelationships, by measuring the charring, thermal penetration, and exposure conditions of the CLT elements. The extent of charring and in-depth heating was found to be primarily determined by the duration of heating—associated to the movable fuel load characteristics and occurrence of selfextinction or char fall-off. Significant in-depth temperature rise beyond the char front continued beyond the decay of the fire and cessation of charring. These findings highlight the importance of designing timber compartments to limit the duration of burning, and to account for the structural implications of thermal penetration during the cooling phase.
2026_SJP48 (Gold OA)	Zhao, J., Zhang, S., Hu, Z., Jomaas, G., Zhang, J., Jiang, H., & Huang, Z. (2026). Effects of crosswind and ullage height on internal temperature distributions of tank fires: Experiments and deep learning predictions. *Applied Thermal Engineering*, *300*, 131329. https://doi.org/10.1016/j.applthermaleng.2026.131329
Abstract	Tank fires are typically characterized by intense combustion, high temperatures, and strong thermal radiation. The coupled effect of crosswind and tank ullage height leads to complex evolution of internal burning parameters. Existing monitoring methods are mainly limited to external measurements, making it difficult to capture internal temperature dynamics. In this study, large-scale tank fire experiments were conducted under the coupled influence of crosswind and ullage height to examine the internal temperature distributions. A dataset was generated from the experimental data, which was then used to predict the flow and temperature distributions using two deep learning methods, namely residual-enhanced multi-layer perceptron (RMLP) and point transformer (PT). Experimental results show that the internal temperature exhibits non-uniform distribution, with high-temperature zones aggregating on the leeward side as wind speed increases. Two distinct flame behaviors were observed at different ullage heights: bottom-contacting and non-bottom-contacting. Both models are capable of predicting the internal temperature field. The RMLP model achieves slightly better pointwise prediction accuracy, while the PT model shows superior capability in reconstructing the overall spatial temperature distribution and demonstrates stronger robustness under bottom-contacting and extreme conditions. Sensitivity analysis and SHAP results indicate that the internal temperature is strongly correlated with radial position r, ullage height-to-diameter ratio h/D, and the coupled effect of wind speed and ullage height (h/D) × u, while the correlation with u and D alone is low, suggesting that wind influences internal temperature primarily through coupling with h/D. This study validates the feasibility of using deep learning for tank internal temperature predictions and provides insights for tank fire research and fire suppression strategy optimization.
2026_SJP49 (Gold OA)	Marrot, L., Pečnik, J. G., Jereb, V., Škrlep, L., Uršič, M., & Sivrikaya, H. (2026). Combined effects of one-sided surface charring and phytic acid impregnation on the surface properties and fire performance of wood. *Scientific Reports*. https://doi.org/10.1038/s41598-026-70642-y
Abstract	Surface charring is a wood modification technique that enhances the aesthetic appearance of wood while increasing durability and service life in outdoor environments. Scots pine (Pinus sylvestris L.) was subjected to one-sided surface charring at temperatures of 210, 240, and 270 °C, followed by impregnation with 10% phytic acid solution. The rise in charring temperature from 210 to 240°C led to

	a notable increase in the weight percent gain (WPG) of PA in the charred wood. Charring treatment significantly reduced lightness as temperature increased compared to untreated control. The highest water contact angles were observed for groups charred at 210°C (115°) and 240°C (116°), whereas phytic acid impregnation decreased the contact angle due to its hydrophilic nature. Reaction to fire of the groups was studied at 25 kW m−2 and 50 kW m−2. Compared with the control group, charred groups displayed generally lower time to ignition (i.e., increased flammability) and a lower peak heat release rate. When applying an irradiance of 25 kW · m-2, groups impregnated with PA did not ignite. When applying 50 kW · m-2, the heat release rate of the PA impregnated groups evolved similarly, displaying a delayed ignition, a sharp reduction of the peak of heat release rate, and releasing almost no heat. However, the PA impregnation negatively increased the generation of VOCs and the smoke production.
2026_SJP50 (Gold OA)	Maragkos, G., Floyd, J., Lucherini, A., Snegirev, A., Igweh, E., & Merci, B. (2026). Large eddy simulations of ventilation-limited compartment fire scenarios using a new dynamic flame extinction and re-ignition model in FDS. *Applications in Energy and Combustion Science*, *27*, 100532. https://doi.org/10.1016/j.jaecs.2026.100532
Abstract	Large eddy simulations of ventilation-controlled compartment fire scenarios conducted with FDS and new dynamic extinction and re-ignition models are presented. Flame extinction is modelled considering an enthalpy balance, based on a critical flame temperature, while re-ignition is allowed if the local resolved temperature exceeds a given re-ignition temperature. The re-ignition temperatures are estimated on the basis of counterflow simulations with hot oxidizers at different strain rates. The determination of the critical flame temperatures is made through well-stirred reactor simulations under different residence times and diluent types/concentrations. The new models are applied in reduced-scale ventilation-limited compartment fire scenarios with variable heat release rate. Comparison against the original model of FDS, relying on constant critical flame and re-ignition temperatures, are made. Overall, the predictions with the new dynamic models agree both qualitatively and quantitatively with the experiments. By considering the local properties of the flow, the new models bring some improvements, compared to the original models of FDS, in particular for the O2 concentrations inside the compartment in ventilation-controlled conditions.
2026_SJP51 (Gold OA)	Rus, N., Mossberg, A., Puccia, V., Wetterqvist, C., Jug, A., & Jomaas, G. (2026). Fire incidents involving photovoltaic systems – An analysis of different national statistics. *Fire Safety Journal*, *165*, 104936. https://doi.org/10.1016/j.firesaf.2026.104936
Abstract	With the increasing number of PV installations, reported PV-related fire incidents are receiving greater attention, although their quantification depends strongly on how such events are recorded. To manage fire safety risks in PV systems effectively, accurate statistics on the probability and consequences of these incidents are essential. National statistics from the UK, Italy, Sweden, and Slovenia were analysed to examine how differences in reporting methodologies influence the observed fire statistics. The findings indicate that different measures may be relevant for assessing ignition frequency. When comparing reported fire numbers, the rate ranges from approximately 4-11 fires per GW annually in the UK, Italy, and Sweden, to about 37 per GW annually in Slovenia. Similarly, the number of incidents per 100,000 installations was found to be approximately 5-22 for the UK, Italy, and Sweden, compared with 75 in Slovenia. These differences are likely influenced by variations in data collection methods and inclusion criteria across the countries. Swedish data also show notable differences in the various measures depending on system size. In the Swedish dataset, DC cables and connectors are the most frequently identified ignition source. Regarding consequences, about 68 % of fires remain confined to the PV equipment, while 24 % damage adjacent surfaces. In 5 % of cases, significant fire spread occurred, while in 3 % the building was completely destroyed. The similarities and differences in the national statistics highlight the need for harmonised data collection to enable meaningful comparison and support data-driven fire safety measures for PV systems.
2026_SJP52 (Green OA)	Maragkos, G., Floyd, J., Lucherini, A., Snegirev, A., Igweh, E., & Merci, B. (2026). Development and application of a dynamic flame extinction and re-ignition model in FDS. *Fire Safety Journal*, *165*, 104927. https://doi.org/10.1016/j.firesaf.2026.104927 http://hdl.handle.net/20.500.12556/DiRROS-31241
Abstract	A new dynamic flame extinction and re-ignition model that considers the local properties of the flow has been developed. The extinction model is based on the default enthalpy balance used by the Fire Dynamics Simulator (FDS) and employs a dynamic calculation of the critical flame temperature, TCF T , derived from well-stirred reactor simulations with different diluent concentrations, which depends on

	the local mixing time and species concentrations. On the other hand, re-ignition is allowed to occur if the cell temperature is above a threshold re-ignition temperature, Tign, derived from counterflow simulations considering hot fuel and oxidizers, which depends on the local strain rate magnitude. The model has been implemented in FDS and validated against two well-characterized scenarios with different fuels (i.e., UMD line burner and FM burner cases) involving flame extinction due to dilution. Overall, improved predictions with respect to the reduction of the combustion efficiency, when compared to the original extinction and re-ignition model of FDS, are obtained. The predicted Tign and TCF T were (significantly) higher and lower, respectively, compared to the default value of FDS. In addition, lower O2 concentrations were qualitatively observed within the flame region with the new model.
2026_SJP53 (Gold OA)	Johra, H., Léard, P., Veit, M., & Jensen, R. L. (2026). Full-scale experimental study on the critical Rayleigh number for the onset of internal natural convection inside a horizontal insulation layer of blown glass wool. *Journal of Building Physics*, *50*(2), 374–437. https://doi.org/10.1177/17442591261447483
Abstract	Glass wool is a common high-performance insulation material employed in buildings. The effective thermal conductivity of such materials with large open-pore structures can drastically increase if internal natural convection takes place inside the latter. This can occur in the case of a thick insulation layer with high porosity (low density) and subjected to a large temperature gradient. Such conditions can be met for blown glass wool insulation during winter in cold-climate regions. Consequently, the accurate assessment of the criteria determining the onset of internal natural convection in porous insulation is fundamental to optimizing the thermal performance of the latter. However, the numerical simulation of such phenomena is very complex and does not yield reliable results. Experimental investigations in realistic conditions are thus necessary. This article reports the findings of a full-scale experimental replication study on the onset of internal natural convection inside a horizontal insulation layer of blown glass wool with joists. The insulation layer is heated from below with a closed boundary enclosure at the bottom and an open boundary at the top. The thickness of the insulation layer is set to 30 cm or 60 cm, with a glass wool density ranging from 11.9 to 19.7 kg/m3, a temperature difference spanning from 5.2 to 59.5 K, and an average temperature ranging from 25.3°C to 26.5°C. The onset of the internal natural convection is identified by the critical Rayleigh number above which the modified Nusselt number (Nu + 1) increases with increasing Rayleigh number. For this configuration, the critical Rayleigh number is found to be situated between 13 and 15. These results are in good agreement with the recommendations from standards and other similar experimental studies on this topic. This study provides additional guidance for insulation design in cold-climate buildings.
2026_SJP54 (Gold OA)	Veit, M., Lucherini, A., Knez, F., Jensen, R. L., Jomaas, G., & Merci, B. (2026). 50 years of gas-phase velocity measurements in fire science: Revisiting the bidirectional probe. *Applications in Energy and Combustion Science*, *28*, 100560. https://doi.org/10.1016/j.jaecs.2026.100560
Abstract	The bidirectional velocity probe, developed by McCaffrey and Heskestad in 1976, remains one of the most widely used instruments for gas-phase velocity measurements in fire research. Despite its extensive use, the original calibration methodology lacks a rigorous uncertainty quantification, and subsequent studies have not always produced consistent results. Therefore, a comprehensive experimental and analytical investigation of the probe's uncertainty, angular response, and Reynolds number dependence was undertaken using the "Guide to the expression of Uncertainty in Measurement" (GUM) framework. Four probe diameters were calibrated in an openjet wind tunnel across a Reynolds number range of $100 \leq Re \leq 8400$ and incident flow angles between 60° and $+60^\circ$ relative to the stream direction. The results show deviations from the traditionally accepted asymptotic flow coefficient of 1.08. A phenomenological model was proposed to describe the probe's angular sensitivity, enabling the integration of the uncertainty from the angular sensitivity into the overall uncertainty budget of the flow measurement. The combined expanded uncertainty in the flow coefficient was found to be approximately 2% with a coverage factor of $k = 2$. Furthermore, the uncertainty is expected to increase substantially when being used for dynamic fire tests. The study highlights the need for individual probe calibration and provides a detailed methodology for uncertainty propagation in experimental fire applications.
2026_SJP55 (Green OA)	Yan, L., Gong, J., Jomaas, G., Liew, K. M., Yang, L., & Ju, X. (2026). Pyrolysis and auto-ignition of pine wood subjected to time-dependent radiation and crosswind. *Proceedings of the Combustion Institute*, *42*, 106644. https://doi.org/10.1016/j.proci.2026.106644 http://hdl.handle.net/20.500.12556/DiRROS-33245
Abstract	Timber structures in wildfire-prone areas are highly vulnerable to dynamic thermal exposures. In open-space fires, crosswind critically modulates the pyrolysis kinetics and the ignition mechanisms of

	combustible build- ing components. Extending existing studies on constant thermal radiation to incorporate such thermal- convection coupling effects is therefore highly significant. To address this problem, pine wood autoignition tests were conducted under five quadratically increasing radiant heat fluxes (heat flux expression: ˙q''ex = at2) with increasing rates (a) of 0.10 0.47 W/m2s2 and crosswind speeds (U∞) of 0 1.2 m/s, during which the ignition phenomena, surface temperature and autoignition time were recorded and analyzed. A condensed-phase numerical model integrating wood pyrolysis, heterogeneous char oxidation reaction, and transient heat transfer was developed to reproduce the experimental measurements. The results showed that the sample ignited across all experimental conditions. The surface temperature exhibited pronounced sensitivity to the heat flux increasing rate. The surface temperature derived from the numerical model agreed well with the experimental results, indicating the numerical model's potential to extend the pyrolysis characteristics dataset by capturing time- dependent heat flux and convective effects. Flaming ignition time decreased significantly as the heat flux increasing rate increased. As the crosswind speed increased, the ignition time exhibited a non-monotonic trend. An analytical ignition prediction model based on the critical mass loss rate exhibits favorable accuracy, with a prediction error of less than 20%. This work fills the gap in wood ignition under coupled crosswind and transient heat, providing validated models/data to aid fire risk assessment and fire-resistant timber design in wildfire- prone areas.
2026_SJP56* (Green OA)	Hu, Z., Zhang, S., Jomaas, G., Ma, H., & Zhao, J. (2027). Experimental study on the effect of ullage height and tank spacing on the ignition of adjacent tanks. *Fuel*, *430*, 141162. https://doi.org/10.1016/j.fuel.2026.141162 http://hdl.handle.net/20.500.12556/DiRROS-33211 *Available online: September 2026, Journal issue in which the paper is published is in 2027.
Abstract	Preventing fire spread between tanks is essential for fuel storage facilities. Therefore, ignition behavior of tank fires with different ullage heights and tank spacings was studied, focusing on the ignition process, ignition mechanism and radiative heat transfer. A series of experiments with n-heptane as fuel was performed with two 0.4 m diameter tanks (Tank I: burning source; Tank II: ignition target) over seven tank spacings (d = 0.2D-0.8D) and four ullage heights (H = 0D-0.3D). The ignition time increased from 2 s to 597 s as the tank spacing increased from 0.2D to 0.7D (H = 0) and from 2 s to 455 s as the ullage height increased from 0D to 0.2D (d = 0.2D). Numerical simulations using fire dynamic simulation confirmed that, near the adjacent tank upper rim, greater tank spacing suppressed flame-driven air entrainment and higher ullage height limited the fuel vapor concen- trations. These results are supported by calculations showing that the view factor decreased with increasing tank spacing and ullage height. Moreover, ullage height enhances a "blocking effect" and contracts the effective flame radiation region and the effective radiation reception region, thus lowering radiative heat flux. Based on the dimensionless analysis, the quantitative relationships between the ullage height, tank spacing, tank diameter and ignition time were analyzed, and a prediction model for the ignition time of the tanks was proposed. These findings offer insights into safer design of tank spacings and provide guidance for storage tank protection strategies.

3.2. Open Access statistics

In line with the Grant Agreement and the funding programme, all publications by researchers of the FRISSBE Team were published in open access. Specifically, 54% were published with Gold Open Access. Where this was not possible, the DiRROS repository provided Green Open Access for 46% of the scientific journal publications (see Figure 4).

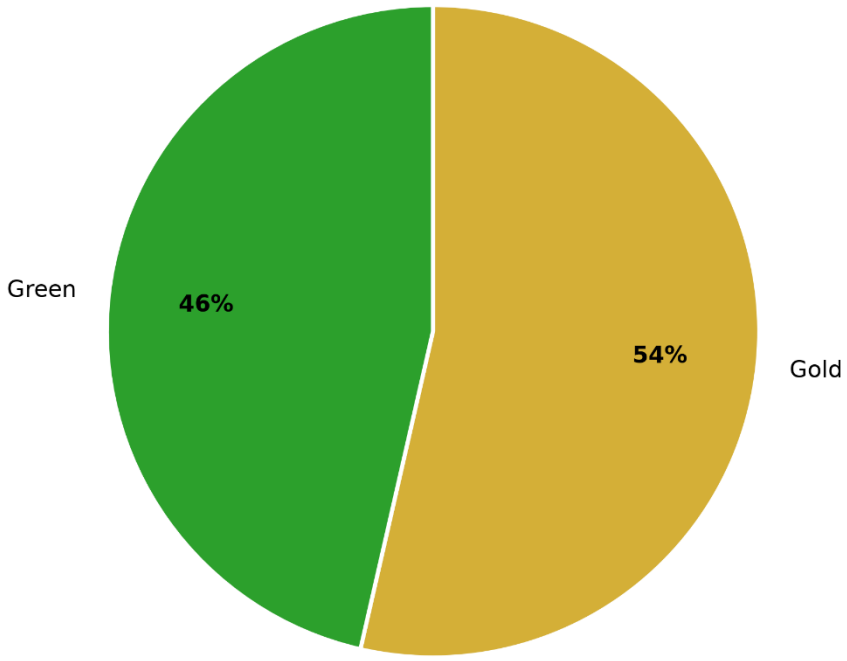


Figure 4 Distribution of scientific journal articles published in Green vs Gold Open Access.

3.3. Journal Quality

As evidence of excellence in fire safety research, FRISSBE aims to disseminate its scientific results through high-quality, peer-reviewed journals indexed in the Science Citation Index (SCI). Publishing in these journals ensures rigorous scientific quality through a thorough editorial process, while maximising the visibility and impact of the research within the international scientific community.

Particular emphasis is placed on publishing in journals with a high scientific impact. The objective was to publish primarily in Q1 journals (top 25% within their subject) and Q2 journals (25–50%) according to the SCImago Journal & Country Rank.

Over the duration of the FRISSBE project, 82% of all scientific journal outputs were published in Q1 journals, demonstrating the high scientific standard of the research conducted within FRISSBE (see *Figure 5*). Furthermore, 16% of the publications appeared in Q2 journals, meaning that 98% of the total scientific output was published in journals ranked within the top 50 % of their field.

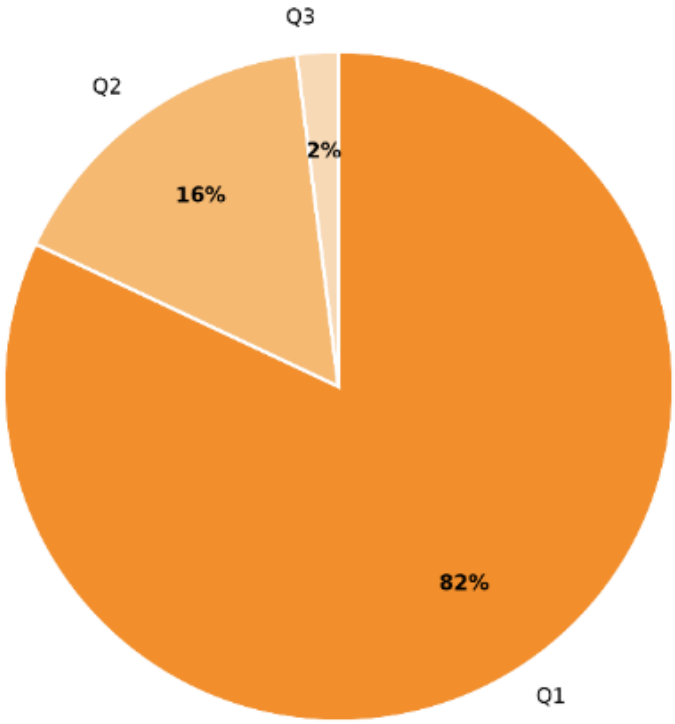


Figure 5 Percentage of scientific publications per SCImagoJournal & Country Rank.

As Fire (Safety) Science and Fire (Safety) Engineering are not specified subject areas for journal evaluation, publications in these fields are primarily published in journals classified under the Engineering subject, with categories such as Building and Construction or Safety, Risk, Reliability and Quality. In addition, journals in related fields, such as Materials Science and Energy were selected where the specific research topics aligned more closely with these subjects. This reflects the highly interdisciplinary nature of fire research, with individual studies often addressing topics that extend beyond traditional areas of engineering. The distribution of the subject areas of the journals selected for publication is shown in Figure 6. It should be noted that a single journal may be assigned to more than one subject.

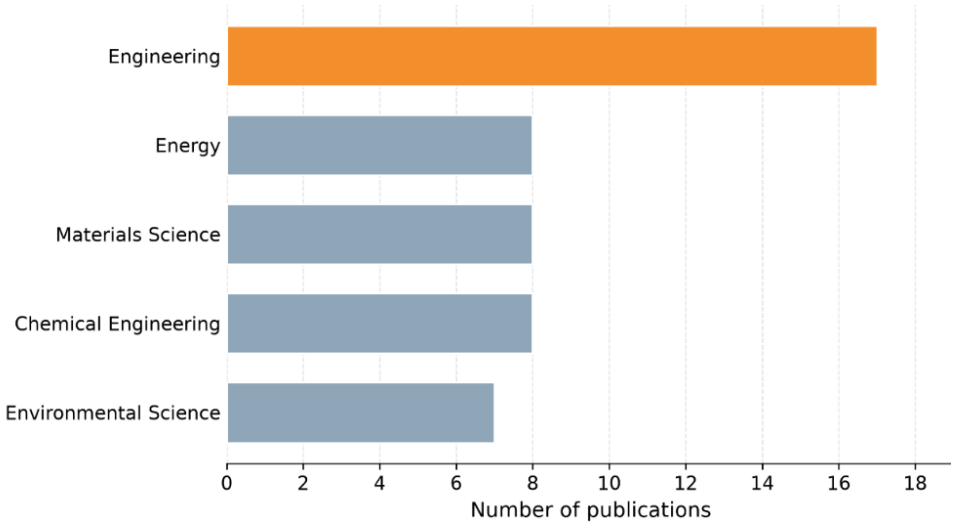


Figure 6 Number of scientific publications per Journal subject area.

FRISSBE researchers published their scientific results in 32 different journals, ensuring that individual research topics were disseminated through journals that were well suited to the subject area and targeted audience. The choice of journal provides broad visibility and scientific impact. Therefore, the Fire Safety Journal and Fire Technology were the most frequently selected journals for scientific publications as shown in Figure 7. Of the 15 papers published in Fire Safety Journal, 10 of these were published based on their submission and presentation at the International Symposium on Fire Safety Science (IAFSS), the premiere symposium in the field. This is the natural result of the relevance to the field of fire science and engineering and their alignment with the research objectives of FRISSBE. Furthermore, a journal publication has also been published in the Proceedings of the Combustion Institute, the most prestigious event with journal publication associated with it in the field of fire science and combustion.

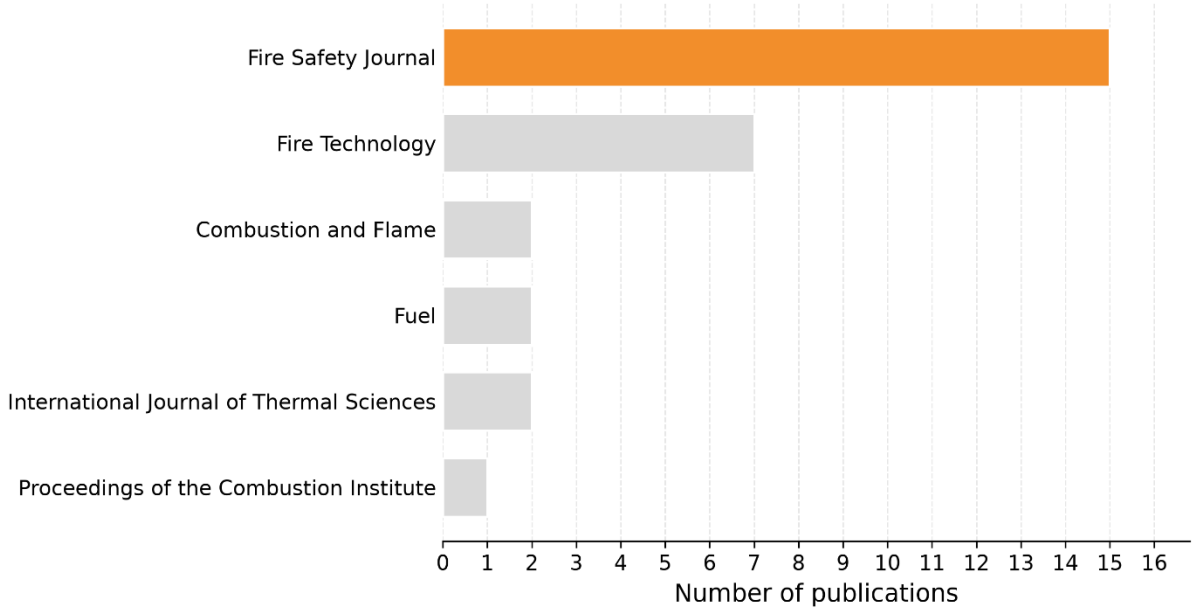


Figure 7 Top five Journals by number of scientific publications.

3.4. Research impact

Achieving high research impact is a key objective of the FRISSBE publication strategy. To pursue this objective, researchers targeted high-quality journals, established close collaborations with leading universities and research institutions, and focused on research topics of strong scientific interest and relevance within the field of fire safety. The resulting citation performance provides an indication of the visibility and uptake of the research.

Across the 56 scientific publications, a total of 345 citations have been recorded. Moreover, 44 publications (79%) have received at least one citation, showing that the visibility of the research extends across a substantial proportion of the publications rather than being limited to only a few highly cited papers. The analysis by career level (Figure 8) also shows a clear upward trend in citation numbers. While previously published papers contribute to their cumulative citation record, an increasing contribution from FRISSBE research is visible from 2022 onwards.

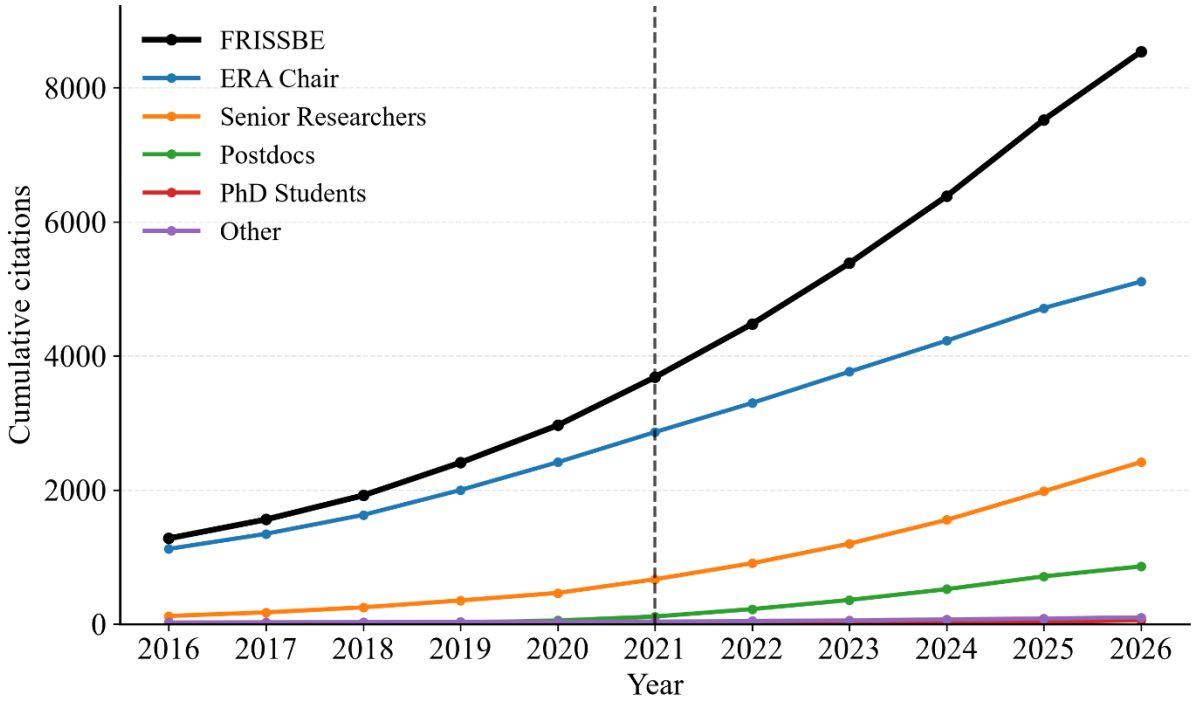


Figure 8 Cumulative citation record by career level.

A comparison between the cumulative citations between FRISSBE and the rest of ZAG is shown in Figure 9, normalized by the number of researchers counted.

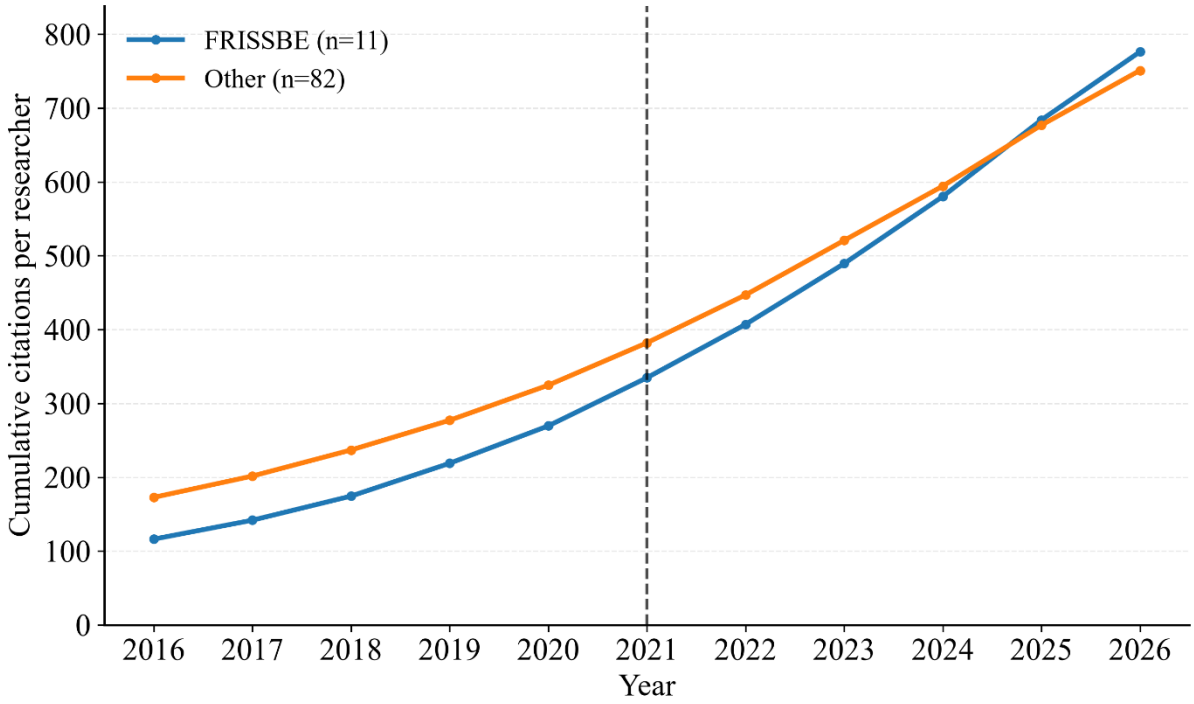


Figure 9 Cumulative citation record for FRISSBE and ZAG in general, normalized by number of researchers counted.

4. PROFESSIONAL ARTICLES

In addition to scientific journal publications, FRISSBE actively disseminates research findings through professional articles (PA), communicating outcomes to firefighters, engineers and other stakeholders in the fire safety industry. This is a key medium for communicating with the interested public, sharing applied results, presenting activities, and highlighting ZAG as a highly relevant partner for the industrial sector and for cooperation with businesses.

A directly related professional journal is Požar (translated as “Fire”), the Slovenian professional magazine dedicated to fire safety, which is published four times a year and informs the public about standards, guidelines, research advancements and relevant activities. Internationally, FRISSBE research has also been featured in widely recognised professional magazines such as the SFPE Europe magazine and the International Fire & Safety Journal. In addition, professional articles have also been published in other Slovene magazines, such as Gradbenik and Elektrotehniška revija, with 22 professional articles written in Slovene in these Slovenian magazines, while the remaining 22 professional articles have been published in international magazines.

The following section provides a list of publications in magazines and journals, together with their abstracts. Publications for which the original text is not in English are marked accordingly.

4.1. List and abstracts of professional articles

Table 3 Overview of published professional articles during the FRISSBE project.

2021_PA1	Fantoft, S. (2021). Forsker på brannsikkerhet. Brann & Sikkerhet, 96(6), 22–27. https://www.brannogsikkerhet.no/files/2023/01/19/Brann_6_2021_.pdf https://www.frissbe.eu/upload/files/FORSKER%20GRUJO.pdf
Abstract	Grunde Jomaas has always been fascinated by flames and fire, and he has built an international academic career at the top level in fire protection. He is currently leading a major research project on sustainable fire safety in Slovenia. Fire-Safe Sustainable Built Environment (FRISSBE) is a commitment to enhance fire safety research in Slovenia. The project has been awarded 2.5 million Euros from the EU to be used to employ 11 people under the leadership of Grunde Jomaas. - We have relatively great freedom when it comes to research topics, but it will be natural to carry out some research on wood and bio-based building solutions, he says. - When wood is used as a building material on a larger scale, fire safety goes from being a personal safety choice to becoming a matter of public safety, and the fire safety must be as good as when we use other materials, he adds.
2022_PA2	Knez, N., Knez, F., & Jomaas, G. (2022). Preskušanje požarnih lastnosti fasade - potreba po preskusni metodi = Testing of facade fire properties - the need for a test method. *Požar*, *28*(1), 28–32
Abstract (trans. SLO)	Facade fires frequencies have increased worldwide in the past decades, and they are of particular concern in tall buildings.Due to their fast spreading and difficult accessibility for fire fighters some of the fires have had very tragic outcomes. Fire safety requirements for facades vary from country to country, which typically

	means that the problem is not fully understood. In Slovenia, to determine the fire properties of facades, it is required to determine the response to fire with small and medium-scale test methods, which do not include structural details important for determining the behavior of the facade in the event of a real fire. Several national large-scale test methoas are available in Europe, and a uniform test method for large-scale façade testing is currently being prepared. It's high time also in Slovenija to introduce an adequate method for determination of fire performance of facades.
2022_PA3	Kristensen, J. S., & Jomaas, G. (2022). Požarna varnost fotovoltaičnih modulov na strehah. *Požar*, *28*(4), 34–39.
Abstract (trans. SLO)	The global capacity of solar photovoltaic (PV) systems has increased exponential over the last decade. In general, PV systems in the built environment can either be building integrated PV (BIPV or building applied PV (BAPV) systems. The BAPVs are well suited for utilization on elevated roof constructions, especially commercial flat roofs on warehouses and production facilities. However, PV systems in the built environment have been linked to fires, which is partly because the technology increase the probability of ignition and partly because building applied PV (BAPV) systems can facilitate flame spread along the roof. A fault tree analysis based on all publicly available data established an annual frequency of 29 fires per gigawatt capacity, which, considering the Solar Initiative in the REPowerEU plan, predicts that there will be many fires related to PV systems in the coming years. Results from a series of fire experiments with BAPV on roofs are presented to show the current state of knowledge. Despite many valuable findings, there is still an imminent need for further research and for implementation of findings into national and European Standards.
2022_PA4	Jomaas, G. (2022). Intervju s prof. dr. Grundejem Jomaasom. *Požar*, *28*(3), 21–23. https://www.szpv.si/wp-content/uploads/Intervju-z-Grundejem-Jomaasom.pdf
Abstract (trans. SLO)	Grunde Jomaas is leading the largest research project in the field of fire safety for a sustainable built environment in Slovenian history. He spoke with Požar about various topics: his first impressions of Slovenia and its people, the Fire-Safe Sustainable Built Environment (FRISSBE) project, and his academic and scientific career to date.
2022_PA5	Jomaas, G. (2022). Požarna varnost in trajnost na razpotju: Kako najti skupno pot naprej? / Fire Safety & Sustainability at a crossroads: How do we find a joint way forward? *Gradbenik* https://www.gradbenik.net/revija/julij-avgust-2022
Abstract (trans. SLO)	The new ZAG Fire Laboratory in Logatec, the largest of its kind in this part of Europe, will officially open in early September of this year, but it will already host the first—and international—scientific workshop of the EU FRISSBE project on June 23 and 24, 2022. The workshop will be attended by several renowned and established experts from around the world who work in various fields of fire research
2022_PA6	Jomaas, G. (2022). POŽAR ne pozna dopusta / Fire takes no vacation. *Gradbenik* https://www.gradbenik.net/revija/september-2022
Abstract (trans. SLO)	At the seminar titled “Fires Don’t Take a Vacation,” the reasons were presented that call for cooperation among lawmakers, engineers, and firefighters to create a sustainable built environment, which cannot exist—and will not exist—without fire safety. On August 11, a seminar titled “Fires Don’t Take a Vacation,” organized by the Slovenian Institute of Construction (ZAG) and the Slovenian Fire Protection Association (SZPV), and moderated by Dr. Aleš Jug (SZPV).
2022_PA7	Jomaas, G. (2022). REPowerEU presents big challenges with respect to PV fire safety. *International fire protection*, *91*, 2. https://ifpmag.com/repowereu-presents-big-challenges-with-respect-to-pv-fire-safety/
Abstract	REPowerEU is a European Commission proposal launched in May 2022 that “plan to make Europe independent from Russian fossil fuels well before 2030, in light of Russia’s invasion of Ukraine.” A recently completed PhD thesis at the University of Edinburgh by Jens Steemann Kristensen (now at DBI in Denmark) investigated fire safety aspects related to PV modules. The following reflects Jens’ very relevant, high-quality research.

2023_PA8	Uršič, M., & Rojas Alva, W. U. (2023). Testiranje li-ionskega baterijskega paketa za uporabo v jadralnih letalih. *Požar*, *29*(1), 43–45. https://www.szpv.si/revija-pozar/revija-pozar-stevilka-1-2023/
Abstract (trans. SLO)	Lithium batteries are widely used with several known hazards. In transport, especially in aviation, these hazards are even more acute, as human lives are seriously endangered in the event of any accident. While the requirements and risks for large commercial aircraft are fairly well researched, for lighter passenger craft with many boutique or custom solutions they are somewhat unclear. The burden of safety regulation is borne by the European and US aviation agencies EASA and FAA, which carry out case-by-case oversight for such products. One such product is a product of Slovenian ingenuity, the FES electric propulsion system from LZ design. Following EASA requirements, we have tested a prototype of a new product, a battery pack based on 18650 Li-ion cells. The thermal runaway of the cell was intentionally triggered and the thermal behaviour of neighbouring cells was monitored. The successful test is the basis for the certification of the new battery pack for use in sailplanes.
2023_PA9	Blumauer, U., Uršič, M., Knez, N., & Marrot, L. S. J. (2023). Raziskovalna dejavnost Požarnega laboratorija ZAG. *Požar*, *29*(1), 6–8. https://www.szpv.si/wp-content/uploads/PDF-clanek-lz-pozarnega-laboratorija.pdf
Abstract (trans. SLO)	ZAG's Fire laboratory is engaged in research for industry, with national and international research institutions, and in cooperation with researchers from other departments at ZAG. The subjects of research are, amongst others, the development of various materials, the development of testing equipment and the experimental testing of prototype products. On the material level, various fire characteristics and reaction to fire are analysed. In research conducted on structural elements, fire resistance, the time of loss of integrity and the time of loss of insulation are determined. For research purposes, temperature and displacements are often measured in more points than the minimum specified in standard tests.
2023_PA10	Rojas Alva, W. U., Uršič, M., Rus, N., Mancini, L., Mauko Pranjić, A., Marini, E., & Bozzini, B. (2023). Polnilni alkalni akumulatorji kot varnejša alternativa litij-ionskim akumilatorjem. *Požar*, *29*(3), 15–20. https://www.szpv.si/wp-content/uploads/Akumulatorji.pdf
Abstract (trans. SLO)	Lithium-ion batteries have been shown to pose a fire hazard due to their tendency to experience thermal runaway. Rechargeable alkaline batteries (RAB) therefore represent a safer alternative for storing electrical energy. Knowing the temperature at which battery cells enter thermal runaway is essential for determining their safety. In this study, Zn-MO RAB battery cells with the international designation CR2032 were tested under destructive thermal conditions in a gravity convection furnace to determine the temperature at which the cell enters thermal runaway. For comparison, commercial lithium-ion batteries (LIBs) were also tested. Morphological characterization was performed using X-ray computed microtomography of the cells before and after testing. The thermal runaway temperature of RAB cells ranged from 291 to 380 °C, which is significantly higher than that of LIB cells (150–156 °C). This demonstrates that RAB battery packs can be considered a safer technology than LIB.
2023_PA11	Rojas Alva, W. U., Uršič, M., & Jomaas, G. (2023). Fire safety of li-ion battery packs for aviation. *SFPE Europe*, *2*(30, [5]), 27–33. https://higherlogicdownload.s3.amazonaws.com/SFPE/93e7d31c-6432-4991-b440-97a413556197/UploadedImages/SFPE_Europe_Digital/Issue_30/Q2_2023_Europe_Digital_Magazine.pdf
Abstract	Lithium-ion battery (LIB) technology is the best used in many sectors that range from transport to the built environment. In edition, there be have developments for using LIB technology for the propulsion of commercial-leisure sails. If not carefully designed, LIB solutions for such planes can pose a safety hazard as a cell can go go into thermal runaway (due to a multitude of reasons), which can potentially endanger the life of the plane's occupant(s). While the safety requirements for the large commercial aircraft that use fossil fuels are strictly regulated, the safety requirements are the defined less for straighter passenger aircraft with will manyutique custom or solutions. The burden of safety regulation is borne by the European agencies and US aviation, EASA and FAA, carry out case-by-case for such products. One product such is the FES electric propulsion system from LZ Design in Slovenia. Following EASA requirements, more fire tests were held with a new product, same a battery pack on type 18650 Li-ion cells, that is used for the propulsion system and powered sailplanes. The thermal runaway of the cell wasally intention triggered, and the thermal behaviour of the adjacent cells was. The successful tests, where the temperature of the adjacent cells was 100 °C at an EASA- test duration of 15 minutes after the thermal runaway of the target cell, are the basis for the certification of the new battery pack for use in powered sailplanes.

2023_PA12	Rojas Alva, W. U., Mladenovič, A., & Šajna, A. (2023). Požari v predorih. *Gradbenik*, *27*(7/8), 48–52. https://www.gradbenik.net/revija
Abstract (trans. SLO)	In light of the recent fire in the Malečnik covered cutting, this article outlines the specific characteristics of fires in tunnels, summarise European and Slovenian legislation on fire safety in road tunnels, highlight some of the most high-profile fires in European and Slovenian road tunnels, describe methods for modelling and testing fires, and explain the effects of high temperatures on concrete with and without polypropylene fibres.
2023_PA13	Rojas-Alva W. U., (2023). Prihodnost gradbeništva. *Gradbenik* https://www.gradbenik.net/revija/julij-avgust-2023
Abstract (trans. SLO)	In light of the recent fire in the Malečnik covered cutting, this article outlines the specific characteristics of fires in tunnels, summarise European and Slovenian legislation on fire safety in road tunnels, highlight some of the most high-profile fires in European and Slovenian road tunnels, describe methods for modelling and testing fires, and explain the effects of high temperatures on concrete with and without polypropylene fibres.
2023_PA14	Rojas-Alva, U., Mladenović, A., & Šajna, A. (2013). Požari v predorih. Transport & Logistika, 23(236), 34–37. https://www.etransport.si/storage/doc/202312/transport-logistika-julij-2023.pdf
Abstract (trans. SLO)	A distinctive feature of the tunnel is that its length is considerably greater than its width and height. In countries with significantly varied terrain, infrastructure such as underground road or railway tunnels is an essential solution for ensuring transport links. Examples include Norway, Japan, Switzerland, Italy, Spain and Slovenia … Tunnels shorten distances and journey times, but in the event of exceptional incidents, such as traffic accidents, they also present certain challenges, with fire being one of the most demanding scenarios from the perspective of the tunnel's structure, as well as for the operator and users
2023_PA15	Jančar, N.(2023). Poleg dimnikov strešne požare netijo tudi sončne elektrane. *Gradnja in bivanje*, 26–29. https://www.finance.si/nepremicnine/poleg-dimnikov-stresne-pozare-netijo-tudi-soncne-elektrarne/a/9017709
Abstract (trans. SLO)	In addition to chimneys, solar power plants also cause roof fires. For every gigawatt of installed capacity in solar power plants, approximately 29 fires occur each year. Technical malfunctions or defects in solar power plants are to blame for about half of the fires involving them, according to Nik Rus, Grunde Jomaas, and Aleš Jug of the Slovenian Institute of Construction (ZAG). In an international study in which Jomaas also participated, researchers found that 51 percent of such fires were caused by a failure of one of the solar power plant's electrical components. In 14 percent of cases, the fire was caused by insulators; in 12 percent, by connectors; in 11 percent, by inverters; and in the remaining cases analyzed, the cause of the fire could not be determined.
2023_PA16	Rus, N. (2023). Pregled smernic za požarno varnost sončnih elektrarn. *Požar*, *29*(4), 20–23. https://www.szpv.si/revija-pozar/revija-pozar-stevilka-4-2023/
Abstract (trans. SLO)	In order to assess the extent to which measures to reduce fire risks at solar power plants are based on verifiable scientific data, a selection of recent guidelines and instructions for fire safety at solar power plants was reviewed. Since the installation of photovoltaic (PV) systems on buildings introduces new fire risks, the implementation of safety measures without a verifiable and scientifically sound basis can have the opposite effect and create a false sense of security. It was found that the proposed preventive measures had limited reference to any scientific basis (experimental or statistical). The findings of this review may encourage future authors of such documents to explain their recommendations more thoroughly or, if possible, to cite data and sources that adequately substantiate the proposed measures.
2023_PA17	Jomaas, G., & Meacham, B. J. (2023). SFPE Symposium: join experts and leaders in advancing fire safety and sustainable building design. *International fire and safety journal*. https://internationalfireandsafetyjournal.com/sfpe-symposium-join-experts-and-leaders-in-advancing-fire-safety-and-sustainable-building-design/
Abstract	The emission of greenhouse gases into the atmosphere from human activities has facilitated significant changes to our global climate. This in turn has resulted in an increase in the magnitude and frequency of climate- and weather-related hazard events, including wildfires. The combination is creating significant

	socio-economic impacts, including property loss, business and insurance losses, illness, injury and death, on top of damages to our ecosystems and environment. The built environment has been recognized as a significant contributor to global greenhouse gas emissions through use of copious amounts of fossil fuel powered electricity, embodied carbon in construction materials, and other inefficient uses of natural resources. This has prompted a decades-long effort to increase environmental, social and financial sustainability of the built environment through better thermal insulation of buildings, use of local alternative energy sources such as photovoltaic systems, material with lower embodied carbon, and more. However, some sustainable building materials, technologies and features have created unintended fire hazards and risks. Likewise, some sustainable community design principles, such as increased densification, may create unintended urban fire risks, especially when located in the wildland urban interface.
2024_PA18	Bellini, E. (2024). Tests show rooftop fires propagate slowly with vertical PV systems. *Pv magazine*. https://www.pv-magazine.com/2024/03/15/tests-show-vertical-pv-slows-rooftop-fires/?utm_source=Global+%7C+Newsletter&utm_campaign=8186cf2410-dailynl_gl&utm_medium=email&utm_term=0_6916ce32b6-8186cf2410-160705128
Abstract	New tests conducted by the Slovenian National Building and Civil Engineering Institute show that vertical PV installations offer improved fire safety compared to diagonal or flat solar arrays. The experiment show, and specific, how a fire can propaganda under inclined panels.
2024_PA19	Jomaas, G., Simakovs, K., & Rus, N. (2024). Mitigating PV fire risk. *Fire risk management*, 20–23. https://www.thefpa.co.uk/login?ReturnUrl=%2fmembership%2fmembers-area%2ffire-and-risk-management-journal-archive%2fapril-2024
Abstract	A shift from carbon-based energy sources is seen as a major component of the drive towards reducing carbon emissions and a sustainable future, with solar energy proving to be one of the main options for moving towards this solution. To that end, a great portion of buildings, from small residential houses to large industrial production facilities and storage warehouses, are going to have photovoltaic (PV) systems installed on their roofs in the coming years. These rovide power for the building itself, as well as returning any surplus back to the national power grid. However, several recent PV-related fires on roofs have caught significant attention in the media - the latest being the fire on the roof of the Lidl distribution centre in Peterborough. It once again raised the question of how these PV systems alter the fire dynamics of roof fires and the potential risk profile of these buildings. To help raise awareness of how installing a PV system affects the fire risks of buildings and to point out some key aspects concerning PV-related fires, researchers from the Slovenian National Building and Civil Engineering Institute (known by its Slovenian acronym, ZAG) recently carried out a demonstration.
2024_PA20	Rus, N., & Jomaas, G. (2024). PV guidelines – are the recommendations sufficiently evidence-based? *SFPE Europe*, *1*(33, [5]), 20–29. https://higherlogicdownload.s3.amazonaws.com/SFPE/93e7d31c-6432-4991-b440-97a413556197/UploadedImages/SFPE_Europe_Digital/issue33/SFPE_Europe_Digital_Magazine_Q1_2024_Issue_33.pdf
Abstract	It is generally recognised that installing PV systems on buildings creates new fire hazards and fire safety challenges. To determine the present status of the scientific basis for the fire safety measures suggested for photovoltaic (PV) systems, recent installation guides, and guidelines for the fire safety of PV installations published by various stakeholder groups, were examined. There was very limited experimental or statistical evidence in the literature supporting the recommended preventive measures. This is worrisome, as proposing fire safety measures without any verified and scientifically sound basis might create a false sense of safety. The review's conclusions will hopefully urge future authors of these kinds of publications to elaborate more on the background for their suggestions or, better yet, include evidence to support their recommendations.
2024_PA21	Staš Zgonik (2024). Sončna elektrarna zveča tako verjetnost požara na strehi kot njegove posledice. *N1* https://n1info.si/poglobljeno/soncna-elektrarna-zveca-tako-verjetnost-pozara-na-strehi-kot-njegove-posledice/
Abstract (trans. SLO)	The proliferation of solar power plants also brings with it new fire risks that we do not yet fully understand. Earlier this month, for example, a solar power plant on the roof of an elementary school in Bistrica near Tržič caught fire. The risk of fires at solar power plants will have to be significantly reduced before we can consider it acceptable, warns world-renowned fire safety expert Dr. Grunde Jomaas, who is currently working in

	Slovenia. “The fire broke out at the school. Next time, it could be at a nursing home or a hospital. I’d like the green transition to be a success story. We shouldn’t give opponents—who downplay fire safety—any additional ammunition to bash solar power plants.”
2024_PA22	Bellini, E. (2024). What happens when fire hits PV systems deployed on sloped roofs. *Pv magazine* https://www.pv-magazine.com/2024/12/09/what-happens-when-fire-hits-pv-systems-deployed-on-sloped-roofs/
Abstract	An international research team has observed how fire propagates in PV systems installed on flat roofs and has found that a certain amount of energy is needed for a fire to start and propagate in the cavity below the solar panels.
2024_PA23	Lucherini, A., Rus, N., & Jomaas, G. (2024). Poletna šola ITB-FRISSBE 2024 o temeljih požarne varnosti za načrtovanje na podlagi inženirskih metod požarne varnosti. *Požar*, *30*(3), 43–44.
Abstract (trans SLO)	The summer school, organized in collaboration with the Slovenian Institute of Civil Engineering (ZAG), specifically the FRISSBE project, and the Polish Institute of Construction Technology (ITB), took place from September 1 to 6, 2024, in Warsaw, with an additional day in Gdańsk on September 7, 2024. The program consisted of a mix of lectures, discussions, practical demonstrations, and case studies, all conducted in English. The lead organizers from ZAG were Professor Grunde Jomaas and Dr. Andrea Lucherini, while Dr. Wojciech Węgrzyński led the efforts on behalf of ITB. The program in Gdańsk was organized by Bogdan Racięga, director of the Baltic Fire Laboratory (BFL).
2024_PA24	Lucherini, A., Racięga, B., Węgrzyński, W., & Jomaas, G. (2024). 2024 ITB-FRISSBE Summer School on Fire Fundamentals for Performance-Based Fire Safety Design. *SFPE Europe*, *3*(35, [4]), 19–14. https://higherlogicdownload.s3.amazonaws.com/SFPE/93e7d31c-6432-4991-b440-97a413556197/UploadedImages/SFPE_Europe_Digital/Issue_35/Q3_2024_Europe_Digital_Magazine.pdf
Abstract	After brainstorming about the needs faced by early-career researchers and fire professionals, a group of established researchers from the Slovenian National Building and Civil Engineering Institute (ZAG) and the Instytut Techniki Budowlanej (ITB) decided to organise the 2024 Summer School on Fire Fundamentals for Performance-Based Fire Safety Design.
2024_PA25	Spearpoint, M., Both, K., Santamaria, S., Lucherini, A., Husted, B. P., & Weghorst, R. (2024). The importance of data in fire safety engineering. *SFPE Europe*, *3*(35, [2]), 9–14. https://higherlogicdownload.s3.amazonaws.com/SFPE/93e7d31c-6432-4991-b440-97a413556197/UploadedImages/SFPE_Europe_Digital/Issue_35/Q3_2024_Europe_Digital_Magazine.pdf
Abstract	Background: On 15th February 2024, Lund University hosted the 9th International Master of Science in Fire Safety Engineering (IMFSE) Day where the topic was “The importance of data in fire safety engineering”. The event provided a unique networking and discussion opportunity for more than 50 IMFSE students, several academics from the core partner institutes (Lund University, The University of Edinburgh, Universitat Politecnica de Catalunya, and Ghent University), and delegates from associated partners and contributors. The day included presentations by four speakers1 followed by a panel discussion moderated by Dr Enrico Ronchi that also included contributions from the students and other attendees. The presentations aimed at covering a wide range of expertise and points of view related to fire safety engineering, from engineering consultancy companies, product manufacturers, researchers, and academics. This article summarises the key points from the presentations and some of the ensuing panel discussion.
2024_PA26	Strategies for solar fire safety. (2024). International Fire & Safety Journal, (37), 32–34. https://digital.internationalfireandsafetyjournal.com/html5/reader/production/default.aspx?pnum=35&edid=fbf0fc12-8972-45ce-8180-8573258215e6&isshared=true
Abstract	Installing a photovoltaic (PV) system on the roof of a building introduces new fire risks to the building. First, the PV installations have been shown to increase the chances of ignition through the failure of any of the electrical components of the system. Second, the PV installation can increase the consequences of a PV-related fire, as a PV system on a roof has been shown to enable faster fire spread, as well as greater extent of fire spread.

2025_PA27	Marrot, L., Jereb, V., Uršič, M., & Sivrikaya, H. (2025). Izboljšanje požarne odpornosti lesenih materialov z ožiganjem površine lesa in trajnostnimi postopki na osnovi bioloških zaviralcev gorenja. Požar, 31(4), 33–35. https://plus-legacy.cobiss.net/cobiss/si/en/bib/55904256
Abstract (trans. SLO)	The spread of wood-frame buildings as sustainable construction materials is restrained by the risk of fire when the wood frame is largely exposed and unprotected, which is desirable for the aesthetic and decorative appearance. The proposed research aims at developing innovative wood treatments for improved fire performance through a combination of advanced charring techniques and the development of bio-based fire-retardants.
2025_PA28	Kahana, L. (2025, January 31). New fire safety testing procedure for PV systems deployed in flat roofs. Pv Magazine. https://www.pv-magazine.com/2025/01/31/new-fire-safety-testing-procedure-for-pv-systems-deployed-in-flat-roofs/
Abstract	The Slovenian National Building and Civil Engineering Institute (ZAG) has introduced a fire safety test that simulates a fire starting on the roof membrane beneath a PV system. The researchers noted the importance of realistic construction methods, including factors such as anchors, adhesives, membrane welding, and ballast use.
2025_PA29	Rus, N. (2025). SFPE 2025 Evropski konferenčno-sejemski dogodek o inženiringu na področju požarne varnosti. Požar, 31(1), 44–45.
Abstract (trans. SLO)	On Wednesday and Thursday, April 9 and 10, a European conference and trade show on fire protection engineering took place in Edinburgh (United Kingdom). It was organized by the umbrella organization SFPE (Society of Fire Protection Engineers) and its European branch, SFPE Europe, and together they managed to bring together around 300 participants—experts, lecturers, and researchers in the field of fire safety. Some side events took place the day before, while the main program was centered on Wednesday and Thursday.
2025_PA30	Kurr, A., & Veit, M. (2025). From theory to testing in action. International Fire and Safety Journal, (43), 74–77. https://digital.internationalfireandsafetyjournal.com/html5/reader/production/default.aspx?pubname=&edid=b9e0a4cf-896c-49af-af52-a44f826eedec
Abstract	Early-career fire safety professionals are challenged by the broadness of the profession. From fire suppression to fire dynamics, from life safety to building egress, from human behaviour patterns to emerging technologies, and from codes and standards to performance-based design frameworks, young engineers and researchers worldwide find themselves drinking information from a firehose. Forced to specialise, early-career fire safety professionals can find themselves in technical and professional silos.
2025_PA31	Awad, B. N., Steranka, K., & Rojas-Alva, U. (2025). Bridging the fire protection gaps. International Fire and Safety Journal, (47), 72–74. https://digital.internationalfireandsafetyjournal.com/html5/reader/production/default.aspx?pubname=&edid=91e95808-5840-4197-862b-3adcd8b8f52c
Abstract	The challenges of providing effective fire and explosion hazard mitigation strategies for Battery Energy Storage Systems (BESS) are receiving appreciable attention, given that renewable energy production has evolved significantly in recent years and is projected to account for 80% of new power generation capacity in 2030 (WEO, 2023). This acceleration towards renewable energy adoption has contributed to the growing imbalance between electricity demand and renewable energy generation solutions (e.g., solar power plants) due to the misalignment between supply and demand (Bowers et al., 2023). One of the robust and reliable solutions for this imbalance is BESS, which can be used to store energy generated during low demand for use during high demand periods. In the US, the cumulative BESS capacity has increased since 2015, with 11.9 GW installed in 2024 (Martin et al., 2025). A significant growth in BESS installation is anticipated worldwide, with over 1 TWh of new installations between 2023 and 2025 (Martin et al., 2025). Figure 1 shows this increasing trend in global battery deployment and directly plots the battery failure rate per deployed GW of battery energy. This graph shows an overall decrease in battery failures per GW installed with increasing installations. Despite the global decrease in battery failure rates per GW installed, the deployment of BESS technology is hindered due to inherent fire and explosion hazards, public

	fear due to misinformation, and knowledge gaps in the fire safety industry, including a lack of clear guidelines or standards for the safety design of BESS across various applications.
2024_PA32	Evans, J. (2024). A fire safety guideline for building applied photovoltaic systems on a flat roof *Civil Engineering.* https://www.flipsnack.com/BE95BDAA9F7/civil-engineering-august-2024/full-view.html
Abstract	Installing a PV system on the roof of a building introduces new fire risks to the building or damages to the system. First, the PV installations have been shown to increase the chances for ignition through the failure of any of the electrical components of the system. Second, the PV installation can increase the consequences by enabling a fire on the roof to spread faster and over a larger area. Thus, PV systems increase both the probability and the consequence of a roof fire. In addition, a PV system on a roof will cause a change in firefighting tactics because they create a substantial physical hindrance and because precautions have to be made when fighting a fire in the proximity of a permanent current carrying installation In order to successfully mitigate the consequences of PV-related fires and reduce the probability of them, effective safety measures need to be put in place. If the proposed safety measure are to adequately serve their purpose, their effectiveness should be confirmed via reference to sound data from reliable scientifical experiments or statistics. Until we have sufficient knowledge about the mechanics of fire risks and how to mitigate them, a precautious approach in the design should be applied.
2025_PA33	Spearpoint, M., Both, K., Santamaria, S., Lucherini, A., Husted, B. P., Weghorst R. (2025) Deconstructing fire data. *Fire risk management : the international journal for fire professionals* https://www.thefpa.co.uk/login?ReturnUrl=%2fmembership%2fmembers-area%2ffire-and-risk-management-journal-archive%2ffebruary-2025
Abstract	On 15th February 2024, Lund University hosted the 9th International Master of Science in Fire Safety Engineering (IMFSE) Day where the topic was “The importance of data in fire safety engineering”. The event provided a unique networking and discussion opportunity for more than 50 IMFSE students, several academics from the core partner institutes (Lund University, The University of Edinburgh, Universitat Politecnica de Catalunya, and Ghent University), and delegates from associated partners and contributors. The day included presentations by four speakers followed by a panel discussion moderated by Dr Enrico Ronchi that also included contributions from the students and other attendees. The presentations aimed at covering a wide range of expertise and points of view related to fire safety engineering, from engineering consultancy companies, product manufacturers, researchers, and academics. This article summarizes the key points from the presentations and some of the ensuing panel discussions.
2025_PA34	Lucherini, A. (2025). Neskladja pri usklajevanju direktive EPBD!: dogodek SBRA v Bruslju o novih požarnih tveganjih zaradi elektrifikacije in prenove stavb. Požar, 31(4), 40.
Abstract	A half-day workshop held on 3rd October 2025 at the University Foundation in Brussels (Belgium) brought together leading voices from research, policy, and industry to examine how Europe’s accelerating renovation and electrification efforts are reshaping fire safety challenges. Hosted by the Slovenian Business & Research Association (SBRA) in collaboration with the FRISSBE Department of the Slovenian National Building and Civil Engineering Institute (ZAG), the event focused on the growing challenges linked to fire safety as Europe advances its goals of building renovation and electrification as part of the Energy Performance of Buildings Directive (EPBD).
2025_PA35	Lucherini, A., & Capuder, M. (2025). Inovacije na področju požarne varnosti v leseni gradnji na Svetovni konferenci o gradnji z lesom (WCTE 2025). Požar, 31(2), 36.
Abstract	From June 22nd to 27th, 2025, the University of Queensland (Australia) has organised the World Conference on Timber Engineering (WCTE 2025, www.wcte2025.org) in Brisbane, Queensland. The conference brought together over 900 leading researchers and industry experts to present cutting-edge advancements in timber construction. Among the standout themes was the increasing focus on fire safety in mass timber buildings, driven by the global shift toward taller structures with more exposed timber elements. Over a dozen technical sessions highlighted developments in fire performance, structural resilience during fire, and the integration of innovative materials and methods to mitigate risk.
2025_PA36	Rus, N. (2025). ZAG na 11. slovenski fotovoltaični konferenci. Požar, 31(2), 38–39.

Abstract (trans. SLO)	On Wednesday, June 18, the 11th Slovenian Photovoltaic Conference was held at the Faculty of Electrical Engineering of the University of Ljubljana. The event, which has been organized for a decade in a row by the Laboratory for Photovoltaics and Optoelectronics (Department of Electrical Engineering), once again brought together researchers, industry representatives, policymakers, and other stakeholders in the field of solar energy. More information about past and future events can be found on their website at http://slo-pv.fe.uni-lj.si/. This year's event was attended by over 100 interested visitors from various stakeholder groups in the field of solar energy production (manufacturers, policymakers, installers, power grid operators, etc.), who listened to 17 speakers. The presentations took place in the faculty's large lecture hall and were opened by the dean, Prof. Dr. Marko Topič. The opening remarks were followed by a presentation by Dr. Uroš Merc, founder of Bisol, a Slovenian manufacturer of solar modules. He emphasized that Slovenia is the only European country that exports more solar modules than it imports.
2025_PA37	Želimorski, T., & Rus, N. (2025). Evropski simpozij o znanosti požarne varnosti (ESFSS) prvič v Sloveniji. Požar, 31(2), 41.
Abstract (trans SLO)	From September 2 to 5, 2025, the 5th European Symposium on Fire Safety Science (ESFSS 2025) will take place at the Grand Hotel Union Eurostars in Ljubljana. This is the premier event in the field of fire safety research in Europe. It will be attended by approximately 200 experts, researchers, entrepreneurs, and representatives of civil society from more than 30 countries, and the plenary speakers will include leading global researchers. The goal of the symposium, which will be held in Slovenia for the first time, remains the same as in the past: to bring together researchers from Europe and beyond to exchange ideas and findings, discuss various aspects of fire safety, and develop new solutions. ESFSS 2025, organized this year by the Department of Fire-Safe and Sustainable Built Environment (FRISSBE) at the Slovenian Institute of Construction (ZAG), is taking place under the auspices of the International Association for Fire Safety Science (IAFSS). The institute's close collaboration with a broad international network places Slovenia at the center of discussions on one of the key topics of the future—fire safety in the era of energy and environmental transformation.
2025_PA38	Jurov, A. (2025). Poletna šola 'Princeton-Combustion Institute on Combustion and Environment'. Požar, 31(2), 37.
Abstract (trans SLO)	Along with 120 participants from various countries, I also attended the Princeton-Combustion Institute Summer School on Combustion and the Environment, which took place at Princeton University in the United States from June 22 to 27, 2025. The school was organized by the Princeton Combustion Institute and was primarily intended for young researchers and experts in the field of combustion and its impact on the environment.
2026_PA39	Košiček, M., Kudryashov, V. A., Rojas-Alva, U., Lucherini, A., Turk, D., Jug, A., & Jomaas, G. (2026, April). Façade Fire Spread. *Fire Risk Management , 20-25.* https://www.thefpa.co.uk/index-of-resources
Abstract	Façades containing combustible materials pose a significant fire risk to buildings, as they can enable rapid fire spread from a single compartment to a large portion of the structure. Therefore, understanding the factors that influence fire propagation in façade systems is of great importance. Within the scope of current research on façade fire safety, several fire tests at different scales were conducted on ETICS (External Thermal Insulation Composite Systems) façades containing EPS, both with and without flame retardants. In this article, the intermediate scale tests from this test series are described to evaluate the parameters affecting local fire spread. The results indicate that the transition from a manageable to a fast and uncontrollable fire spread is closely associated with the formation of an air channel within the insulation layer of the façade. This air gap can induce a chimney effect, resulting in rapid and uncontrolled vertical fire spread. To prevent fire propagation, or at least to prolong the period during which the fire remains controllable, the quality of the façade installation is crucial. Although the incorporation of flame retardants into combustible materials can contribute to slowing fire spread, their effectiveness is limited when deficiencies in passive fire protection and façade installation are present.
2026_PA40	Košiček, M., Kudryashov, V. A., Rojas Alva, W. U., Lucherini, A., Turk, D., & Jug, A. (2026). Eksperimentalna raziskava dejavnikov lokalnega širjenja požara v fasadnih sistemih ETICS. Požar, 32(1), 30–33.

Abstract (trans. SLO)	Facades containing combustible materials pose a significant fire hazard to the buildings on which they are constructed, as they allow fire to spread rapidly from a single room to a larger portion of the structure or the entire building. Understanding the factors that influence fire spread through facade systems is therefore of great importance. As part of our research on facade fire safety, we conducted several fire tests on ETICS facades based on expanded polystyrene, with and without flame retardants, on various scales. This article describes the medium-scale tests, which were designed to evaluate the factors influencing the local spread of fire along a facade. The results show that the transition from a still-manageable situation to rapid fire spread—which can spiral out of control—is closely linked to the formation of an air channel within the facade's insulation layer. This can cause a chimney effect, leading to rapid and uncontrolled vertical fire spread. To prevent the spread of fire—or at least to prolong the time during which the fire remains manageable—the quality of the facade system's installation is of critical importance. The addition of flame retardants to combustible materials can help slow the spread of fire, but their effectiveness is limited if there are errors or a lack of passive fire safety measures during the installation of the facade.
2026_PA41	Rus, N. (2026). Laboratorijski poskusi na poti k požarno varnim sončnim elektrarnam. ER, 27(2), 49–52.
Abstract (trans. SLO)	Understanding the impact of various parameters on fire development at a rooftop solar power plant is crucial for effectively reducing the fire risk posed by such installations. Experimental laboratory tests using specific materials and products arranged in a realistic configuration provide valuable insight into the actual processes involved in fire development on a roof with a solar power plant, from the origin of the ignition source through fire spread to the final extent of damage. The results show that fire development is decisively influenced by system parameters related to the interaction between the solar power plant and the roof and its structure, while differences among individual materials and components have a limited impact in this context. Due to the numerous influencing factors, risk management approaches are also diverse: ranging from limiting ignition sources and using fire detection systems to design adjustments, such as module configuration (height and tilt), maintaining clearances from other roof elements, and ensuring conditions for effective firefighter response. It is crucial to consider the solar power plant as part of the system together with the roof, as examining individual materials and components in isolation has proven insufficient in the past. For long-term safe and reliable operation, solar power plants must be properly designed, installed to a high standard, and regularly maintained.
2026_PA42	Veit, M., Lucherini, A., Jomaas, G., & Merci, B. (2026). Infrared distortions. International Fire and Safety Journal, (56), 28–29. https://digital.internationalfireandsafetyjournal.com/html5/reader/production/default.aspx?pubname=&edid=03e32339-bb36-47e1-a991-ce0abaca7dae
Abstract	Thermal imaging cameras (TICs) are one of the essential tools used by firefighters. Using sensors that operate in the long-wave infrared (IR) spectrum, these devices convert heat into visible images, enabling first responders to see through smoke, navigate through burning buildings, detect hotspots, and locate people quickly, even in zero-visibility conditions. But how good is the current technology? And, more importantly, how do we make sure it serves well the purpose of the people using it?
2026_PA43	Bellini, E. (2026, July 31). Study shows consequences of PV-related fires are generally limited in severity. Pv Magazine. https://www.pv-magazine.com/2026/07/31/study-shows-consequences-of-pv-related-fires-are-generally-limited-in-severity/
Abstract	An international study analyzed PV-related fires across the UK, Italy, Slovenia, and Sweden, showing that differences in reported fire rates are largely driven by national data collection methods and definitions. The researchers found that PV fires remain relatively rare, with data revealing that DC cables and connectors are the most common ignition sources.
2026_PA44	Lucherini, A., Košiček, M., Kudryashov, V. A., Rojas Alva, W. U., Jug, A., & Jomaas, G. (2026). Primerjava in omejitve požarnega preskušanja fasad: od laboratorijskih preskusov majhnega merila do novega evropskega preskušanja fasad v velikem merilu. Požar, 32(2), 26–30.
Abstract (trans. SLO)	Façades are one of the key elements in building fire safety, as they provide a pathway for fire to spread rapidly from one part of a building to another. A reliable assessment method for testing façade fire performance is therefore essential. This paper presents and compares three façade fire test methods

	performed at different scales: the Single Burning Item (SBI) test, the intermediate-scale method based on ISO 13785-1, and the emerging European large-scale approach currently under development towards standardisation. The comparison highlights significant differences in fire exposure, specimen size, performance criteria, and representativeness of construction details. The SBI test was primarily developed to evaluate the contribution of compartment linings to flashover, and mainly investigates lateral flame spread under limited thermal exposure. The intermediate-scale ISO method provides improved assessment of vertical fire spread and the influence of details near the fire source. The European large-scale approach aims to reproduce more realistic fire scenarios through substantially larger specimens and higher thermal exposure, enabling a more representative evaluation of vertical fire spread and façade detailing. Although all methods provide useful information, their results must be interpreted within the limits of their specific boundary conditions and assessment criteria. Façade fire test results should therefore not be used to predict real building performance, but rather as part of a broader assessment that considers the intended application, evaluates different fire scenarios, and assesses the consequences of fire spread.

5. CONFERENCE CONTRIBUTIONS

Attending and presenting at scientific conferences provides an important opportunity for direct interaction with the research community. Conferences enable the direct dissemination of new findings, provide rapid feedback from peers, and facilitate discussion of research approaches. Additionally, conferences promote the establishment of new professional connections and collaborations, help identify potential avenues for further work, and support the development of joint research activities. The list presented in the following sections includes published conference contributions in peer-reviewed proceedings that represent recognised scientific outputs.

5.1. List of conference contributions

Table 4 Overview of conference contributions during the FRISSBE project.

2021_CC1*	Manes, M., Jomaas, G., Rush, D., Messerschmidt, B. (2021). What is the role played by fire statistics? Challenges and benefits in their application towards improved fire safety. 10.14264/07de9b8 * *Conference paper available upon login only*
2022_CC2	Seweryn, A., Lucherini, A., & Franssen, J.-M. (2022). An apparatus for applying fire-like heat flux to bench-scale samples. In L. Jiang (Ed.), *Proceedings of the 12th International Conference on Structures in Fire* (pp. 611–622). The Hong Kong Polytechnics University. https://3af639b4-75ac-4471-baeb-457d236967eb.filesusr.com/ugd/d09606_da77cc8d5a314860a4c0a9b8ccb4337d.pdf
2023_CC3	Lucherini, A., Šejnová Pitelková, D., & Mózer, V. (2023). Predicting the effective char depth in timber elements exposed to natural fires, including the cooling phase. In A. Q. Nyrud & K. A. Malo (EDs.), *WCTE 2023: Proceedings from the 13th World Conference on Timber Engineering* (pp. 1681–1690). World Conference on Timber Engineering. doi:10.52202/069179-0226
2023_CC4	Blumauer, U., Lucherini, A., & Kržan, M. (2023). Preskus požarne odpornosti šest-metrskega lesenega kompozitnega nosilca. In P. Može, M. Gams, & D. Malnar (Eds.), *Zbornik 44. zborovanja gradbenih konstruktorjev Slovenije* (pp. 269–277). Slovensko društvo gradbenih konstruktorjev.
2024_CC5	Blumauer, U., Lucherini, A., & Kržan, M. (2024). Fire resistance test of 4-m long composite timber girders. In Y. Wang & J. Xiao (Eds.), *Proceedings of the the 8th International Conference on the Applications of Structural Fire Engineering ASFE' 24* (pp. 163–169).

2024_CC6	Lucherini, A., Van Coile, R., & Merci, B. (2024). Comparing various methods for estimating the fire decay and the cooling phase in structural fire engineering. In L. Simões da Silva (Ed.), *Proceedings of the 13th International Conference on Structures in Fire* (pp. 61–72). CMM – Portuguese Steelwork Association. https://events.cmm.pt/event/content/index.php?target=showContent&id_pagina=126&defLang=2&event=10
2024_CC7	Lucherini, A., Ni, S., Unobe, D., Gernay, T., Chaudhary, R. K., Peng, M., & Van Coile, R. (2024). Application of cost-benefit analysis methodology for fire safety measures in structural fire engineering. In L. Simões da Silva (Ed.), *Proceedings of the 13th International Conference on Structures in Fire* (pp. 25–36). CMM – Portuguese Steelwork Association. https://events.cmm.pt/event/content/index.php?target=showContent&id_pagina=126&defLang=2&event=10
2024_CC8	Charlier, M., & Lucherini, A. (2024). Delivering sustainable buildings: implications and challenges for structural fire engineering. In L. Simões da Silva (Ed.), *Proceedings of the 13th International Conference on Structures in Fire* (pp. 1021–1032). CMM – Portuguese Steelwork Association. https://events.cmm.pt/event/content/index.php?target=showContent&id_pagina=126&defLang=2&event=10
2024_CC9	Put, F., Lucherini, A., Van Coile, R., & Merci, B. (2024). CFD-based analysis of thermocouple measurements in the fire decay and cooling phases in relation to the adiabatic surface temperature. In L. Simões da Silva (Ed.), *Proceedings of the 13th International Conference on Structures in Fire* (pp. 1009–1019). CMM – Portuguese Steelwork Association. https://events.cmm.pt/event/content/index.php?target=showContent&id_pagina=126&defLang=2&event=10
2024_CC10	Jovanović, B., Caspeele, R., Reynders, E., Lombaert, G., Put, F., Lucherini, A., & Van Coile, R. (2024). Assessment of burnout performance of a concrete beam using a novel electric radiant panel. In L. Simões da Silva (Ed.), *Proceedings of the 13th International Conference on Structures in Fire* (pp. 677–687). CMM – Portuguese Steelwork Association. https://events.cmm.pt/event/content/index.php?target=showContent&id_pagina=126&defLang=2&event=10
2024_CC11	Urban, D. L., Ruff, G. A., Ferkul, P. V., Easton, J., Johnston, M., Owens, J. C., Rojas Alva, W. U., & Jomaas, G. (2024). Preliminary results from the Saffire VI Experiment. In *53rd International Conference on Environmental Systems 2024* (pp. 1–7). https://hdl.handle.net/2346/98994
2024_CC12	Han, L., Rojas Alva, U., Schwarzkopf, M., Pečnik, J. G., Sandberg, D., Jomaas, G., & Kutnar, A. (2024). An innovative engineered wood product made from densified wood with enhanced fire performance. In L. Makovická Osvaldová, L. E. Hasburg, & O. Das (Eds.), *Wood & Fire Safety 2024* (pp. 62–70). Springer. https://doi.org/10.1007/978-3-031-59177-8_8
2024_CC13	Manes M., Lucherini A., Rojas-Alva W. U. (2024). A comprehensive evaluation of fire incidents scenarios in secondary schools in England to develop a framework for the environmental analysis of fire safety solutions in the built environment
2024_CC14	Put, F., Jovanović, B., Symoens, E., Lucherini, A., Merci, B., & Van Coile, R. (2024). High-Intensity Fast-Response Electric radiant Panel (HIFREP) for increased accuracy on thermal boundary conditions during fire testing. In *4th European Symposium on Fire Safety Science* (pp. 1–6). doi:10.1088/1742-6596/2885/1/012105
2024_CC15	Veit, M., Lucherini, A., Maragkos, G., & Merci, B. (2024). Predicting the total wall time of CFD simulations of single-compartment fires. In *4th European Symposium on Fire Safety Science* (pp. 1–6). doi:10.1088/1742-6596/2885/1/012100
2024_CC16	Giuliani, L., Sløk, T., Olsen, L. R., & Lucherini, A. (2024). Integrity of intumescent coatings on steel elements subjected to large mechanical deformations. In *NFSD, Nordic Fire & Safety Days* (pp. 119–120). RISE Research Institutes of Sweden. https://www.diva-portal.org/smash/get/diva2:1869356/FULLTEXT04.pdf

2024_CC17	Stølen, R., Fjærestad, J. S., Mikalsen, R. F., & Jomaas, G. (2024). Experimental study of fire propagation on sloped roof with building applied photovoltaics. In *4th European Symposium on Fire Safety Science* (pp. 1–6). doi:10.1088/1742-6596/2885/1/012047
2025_CC18	Rus, N., Puccia, V., Jug, A., & Jomaas, G. (2025). PV-related rooftop fires – national statistics and the impact of reporting methods. In A. Lucherini, L. Marrot, U. Blumauer, & U. Rojas Alva (Eds.), *5th European Symposium on Fire Safety Science* (pp. 1–6). IOP. doi: 10.1088/1742-6596/3121/1/012050
2025_CC19	Lucherini, A., & Mózer, V. (2025). Investigating the thermal penetration in structural timber elements exposed to natural fires. In K. Rischmiller (Eds.), *World Conference on Timber Engineering 2025* (pp. 3674–3683). World Conference on Timber Engineering. doi:10.52202/080513-0450
2025_CC20	Lucherini, A., Adikey, R., Jomaas, G., & Torero, J. L. (2025). Principles for the fire performance of external wall systems. In A. Lucherini, L. Marrot, U. Blumauer, & U. Rojas Alva (Eds.), *5th European Symposium on Fire Safety Science* (pp. 1–6). IOP. doi:10.1088/1742-6596/3121/1/012020
2025_CC21	Li, Q., Zhang, S., Kong, X., Zhao, J., & Jomaas, G. (2025). Experimental study of the fire damage characteristics of photovoltaic modules. In A. Lucherini, L. Marrot, U. Blumauer, & U. Rojas Alva (Eds.), *5th European Symposium on Fire Safety Science* (pp. 1–6). IOP. doi:10.1088/1742-6596/3121/1/012036
2025_CC22	Ostapska, K., Íñiguez-González, G., Llana, D. F., Wasilewski, K., Denstad, D., Zalegowski, K., Pelczynski, J., Pazlar, T., & Lucherini, A. (2025). Field and laboratory testing of 170-year-old timber specimens: case study of a wharf in Trondheim, Norway. In H. Turkulin, V. Rajčić, & T. Sedlar (Eds.), *Proceedings of the SHATIS 2025 – 7th International Conference on Structural Health Assessment of Timber Structures* (pp. 108–118). University of Zagreb Faculty of Forestry and Wood Technology. https://shatis25.com/proceedings/
2025_CC23	Traina, G., Rojas Alva, U., Jug, A., Cancelliere, P., & Lucherini, A. (2025). Correlating cone calorimeter and SBI fire test results for ETICS with a range of material combinations. In *Interflam 2025* (pp. 552–561).
2026_CC24	Manes, M., & Rojas-Alva, U. (2026). Analysing European fire incidents in electric vehicles. In M. Lázaro, & D. Alvear (Eds.), *Proceedings of the VIII Ibero-Latin American Fire Safety Congress* (pp. 287–297). GIDAI, Universidad de Cantabria. doi:10.22429/Euc2026.007
2026_CC25	Yarmohammadian, R., Put, F., Jovanović, B., Thienpont, T., & Lucherini, A. (2026). Assessing various techniques for the post-fire assessment of concrete structures. In M. F. Green (Ed.), *Proceedings of the 14th International Conference on Structures in Fire* (pp. 350–359). Queen's University; York University; NRC Canada. https://queensuca-my.sharepoint.com/:b:/g/personal/greenm_queensu_ca/IQD9jFSrqNReTLg4PJ-1TW8FAU5TLoX1PgCUhBoelMs_tal?e=BFmfOu
2026_CC26	Jovanović, B., Van Coile, R., & Lucherini, A. (2026). Reliability-based calibration of the zero-strength layer in the design of timber structures exposed to fire. In M. F. Green (Ed.), *Proceedings of the 14th International Conference on Structures in Fire* (pp. 573–582). Queen's University; York University; NRC Canada. https://queensuca-my.sharepoint.com/:b:/g/personal/greenm_queensu_ca/IQD9jFSrqNReTLg4PJ-1TW8FAU5TLoX1PgCUhBoelMs_tal?e=BFmfOu
2026_CC27	Put, F., Lucherini, A., Merci, B., & Van Coile, R. (2026). Eurocode parametric fire curves: improved consistency in the formulation for the fire decay and cooling phases. In M. F. Green (Ed.), *Proceedings of the 14th International Conference on Structures in Fire* (pp. 739–748). Queen's University; York University; NRC Canada. https://queensuca-my.sharepoint.com/:b:/g/personal/greenm_queensu_ca/IQD9jFSrqNReTLg4PJ-1TW8FAU5TLoX1PgCUhBoelMs_tal?e=BFmfOu
2026_CC28	Kudryashov, V. A., Polishchuk, E. Yu., & Nguen, T. K. (2026). Steel profiled sheeting fire resistance tests: extended experimental results and future proposals. In M. F. Green (Ed.), *Proceedings of the 14th International Conference on Structures in Fire* (pp. 1332–1341). Queen's University; York University; NRC Canada. https://queensuca-my.sharepoint.com/:b:/g/personal/greenm_queensu_ca/IQD9jFSrqNReTLg4PJ-1TW8FAU5TLoX1PgCUhBoelMs_tal?e=BFmfOu
2026_CC29	Manes, M., & Rojas Alva, W. U. (2026). Statistical analysis of fire incident rates in the e-mobility sector

2026_CC30	Bedon, C., Wang, Y., Cella, N., Fasan, M., Jomaas, G., Lucherini, A. (2026) Experimental and Numerical Analysis of Glass-Glass BIPV Facade Modules in Fire. https://doi.org/10.47982/cgc.10.769
2026_CC31	Jurov, A., Rus, N., Simakovs, K., & Jomaas, G. (2026). Photovoltaic module glass breakage behavior on different roofing systems. In C. Bedon & Y. Wang (Eds.), *Final 3FiRES booklet* (pp. 90–97). Edizioni Università di Trieste. hdl:10077/38412

6. OTHER PUBLICATIONS

6.1. List of other publications from the FRISSBE project

Other publications represent an important part of FRISSBE's research output, as they include books, book chapters, reports and monographs that communicate significant research findings, knowledge and impact. The overall activities and representation of the FRISSBE Team were also communicated through newsletters, such as the IAFSS Newsletter, which is published twice a year and provides a leading platform for disseminating information within the international fire safety research community. Newsletters also provide a key communication channel for scientific developments, upcoming events and activities within different organisations.

Table 5 Overview of other publications during the FRISSBE project.

2021_OP1	Grunde Jomaas, Augustin Guibaud, Sonia Fereres Rapoport, Jose Torero Cullen, Jean-Louis Consalvi, Ulises Rojas Alva, Florian Meyer, Christian Eigenbrod, Nickolay Smirnov and Guillaume Legros. (2021). White Paper #08: Applied Space sciences, 2.8 Fire Safety - a robust, science-based protocol for materials selection. *ESA SciSpacE white papers* https://esamultimedia.esa.int/docs/HRE/08_PhysicalSciences_Applied_Space_sciences.pdf *This publication paved the way for an ERC Synergy grant of 14M Euros, where the supervisor of Martin Veit and Elijah Igweh (Bart Merci) is one of the PI's.*	Report
2023_OP2	Fahy, R. (Ed.). (2023). *Fire Safety Science News*, (49). IAFSS. https://iafss.org/wp-content/uploads/2023/03/No-49-Fire-Safety-Science-News-March-2023.pdf	Newsletter
2023_OP3	Huang, X., & Johansson, N. (Eds.). (2023). *Fire Safety Science News*, (50). IAFSS. https://iafss.org/wp-content/uploads/2023/10/00-No-50-Fire-Safety-Science-News_v10.pdf	Newsletter
2024_OP4	Lucherini, A., & Bedon, C. (2024). Understanding the failure mechanisms of building-integrated photovoltaics (BIPV) under different thermal and mechanical conditions. In C. Bedon & Y. Wang (ur.), *First-year 3FiRES booklet* (pp. 60-67). Edizioni Università di Trieste. https://www.openstarts.units.it/handle/10077/36718 https://www.openstarts.units.it/handle/10077/36718	Chapter in a monograph
2024_OP5	Jomaas, G., Jug, A., & Rus, N. (2024). Fire safety guideline for building applied photovoltaic systems on flat roofs. Slovenian National Building and Civil Engineering Institute.	Book

	https://www.zag.si/wp-content/uploads/2025/01/FRISSBE-ZAG-BAPV-Fire-Safety-Guideline-May-2024.pdf	
2024_OP6	Jomaas, G., Jug, A., & Rus, N. (2024). Smernica o požarni varnosti fotonapetostnih sistemov na ravnih strehah. Zavod za gradbeništvo Slovenije. https://www.zag.si/dl/smernica-pv.pdf	Book
2024_OP7	Huang, X., & Johansson, N. (Eds.). (2024). *Fire Safety Science News*, (51). IAFSS. https://mcusercontent.com/3acff19c557a0cb1d5f2a3ba5/files/f3396025-670a-ccd4-0275-636a6fa73091/00_No_51_Fire_Safety_Science_News_final.pdf	Newsletter
2024_OP8	FRISSBE Team (2024). News from ZAG. *IAFSS Newsletter #51* https://mcusercontent.com/3acff19c557a0cb1d5f2a3ba5/files/f3396025-670a-ccd4-0275-636a6fa73091/00_No_51_Fire_Safety_Science_News_final.pdf	Newsletter
2024_OP9	Huang, X., & Johansson, N. (Eds.). (2024). *Fire Safety Science News*, (52). IAFSS. https://iafss.org/wp-content/uploads/2024/12/00-No-52-Fire-Safety-Science-News_original.pdf	Newsletter
2025_OP10	Bedon, C., Lucherini, A., & Stochino, F. (Eds.). (2025). Fire safety engineering - measures, policies, and applications. IntechOpen. doi:10.5772/intechopen.1004964	Book
2025_OP11	Veit, M., Lucherini, A., Jomaas, G., & Merci, B. (2025). Measuring thermal image quality for fire service applications. Fire Protection Research Foundation. https://www.nfpa.org/education-and-research/research/fire-protection-research-foundation/projects-and-reports/measuring-thermal-image-quality-for-fire-service-applications	Report
2025_OP12	Wiesner, F., Brandon, D., Lucherini, A., & Palma, P. (2025). Structural fire behaviour. In G. Fink, R. Jockwer, & J. M. Cabrero (Eds.), Holistic design of taller timber buildings (pp. 288–299). Springer. https://doi.org/10.1007/978-3-032-02098-7_22	Chapter in Book
2025_OP13	Pope, I., Čolić, A., Karannagodage, C., Ali Awadallah, A. A., & Lucherini, A. (2025). Compartment fire dynamics in taller timber buildings: guidance for performance-based fire safety engineering. In G. Fink, R. Jockwer, & J. M. Cabrero (Eds.), Holistic design of taller timber buildings (pp. 272–287). Springer. https://doi.org/10.1007/978-3-032-02098-7_21	Chapter in Book
2025_OP14	Huang, X., & Johansson, N. (Eds.). (2025). *Fire Safety Science News*, (53). IAFSS. https://iafss.org/wp-content/uploads/2025/07/00-No-53-Fire-Safety-Science-News_20250612.pdf	Newsletter
2025_OP15	Huang, X., & Johansson, N. (Eds.). (2025). *Fire Safety Science News*, (54). IAFSS. https://iafss.org/wp-content/uploads/2025/11/00-No-54-Fire-Safety-Science-News_2.pdf	Newsletter
2025_OP16	Jomaas, G., Jug, A., & Rus, N. (2025). Guida alla sicurezza antincendio per gli impianti fotovoltaici installati sugli edifici con tetti piani. Slovenian National Building and Civil Engineering Institute. https://www.zag.si/dl/lineaguidaFV.pdf	Book
2025_OP17	Jomaas, G., Jug, A., & Rus, N. (2025). Doporučení pro požární bezpečnost fotovoltaických systémů instalovaných na plochých střechách budov. Slovenian National Building and Civil Engineering Institute. https://www.zag.si/dl/doporuceni-fv.pdf	Book

2025_OP18	Jomaas, G., Jug, A., & Rus, N. (2025). Smjernice za zaštitu od požara fotonaponskih sustava na ravnim krovovima. Zavod za gradbeništvo Slovenije. https://www.zag.si/dl/smjernice-fn.pdf	Book
2026_OP19	Jomaas, G., Jug, A., & Rus, N. (2026). Guía de seguridad contra incendios para sistemas fotovoltaicos instalados en cubiertas planas. Slovenian National Building and Civil Engineering Institute. https://www.zag.si/dl/guiaPV.pdf	Book
2026_OP20	Steranka, K., Awad, B. N., Milke, J., Rojas Alva, U., Gagnon, L., Chia-Liu, A., & Gallo, J. (2026). Assessing hazards and risk mitigation for utility-scale lithium-ion battery energy storage systems (N. Ryder, G. Jomaas, & A. J. Tarbet, Eds.). SFPE Foundation. hdl:20.500.14534/30	Report
2026_OP21	Lucherini, A., Bedon, C., & Del Bello, R. (2026). Experimental investigation on the failure mechanism of building-integrated photovoltaics (BIPV) under different fire conditions. In C. Bedon & Y. Wang (Eds.), Final 3FiRES booklet: workshop and network updates about research on BIPV photovoltaic facades for fire spread mechanisms, structural failures and resilience improvement methodologies (pp. 42–49). Edizioni Università di Trieste. https://www.openstarts.units.it/handle/10077/38412	Chapter in a monograph
2026_OP22	Jomaas, G. (2026). Fundamentals of Premixed Flames. *SFPE Handbook of Fire Protection Engineering* (pp. 299-315). Springer Nature.	Chapter in Book

7. NUMBERS OF PUBLICATIONS IN FIRE SCIENCE AT ZAG

7.1. List of publications three years prior the start of the FRISSBE project

A list of all ZAG peer-reviewed publications for the period 2018–2020 was presented in *D5.1 "Statement on ZAG's peer-reviewed publications published 3 years prior to the FRISSBE ERA Chair"*. It summarised a total of 14 publications related to the field of fire science, of which 10 are related to this deliverable, covering one scientific review article and five scientific articles (listed here as six scientific journal publications) and four scientific conference proceedings (listed here as four conference contributions), excluding abstract contributions. For the purpose of completeness, the list is summarized here.

Table 6 Overview of published scientific journal publications three years prior to the FRISSBE project.

Scientific journal publications		**Type of publication, According to SICRIS**
1	Legan, L., Retko, K., Peeters, K., Knez, F., & Ropret, P. (2020). Investigation of proteinaceous paint layers, composed of egg yolk and lead white, exposed to fire-related effects. *Scientific Reports, 10*, Article 18961. https://doi.org/10.1038/s41598-020-75876-y	1.01 Original Scientific articles
2	Peeters, K., Uršič, M., Tavzes, Č., & Knez, F. (2020). The use of bench-scale tests to determine toxic organic compounds in fire effluents and to subsequently estimate their impact on the environment. *Fire Technology*. https://doi.org/10.1007/s10694-020-01065-y	1.02 Review article

3	Ducman, V., & Radeka, M. (2019). Alkali activated green building materials—Selected case study of alkali activated aggregate. *Ceramics in Modern Technologies, 1*(3), 173–177. https://doi.org/10.29272/cmt.2018.0006	1.01 Original Scientific articles
4	Kvočka, D., Lešek, A., Knez, F., Ducman, V., Panizza, M., Tsoutis, C., & Bernardi, A. (2020). Life cycle assessment of prefabricated geopolymeric façade cladding panels made from large fractions of recycled construction and demolition waste. *Materials, 13*(18), Article 3931. https://doi.org/10.3390/ma13183931	1.01 Original Scientific articles
5	Turk, J., Oven, P., Poljanšek, I., Lešek, A., Knez, F., & Malovrh Rebec, K. (2019). Evaluation of an environmental profile comparison for nanocellulose production and supply chain by applying different life cycle assessment methods. *Journal of Cleaner Production*, Article 119107. https://doi.org/10.1016/j.jclepro.2019.119107	1.01 Original Scientific articles
6	Češarek, P., Kramar, M., & Kolšek, J. (2018). Effect of creep on behaviour of steel structural assemblies in fires. *Steel and Composite Structures, 29*(4), 423–435. https://doi.org/10.12989/scs.2018.29.4.423	1.01 Original Scientific articles

Table 7 Overview of conference contributions three years prior to the FRISSBE project.

Conference contribution	
1	Knez, N., Knez, F., Ducman, V., Tamburini, S., Natali, M., & Bernardi, A. (2018). Reaction to fire properties of wood waste-based geopolymer panels. In I. M. Martins, C. Ulsen, & Y. Villagran (Eds.), *The proceedings of the IV International Conference Progress of Recycling in the Built Environment* (RILEM Proceedings, PRO 124, pp. 488–495). RILEM Publications.
2	Kolšek, J., & Rebec, A. (2018). Comparison of simplified and advanced design of steel structures in fire. In M. Kaloop (Ed.), *Advanced materials and application: International Symposium on Advanced Materials and Application (ISAMA 2018), Seoul, South Korea, January 19–21, 2018* (Advanced Materials Research, Vol. 1147, pp. 24–29). Trans Tech Publications. https://doi.org/10.4028/www.scientific.net/AMR.1147.24
3	Kolšek, J. (2018). Comparison of simplified and advanced simulation of a fire in a factory of XPS panels. In M. Kaloop (Ed.), *Advanced materials and application: International Symposium on Advanced Materials and Application (ISAMA 2018), Seoul, South Korea, January 19–21, 2018* (Advanced Materials Research, Vol. 1147, pp. 30–35). Trans Tech Publications. https://doi.org/10.4028/www.scientific.net/AMR.1147.30
4	Pečenko, R., Tomažič, K., Planinc, I., Huč, S., & Hozjan, T. (2018). Numerical investigation on design method of timber structures exposed to parametric fire. In *Conference proceedings: International scholarly and scientific research & innovation* (World Academy of Science, Engineering and Technology, Part XIX, Vol. 20, No. 1, pp. 2164–2173).

To summarize, the number of publications before and after the initiation of the FRISSBE project is shown in Figure 10, displaying a significant increase in scientific publications in the field of fire science at ZAG.

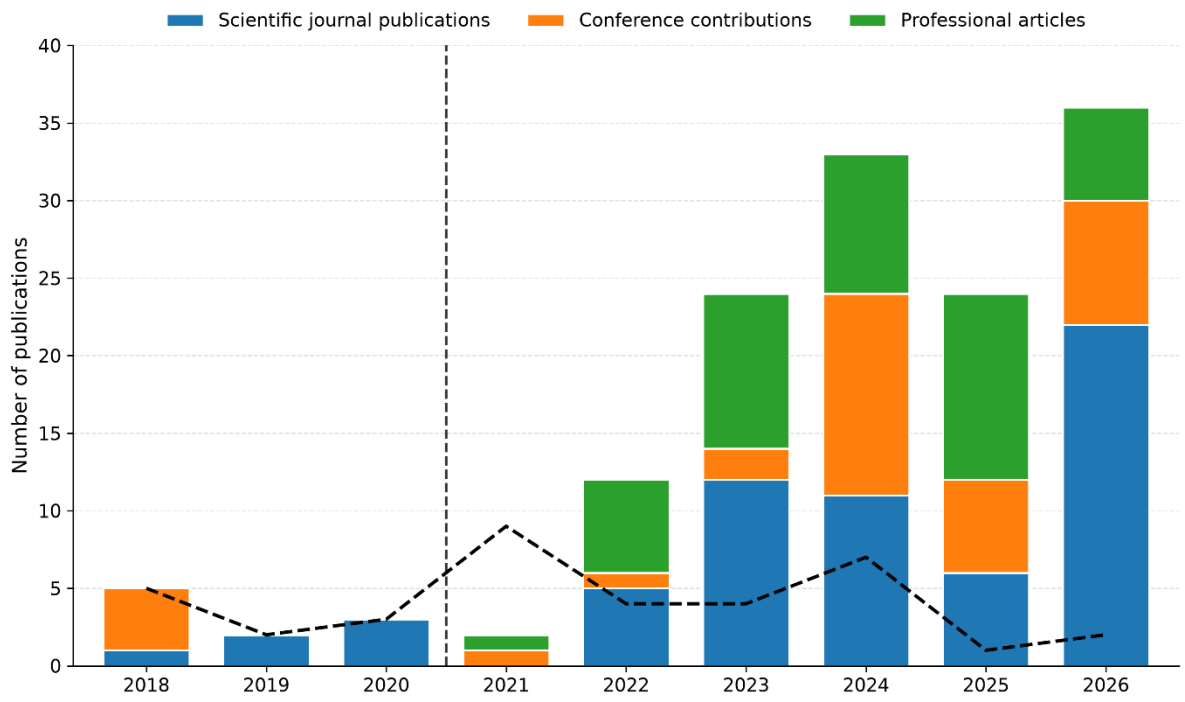


Figure 10 Scientific, conference and professional publications before (before 2021) and during (2021 – 2026) the FRISSBE project. The dashed line represents fire related publications (scientific journal papers, conference contributions and professional articles) performed by ZAG, no produced within the FRISSBE project.

7.2. In the timeline of the FRISSBE project, from other departments

The following tables present other fire related publications performed by the ZAG team that were not produced within the FRISSBE project. These publications demonstrate the active involvement of fire research at ZAG across different departments and research areas. This is also visualized on Figure 10 with a dashed line.

Table 8 Overview of published scientific journal publications in the field of fire science, during the FRISSBE project from other departments.

Scientific journal publications		**Type of publication**
1	Pondelak, A., Knez, N., Škapin, S. D., Humar, M., & Sever Škapin, A. (2026). Enhancing the fire resistance and fungal durability of solid wood via magnesium carbonate-based mineralization method. *Construction and Building Materials*, *525*, Article 146355. [COBISS.SI-ID 275810563]	1.01 Original Scientific articles
2	Sitar, M., Dolenec, S., Knez, N., Hren, M., Lesar, B., & Pondelak, A. (2026). In-situ hydroxyapatite mineralization in beech and pine wood: Effects of leaching on fire behavior. *European Journal of Wood and Wood Products*, *84*(2), Article 58. [COBISS.SI-ID 275407619]	1.01 Original Scientific articles
3	Repič, R., Pondelak, A., Kržišnik, D., Humar, M., Knez, N., Knez, F., & Sever Škapin, A. (2024). Environmentally friendly protection of European beech against fire and fungal	1.01 Original Scientific articles

	decay using a combination of thermal modification and mineralisation. *Wood Material Science & Engineering, 19*(1), 33–44. [COBISS.SI-ID 157967107]	
4	Pečenko, R., Knez, N., Hozjan, T., Šejna, J., Cábová, K., & Turk, G. (2024). On the char front temperature of beech (*Fagus sylvatica*). *Wood Science and Technology, 58*(4), 1535–1553. [COBISS.SI-ID 203177987]	1.01 Original Scientific articles
5	Knez, F., Uršič, M., Knez, N., Peeters, K., Franko, M., & Zidar, P. (2021). Use of the modified controlled atmosphere cone calorimeter for the assessment of fire effluents generated by burning wood under different ventilation conditions. *Fire and Materials*, 1–8. [COBISS.SI-ID 84845571]	1.01 Original Scientific articles
6	Pondelak, A., Sever Škapin, A., Knez, N., Knez, F., & Pazlar, T. (2021). Improving the flame retardancy of wood using an eco-friendly mineralisation process. *Green Chemistry, 23*(3), 1130–1135. [COBISS.SI-ID 48775683]	1.01 Original Scientific articles
7	Knez, N., Kariž, M., Knez, F., Ayrilmis, N., & Kitek Kuzman, M. (2021). Effects of selected printing parameters on the fire properties of 3D-printed neat polylactic acid (PLA) and wood/PLA composites. *Journal of Renewable Materials, 9*(11), 1883–1895. [COBISS.SI-ID 64464899]	1.01 Original Scientific articles
8	Peeters, K., Uršič, M., Tavzes, Č., & Knez, F. (2021). Review: The use of bench-scale tests to determine toxic organic compounds in fire effluents and to subsequently estimate their impact on the environment. *Fire Technology, 57*(2), 625–656	1.02 Review Article

Table 9 Overview of professional articles in the field of fire science, during the FRISSBE project from other departments.

Professional articles	
1	Kočman, P., Češarek Kolšek, J., Bratina, S., & Blumauer, U. (2024). Prednapeti betonski nosilci pri požarni obremenitvi. *Požar, 30*(3), 18–19. [COBISS.SI-ID 212981507]
2	Ažbe, T., Blumauer, U., & Ogrin, A. (2023). O zgodovinskih požarih in njihovem vplivu na zakonodajo: Pirotehnični industrijski obrati. *Požar, 29*(4), 32–35. [COBISS.SI-ID 180743683]
3	Stopar, N., & Knez, F. (2024). Zaščita jeklenih elementov z reaktivnimi premazi. *Požar, 30*(2), 27–29. [COBISS.SI-ID 202346755]
4	Knez, F., Knez, N., & Uršič, M. (2024). Sproščanje strupenih plinov pri gorenju reciklirane gume. *Požar, 30*(3), 30–32. [COBISS.SI-ID 213236483]
5	Knez, N., & Knez, F. (2023). Srečanje Evropskega združenja požarnih laboratorijev EGOLF v Ljubljani. *Požar, 29*(2), 7–8. [COBISS.SI-ID 158275331]
6	Knez, N., & Knez, F. (2023). SZPV in Požarni laboratorij ZAG. *Požar, 29*(3), 6–7. [COBISS.SI-ID 170284035
7	Grum, S., & Knez, F. (2023). Požarno odporna vrata, priprava vzorcev, preskus in klasifikacija. *Požar, 29*(4), 6–8. [COBISS.SI-ID 180740611]
8	Blumauer, U., Knez, F., & Knez, N. (2022). Vključevanje požarne varnosti v mednarodne projekte, povezane s trajnostno gradnjo. *Požar, 28*(2), 30–32. [COBISS.SI-ID 118669827]
9	Knez, F., Knez, N., Blumauer, U., & Želimorski, T. (2022). Predstavitev novega Požarnega laboratorija ZAG v Logatcu = Presentation of new Fire laboratory ZAG in Logatec. *Požar, 28*(3), 15–20. [COBISS.SI-ID 128795395]
10	Knez, N., & Knez, F. (2022). Dovzetnost gradbenih proizvodov za neprekinjeno tlenje = Building product's propensity to undergo continuous smouldering. *Požar, 28*(4), 22–24. [COBISS.SI-ID 137545987]

11	Knez, N., Knez, F., & Uršič, M. (2021). Merjenje koncentracije strupenih dimnih plinov pri požaru. *Požar, 27*(1), 34–36. [COBISS.SI-ID 64582147]
12	Knez, N., Pondelak, A., Sever Škapin, A., Knez, F., & Repič, R. (2021). Mineralizacija lesa za izboljšanje lastnosti odziva na ogenj. *Požar, 27*(2), 20–23. [COBISS.SI-ID 72335875]
13	Stopar, N., Blumauer, U., & Knez, F. (2021). Hibridni požarni preskusi. *Požar, 27*(3), 28–30. [COBISS.SI-ID 95461379]
14	Grum, S., & Knez, F. (2021). Bistvene tehnične značilnosti, preskušanje in razvoj standardizacije za požarno odporna vrata. *Požar, 27*(4), 29–31. . [COBISS.SI-ID 95573251]

Table 10 Overview of conference contributions in the field of fire science, during the FRISSBE project from other departments.

Conference contributions		**Type of publication**
1	Pečenko, R., Blumauer, U., Turk, G., et al. (2025). Charring characteristics of timber elements exposed to natural fire. In *World Conference on Timber Engineering 2025*. [COBISS.SI-ID 242358531]	1.08 Published scientific paper at a conference
2	Ogrin, A., Knez, F., & Blumauer, U. (2024). Heated steel bearing elements continuing through fire compartment boundaries. In *Proceedings of the 13th International Conference on Structures in Fire* (pp. 1207–1216). [COBISS.SI-ID 204282883]	1.08 Published scientific paper at a conference
3	Pondelak, A., Repič, R., Škrlep, L., Knez, N., Knez, F., & Sever Škapin, A. (2022). Green approach in wood mineralization for improvement of fire properties. In *IRG documents database and compendium*. . [COBISS.SI-ID 117543171]	1.08 Published scientific paper at a conference
4	Repič, R., Pondelak, A., Knez, N., Knez, F., Kržišnik, D., Humar, M., & Sever Škapin, A. (2021). Okolju prijazna zaščita lesa proti gorenju in glivnemu razkroju s kombiniranjem termične modifikacije in mineralizacije lesa. In *Gozd in les 2021: Podnebne spremembe* (pp. 19–24). [COBISS.SI-ID 66470915]	1.08 Published scientific paper at a conference
5	Češarek Kolšek, J., Blumauer, U., & Bratina, S. (2024). Zasnova dveh prednapetih nosilcev za izvedbo preizkusa v požarnem laboratoriju. In *45. zborovanje gradbenih konstruktorjev Slovenije* (pp. 341–350). [COBISS.SI-ID 214947075]	1.09 Published professional paper at a conference

8. COLLABORATIVE EFFORTS

8.1. Intra-Institutional Collaborations

With the establishment of the Department for Fire-safe Sustainable Built Environment (590) and the start of the FRISSBE project, one of the objectives defined in the Grant Agreement was to enhance intra-institutional cooperation. An important outcome of this objective is the increasing number of research outputs resulting from collaborative authorship through joint internal and cross-organisational research projects.

As described in the previous section, publications attributed to the FRISSBE project currently include contributions from the ERA Chair Holder, the Head of the Department, and members of the Fire Research and Innovation Unit (560) within the

Department for Fire-safe Sustainable Built Environment. Researchers within the unit not only lead their own research projects but also collaborate extensively on joint research activities. As a result, a total of 22% of publications within the three groups, scientific journal publications, professional articles and conference contributions, include two or more co-authors from the Fire Research and Innovation Unit (560), as shown in Figure 11. This close collaboration promotes knowledge exchange within the unit, enables researchers to combine complementary expertise, strengthens the scientific quality of the research, and fosters a collaborative environment in which expertise is shared and mutual support is readily available.

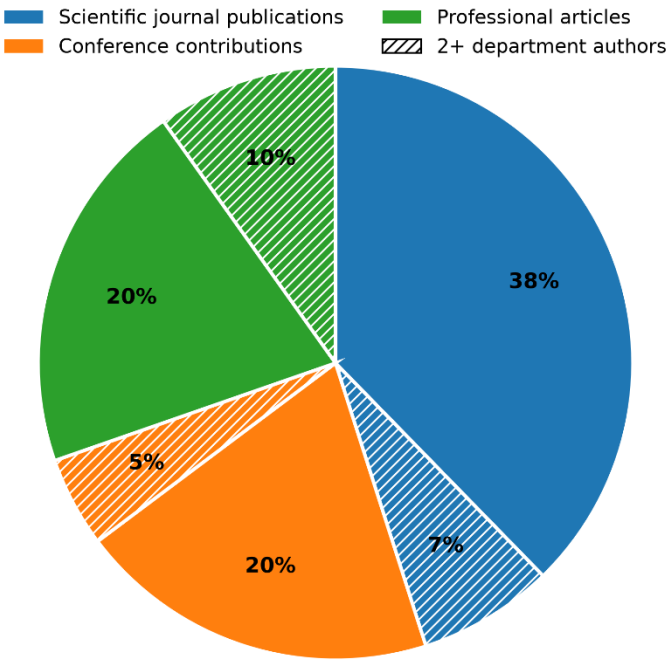


Figure 11 Percentage of co-authorship within the 560 Unit.

In addition, close collaboration has been established with the Section Fire Laboratory and Fire Engineering (530), which is also part of the same department. Besides providing substantial support for experimental testing and laboratory work, Section 530 is also actively involved in research. This close collaboration with members of Section 530 has resulted in joint authorship in 5 professional publications and 2 conference contributions and one original scientific article.

Collaboration also extends beyond the Department for Fire-safe Sustainable Built Environment (590) to other departments within ZAG's organizational units. Professional publications and conference contributions have been co-authored with researchers from the Department of Building Physics (500) and the Department of Structures (600), reflecting the interdisciplinary nature of the research activities carried out within FRISSBE. To date one scientific journal publication has been published in collaboration with the Department of Materials (400), involving the Laboratory for Stone Aggregates and Recycled Materials (420). In addition, two

further scientific journal manuscripts involving this department are currently under preparation or in the peer-review process.

The strengthening of interdisciplinary collaboration is further demonstrated through internal research projects such as TiRex. Although the project is scheduled to conclude in April 2027, a substantial amount of research and experimental work has already been completed. TiRex involves the Department of Structures (600), including the Section for Timber Structures (640) and the Laboratory for Structures (680). Upon completion of the project, additional scientific journal publications with joint authorship between the participating departments and research units are expected.

8.2. External collaborations

One of the objectives of WP4 (*Final Report on Establishing and Strengthening Cooperation*, Deliverable D4.4) was to establish and strengthen collaborative activities between universities, research institutions, and professional organizations, thereby creating long-term partnerships and fostering joint research efforts. Collaboration with world-leading experts contributes to high-quality research through the exchange of skills and knowledge, the sharing of resources and infrastructure, and the development of complementary expertise, providing mutual benefits for all partner organizations. Figure 12 presents a world map illustrating the geographical distribution of FRISSBE's international research collaborations

Overall, 71 % of publications resulted from collaborative work with institutions outside of ZAG. At the national level, the close collaboration with the University of Primorska and InnoRenew CoE (FRISSBE ecosystem) also led to a substantial number of publications in highly ranked scientific journals.

Naturally, the majority of collaborations were established within Europe, reflecting Slovenia's geographical location and the strong European research network fostered throughout the project. Within Europe, particularly strong partnerships were developed with institutions in Belgium and the United Kingdom (UK), resulting in 36 and 27 publications respectively as shown in Figure 12.

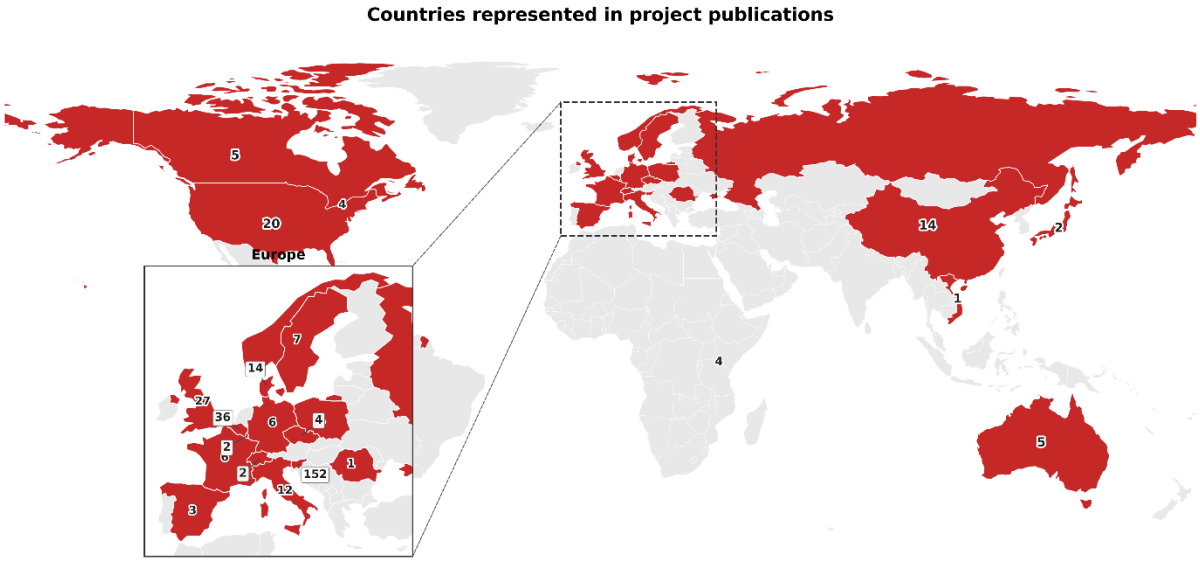


Figure 12 Global distribution of participating countries for co-authors to the publications published in the FRISSBE project. Each country is counted once per publication, regardless of multiple authors from the same country.

Throughout the FRISSBE project, collaborations expanded to partners across the globe. Publications, including scientific journal articles, professional publications, and conference papers, were co-authored with researchers and institutions from 24 countries spanning 4 continents (see Figure 12). These international collaborations were particularly strong for scientific publications, with 96 % of scientific journal articles including one or more co-authors from institutions outside Slovenia. Corresponding shares were 20% for professional publications and 90% for conference publications. This broad international collaboration demonstrates the global reach of the FRISSBE network and its integration into the international fire safety research community.

9. CONCLUSION

This report demonstrates the successful integration of FRISSBE into the international fire research community and highlights the publication performance achieved since the start of the project. The targeted numbers of both scientific and professional publications were exceeded, demonstrating a sustained capacity to develop and disseminate research. The choice of audience was well balanced between scientific community and professional and industrial sectors. Contributions span different career levels within FRISSBE, and the recruitment of postdoctoral researchers further strengthens the team's research capacity and provides a basis for continued publication activities beyond the project period.

Scientific publications target high-quality, field-specific journals, while professional publications support the dissemination of research findings to practitioners and industry. Conference contributions complement these outputs by providing

opportunities to present research, establish new connections and strengthen existing collaborations.

The analysis further demonstrates that FRISSBE is well established within ZAG's research network, while maintaining a strong and growing approach to international collaboration. These collaborations extend across Europe and beyond, with substantial connections to research institutions in North America and Asia. The distribution of authorship also demonstrates FRISSBE's ability to contribute to research in different roles, ranging from executing research, leading and coordinating activities, to contributing as a collaborative partner.

The research portfolio remains closely aligned with FRISSBE's overall objective of advancing fire safety. It covers a broad range of topics across fire engineering, building performance and materials. The increasing citation numbers provide an encouraging indication of the well-established and growing visibility and uptake of the research within the scientific community. Overall, the results demonstrate that FRISSBE has established a strong foundation for continued scientific leadership, international collaborations and knowledge transfer beyond the project period.