Fire Safety and Photovoltaic Panels on Building Roofs Workshop

Final Proceedings by:

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Foreword

The “Fire Safety and Photovoltaic Panels on Building Roofs Workshop” event was held on March 8, 2023, at the Danish Embassy in Brussels, Belgium. The event was co-organized by the National Fire Protection Association (NFPA) and the Fire Protection Research Foundation (FPRF) and hosted by The Permanent Representation of Denmark to the EU.

As part of the REPowerEU plan, the EU Commission has set the ambitious target to make the installation of rooftop solar energy compulsory for all existing public and commercial buildings by 2027 and all new residential buildings by 2029. This will result in the unprecedented transformation of European building stock and a significant uptake in photovoltaic (PV) panel technology on rooftops. This transformation has the potential to have significant benefits from a climate and energy perspective, but it will also bring safety challenges that should be anticipated and addressed upfront. Rooftops will be heavily loaded with electrical equipment directly exposed to weather-related hazards. Consequently, we can expect more rooftop fires to occur.

Initial findings indicate that risk related to the installation of PV panels is not only associated with increased fire load and possibility of ignition, but also with how a fire develops on a roof. This change in fire behavior may increase the extent and speed of the fire spread and thus also the intensity of fires. At the same time, the presence of electrically charged PV modules poses an additional challenge for firefighters dealing with such rooftop fires.

Large international insurance companies, which understand and follow fire risk in buildings, have already acknowledged the additional fire risks of PV systems installed on roofs and published recommendations on how to mitigate these risks posed to buildings, investments, and human life. The key point is to have the right conditions in place to ensure a safe large-scale rollout of PV systems. Recommendations from the insurance industry are generally applied for large industrial and commercial projects. Nevertheless, these fire safety measures should also apply to high-risk public buildings such as schools and hospitals. Recommendations from insurance companies have yet to be considered by national regulations and EU legislation.

The primary objective of this workshop was to review the latest information, experiences, and research related to fire safety of photovoltaic panel installations on commercial building proofs to identify best practices for safety and installation, considerations for new policy recommendations and regulations, as well as knowledge gaps. Understanding the additional risks PV installations pose and taking steps to mitigate them is crucial to ensure the safety and publicly endorsed roll out of PV panels on rooftops as an efficient renewable energy solution.

The workshop discussions highlighted that there is a need to develop guidance for installation of photovoltaic panels on building roofs and safety measures to mitigate new fire risks based on fire safety science and informed by the fire protection community.
Acknowledgements

We express special thanks to the sponsors of this workshop:

Thank you to the workshops host The Permanent Representation of Denmark to the EU and to the speakers who shared their expertise on this topic: Birgitte Messerschmidt (Director of Research, NFPA); Ciaran Cuffe (Ir. Greens, Rapporteur EPBD); Stefan Moser (Head of Unit B.3 Buildings and Products, EU
This workshop summary report has been prepared by Amanda Kimball, Executive Director at the Fire Protection Research Foundation. The information contained herein is based on the input of numerous professionals and subject-matter-experts. While considerable effort has been taken to accurately document this input, the final interpretation of the information contained herein resides with the report author. The content, opinions and conclusions contained in this report are solely those of the authors and do not necessarily represent the views of the Fire Protection Research Foundation, NFPA, Technical Panel or Sponsors. The Foundation makes no guaranty or warranty as to the accuracy or completeness of any information published herein.

**About the Fire Protection Research Foundation**

The Fire Protection Research Foundation plans, manages, and communicates research on a broad range of fire safety issues in collaboration with scientists and laboratories around the world. The Foundation is an affiliate of NFPA.

**About the National Fire Protection Association (NFPA)**

Founded in 1896, NFPA is a global, nonprofit organization devoted to eliminating death, injury, property and economic loss due to fire, electrical and related hazards. The association delivers information and knowledge through more than 300 consensus codes and standards, research, training, education, outreach, and advocacy; and by partnering with others who share an interest in furthering the NFPA mission. [All NFPA codes and standards can be viewed online for free.](https://www.nfpa.org)

NFPA's [membership](https://www.nfpa.org) totals more than 65,000 individuals around the world.

**Keywords:** Photovoltaic panels, fire safety, workshop, sustainability

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# Table of Contents

Foreword ................................................................................................................................................... ii  
Acknowledgements .................................................................................................................................... iii  
Table of Contents ..................................................................................................................................... v  
Background and Overview ....................................................................................................................... 1  
Overview of the Presentations .................................................................................................................. 3  
Presentations: Observations and Summaries .......................................................................................... 4  
Annex A: Workshop Participants and Attendees ..................................................................................... 14  
Annex B: PowerPoint Slides ...................................................................................................................... 16
Background and Overview

To address the environmental crisis head-on, entities are working to implement policies to further understand the crisis and prepare critical environmental preservation and restoration initiatives. These initiatives and their recommendations range in scope from consumer level recommendations such as recycling and minimizing electrical usage to infrastructural overhauls of commercial buildings and construction practices.

Considering current events and the availability of energy, European Union leaders agreed to entirely phase out its use of all Russian energy imports as soon as possible. The plan to shift these resources was titled the REPower EU plan. This report documents a workshop detailing the fire safety impacts of working toward an ambitious target to make the installation of rooftop solar energy compulsory for all existent public and commercial buildings with floor area larger than 250 m² by 2027 and all new residential construction by 2029. This effort will result in an unprecedented transformation of European building practices and a significant increase in photovoltaic (PV) panel technology on rooftops.

The goal of this workshop was to engage with key industry stakeholders (political representatives to industry or commercial representatives) to review the latest research concerning fire safety of photovoltaic panels installed on commercial buildings and collaboratively identify and implement safety precautions to mitigate fire risk associated with the photovoltaic panels.
<table>
<thead>
<tr>
<th>Time</th>
<th>Session Title</th>
<th>Presenters</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:00 – 1:20 pm</td>
<td>Welcome and Introduction</td>
<td>Moderated by: Birgitte Messerschmidt (Director of Research, NFPA)</td>
</tr>
</tbody>
</table>
| 1:20 – 2:00 pm | Presentation #1  
Perspective of the European Parliament, EU Commission, and Member State - EU Solar Rooftop initiative – how to address safety considerations for buildings. | Ciaran Cuffe (Ir, Greens, Rapporteur EPBD), Stefan Moser (Head of Unit B.3 Buildings and Products, EU Commission), and Diana Horvat (Head of Sector, Energy Efficiency in Buildings, Croatian Ministry of Construction) |
| 2:00 – 2:40 pm | Presentation #2  
Experience of Building Owner and User                                           | Tom Pedersen (Engineering Leader at Ingka Real Estate, IKEA)                                 |
| 2:40 – 3:00 pm | Break                                                                           | All Participants                                                                            |
| 3:00 – 4:00 pm | Presentation #3  
Reviewing the Latest Research                                                   | Grunde Jomaas (PhD, Professor, FRISSBE, ZAG), Dong Zeng (Ph.D., Principal Research Scientist, FM Global), and Amanda Kimball (Executive Director, FPRF) |
| 4:00 – 4:40 pm | Presentation #4  
Insurer and Fire Service Perspective                                              | Phil Smith (VP, Manager - Building Materials at FM Approvals), Steve Plummer (Operations Chief Engineer at FM Global), and Bart van Leeuwen (Watch Commander at Fire Department Amsterdam-Amstelland) |
| 4:40 – 5:00 pm | Summarizing Discussion                                                          | Birgitte Messerschmidt, NFPA                                                                 |

Table 1: Workshop Agenda

March 8, 2023
Overview of the Presentations

Birgitte Messerschmidt of the National Fire Protection Association (NFPA) initiated the event by providing an overview of the REPowerEU plan and its implications on commercial building and construction in addition to its intended environmental impact.

Following this introduction, there were four blocks of presentations. The first was a discussion that focused on the perspectives from representatives from the EU Commission, the European Parliament, and a Member State (Croatia). The second gave the experience of a building owner and user. The third focused on the latest research and the fourth provided a perspective from insurers. Figure 1 shows an overview of the talks that used slides, and all the slides used in the workshop are included as Annex B.

![Overview of presentations](image-url)
Perspective of the European Parliament, European Union Commission, and Member States Summary

- Ciaran Cuffe (Ir, Greens, Rapporteur EPBD)
- Stefan Moser (Head of Unit B.3 Buildings and Products, EU Commission)
- Diana Horvat (Head of Sector, Energy Efficiency in Buildings, Croatian Ministry of Construction)

The representative from the European Parliament was asked whether they in the Parliament were aware of the fire risks with PV on rooftops when creating regulation. He stressed that Europe must move quickly due to external factors (i.e., energy reliance on Russia). However, it was noted that there will need to be inspections and checks in place to ensure safe installations.

The representative from the European Commission was asked whether the EC’s plan to ensure that the installation of PV on roofs does not impact the safety of buildings. He noted that the EU Green Deal is a much broader challenge, they are changing the building stock which needs to be reflected in urban planning and risk assessments. As part of these initiatives, there is going to be more electric – cars, batteries, heat pumps, more wiring, smart systems. With this, fire safety, security, and health are all issues of concern. These topics need to be integrated in reflections in how to transition the building stock more broadly. The national governments have a responsibility here but need support with knowledge of best practices. This goes much further than rooftops.

He further noted the involvement of other stakeholders. Insurance as well as fire brigades play a role in ensuring safety. Occupants need to be informed as well of any changes to emergency responses with fires involving all these additional electrical components. He pointed out that we have figured out other risks as manageable, need to employ risk assessments and implement proper mitigations. From the EC perspective, they are not in charge of fire safety directly, but see a role to put this issue on the agenda and reflected in the legal text for member states to consider. There is also a need to make sure exchange takes place across relevant departments (energy and others).

The representative from Croatia was asked about the member state perspective on what they are seeing the impact of this regulation on fire safety. She noted that they are concerned about the roll out of PV panels, but Croatia has produced guidelines for analysis of existing buildings undergoing major renovations, which was a good step forward toward concerns around PV on roofs. There is a need for a certificate before installation of PV on roofs now and major renovations must be concerned with energy efficiency, fire safety, seismic concerns, and indoor climate conditions. She did note that implementing this is difficult coming from a small country. She would also like support from the Commission to estimate the scale and impact of the new risk.

It was noted that the testing in place does not consider the increased risk of PV installations and whether tools can be provided to member states. It was stated that any new building component not widely used must be assessed, including PV. There needs to be certification by competent professionals. The European Parliament has strengthened the original language on fire safety and inspections in the EU’s Buildings Directive which is currently being discussed. While this is a challenge for member states, it is also an opportunity. The overall benefits are strong – for major renovations it is also an opportunity to consider other issues – like accessibility. There will be a requirement for member states to inform and educate owners, tenants, and local municipalities about fire safety practices.
A member of the CEN 127 roofing committee noted that they are debating on PV related to building attached vs building integrated as the two installations fall under different regulations. The committee has no mandate from CEN to work on this topic; therefore, all they can do is to draft a technical report based on the experience of the member states on fire with PVs. They lack information and a mandate to do more.

It was pointed out that fire safety is within the responsibility of the EU member states, but they rely on the tools in the form of harmonised standards. Unfortunately, technical committees do not have the tools to provide (tests, etc.) for roof mounted PV panels. What role does the EC play in providing tools?

Member states are large enough and capable enough to find knowledge on their own and have done this in other arenas. However, it was agreed that there is a need to document best practices across experience and share. Technology today is moving much faster than regulation and standardization. This new risk needs careful consideration, but there have been other risks inherent in buildings that we are able to manage now. By adding PV installations on roofs, we are replacing existing risks with new risks – are the new risks greater? Lower? Same? There are risks today with using natural gas in buildings for heating and cooking, electrification changes the risk, but might not increase in all cases. We have learned to live with many risks by using assessment methods, which need to be adjusted to new risks and ensure proper monitoring, checks, mitigations, and risk assessments. This is a wider issue that goes beyond buildings and Europe. Optimistic that this is surmountable. The change in risk needs to be taken seriously but needs to be done. And it needs to be done as part of design, installation, and ongoing maintenance. Fire safety should be included in national building plans and inspections should be increased.

A building owner provided perspective from the audience. Certification of installers has been an issue. There are lots of installers coming and going and there is a need for some sort of certification to separate qualified firms. Need to work with fire service, utility and other local authorities that are not well informed in all cases. Also, there is a need to educate local authorities so that their requests are reasonable. Need to establish minimum requirements for plants on roofs and the roof structure it is built on. On another issue, when European locations invest in these projects, they need to import most of the panels from outside Europe. It would benefit Europe to increase PV panel production.

A researcher from the audience provided perspective as well. In the past decade, when working with building applied PV, there is a misconception that if we certify step by step with the components that we are good. However, we need to consider this as part of the entire system, this is where guidance is needed. This is a massive parametric undertaking that we need to understand much better across all types of buildings – timber, older buildings – and it would be better to have consistent rules across Europe on fire safety.

A representative from the solar industry in Europe noted that if we have bad public perception, there will be less of a demand, which is bad for business and the implementation of solar panels. PV systems do not cause all of the fires, but we need more research on how they impact fire spread. The solar industry is happy to work together with insurance companies and others to try to find solutions to these problems.

The representative from Croatia was asked if they would like to see something from the Commission to help improve their existing guidelines. Noted that awareness of the problem is the first issue. Technical guidelines would be of significant help in terms of choosing between methods and processes to come up with the best way to do things.

The EU Parliament representative and EC representative were asked if there is a potential risk of barriers to trade if there are unharmonized requirements? They do not want to see interference in the EU, but also do not want to step on the toes of the member states. There are differing definitions of energy use in the member states, so that
will need to be accounted for. Member states also need to consider local issues. The big issue is that we need to acknowledge that the building components work together as a system, and we need to understand how it works together as a whole.

Construction products and appliances on the market will need to be certified as safe. When they are put together in a system, they interact together and with the building. The risks of this need to be identified through a specific risk assessment that should be informed by guidance. To do this, we need experts globally taking to each other – fire safety, renewable energy, others. The main question is to what extent would EC guidelines add value to what is already happening? Would they be able to go beyond a level of generality that would be useful? It was pointed out that the EC must stay at a general level. There is a need to make sure there is enough qualified installers, inspectors, which will need to be enforced through monitoring and education of fire service. Need the right balance between what the EC does vs member states. There is a balance between creating unnecessary bureaucracy and usefulness.

We currently lack the knowledge to give proper guidance. We need resources/funding to do this. There could be an opportunity to apply for funding for pilot projects in Europe through the Parliament. There are other funding streams as well, like Horizon.

Perspective of the Building Owner
Tom Pedersen (Engineering Leader at Ingka Real Estate, IKEA)

Generally, business is moving toward e-commerce away from cash and carry and as a result, have large logistical warehouses where the value of the building is much greater than the value of the PV plant. The main issue is that owners do not want to interrupt the core business. However, there is an ambition to further invest in renewable energy before 2030.

He noted that IKEA started with small rooftop PV installation in 1996 with four test plants in Belgium, Germany, Spain, and US – all the same system in different climates. They tried to do it all by themselves and found that was not the way to go. Their first commercial project was in 2010 in Belgium. The procurement strategy now is a turnkey agreement with a reliable Engineering, Procurement, and Construction (EPC) company that is responsible for design, procurement, and construction. They also operate and maintain for the first couple of years and provide a performance guarantee on the installation. This is more expensive but get better performance. He noted that there is a lot of turnovers in these types of companies in the marketplace. Of the thirty that started on their short list, only 10% are still around.

Have had thirty fire incidents to date, which compared to fire in core business is not a lot. Most fires were caused by poor workmanship, low quality materials, design errors, and damage during operations. The key factors to limit loss: good quality PV, OM (operation and maintenance) routines, quality roofing, working with the fire service – when they arrive on scene, tell them what to expect. Additionally, they have done some research and testing together with partners that shows the importance of the roof buildup below the installation. Big companies have resources to invest in testing, smaller companies need more help.

He was asked that with IKEA’s experience, would there be a benefit of an EU guideline? Yes, would like to have more guidance on installations. Specifically, need more guidance on fires starting from the roof where there is no fire protection installed (fire detection, sprinklers), material standards, certification of installers. There needs to be a central place for guidance – some countries have extensive experience, but others are just starting, and they could really learn from others. Everyone keeps relearning the same things – if we have guidance, not everyone is starting at zero. Also, there are not enough current installers to be able to comply with the aggressive timeline–
how do we ensure qualifications? He also noted that even within countries and different cities they get different requests from the authorities. There was a question in the audience about if the process for creating a qualification standard using UL 17065, *Conformity Assessment – Requirements for Bodies Certifying Products, Processes and Services*, could help. Underwriters Laboratory is working with stakeholders on other topics and can apply the same process here.

There was a discussion on roofing requirements, and it was noted that IKEA has an internal standard requiring PIR Class 1 or mineral wool insulation. IKEA tends to build mostly new buildings but has bought some logistical buildings. However, they would not install PV panels on roofs outside their current requirement. They do not have a standard on panels because they have found through testing that the amount of fuel in the panels is not significant, only enough to sustain a fire below the panels.

On the issue of coordinating with the local fire department, you can invite the local fire department, but that is still not enough because another nearby fire department could show up on the day of an event. IKEA has a trained fire response team for each unit, and they usually manage the fire before the FD arrives and they also greet the FD when they get on scene and inform them. There have been developments on robotic fire protection but have not used it. They have used drones with thermal cameras to detect problems before a big issue.

**Latest Research**

*Grunde Jomaas (PhD, Professor at University of Primorska and FRISSBE ERA Chair Holder (ZAG))*

PV panels on all buildings means installations on all types of construction and people interacting with the systems and there are stakeholder concerns related to fire safety. He noted a $20 M loss to the ASKO building fire in Norway in 2017.

Based on analysis of available data there is an expected rate of 29 fires/year/GW PV installed. However, it is difficult to obtain the total number because many jurisdictions do not include details on PV in losses – and smaller incidents are not reported. Italy seems to have the best data. It was noted that some of these fires are going to be significant and we need to reduce the consequences.

PV installations impact the fire dynamics and increase the extent and speed of the fire spread. PV modules influence ignition, heating of materials, spread of fire, pyrolysis, and feedback loop. The research conducted looked at gap height, influence of inclination, material properties, and type of PV module. It was found that even small changes can impact the results. Researchers have also used different roof construction mockups to consider existing buildings as well. Even variables like the small edge of the PV panel can cause smoke layer build up and can impact spread. In addition, inclined installations had more spread due to flame length.

There is a need for a high-fidelity, in-depth parametric system at different scales to understand the system. System analysis is the key and testing systems as built is recommended. Membranes that prevent spread without panels burn readily with panels installed. In addition, research conducted so far has found there is a critical gap height. For retrofits, mitigation layers are often needed. Fire safety of PV modules on buildings needs further research now – a small investment needed for substantial gain.
The presentation started by stating that **FM Global have seen some big fire losses here**. There are multiple ignition sources, wind affects fire spread, and firefighting is challenging. They have found through their research that the presence of PV panel changes the shape of the flame and can preheat and promote fire spread. **There is a need for a comprehensive fire test that robustly tests fire spread of roof/PV panel combination to see how it acts as a system.** FM Global is currently using a modified ASTM E108 test. It is a large-scale test for roof fire spread.

He agreed with the previous speaker that the presence of PV panels on the roof makes the fire spread regardless of the type of roof system due to the impact of the panel on the flames. At FM Global they tested: six roof assemblies (class A rated), five PV panels (panel and frame tested together), and different configurations. The back sheet of PV panel is the only fuel contribution, and the real effect is on “cavity fire spread”. There are many unpredictable effects due to the different components, so they agree that there is a need to test actual installations. As an example, they had to shut down a test with PV panel installed with PVC membrane and PIR rooftop, even though the roof passes E108.

Rooftop PV loss could be severe and impact sustainability goal. Research shows that a robust test is needed to consider the combination of roof and PV installation. **Mitigation research is needed to address fire hazard of PV panels installed on existing roofs.**

**Amanda Kimball (Executive Director, FPRF)**

The Fire Protection Research Foundation has been doing research on PV and fire since 2010 with a project focused on **Fire Fighter Safety and Emergency Response for Solar Power Systems**. The Property Insurance Research Group (PIRG), a group of property insurers that plan and sponsor research under the Foundation has supported multiple research projects on PV fire safety. The first from 2014 considered all the potential hazards of roof-top PV systems: **Commercial Roof-Mounted Photovoltaic System Installation Best Practices Review and All Hazard Assessment**. There was also a roundtable discussion with insurers, fire service representatives, and electrical specialists that was documented here: **Property Insurance Research Group Forum on PV Panel Fire Risk: A Literature Review**.

The Foundation has also conducted some research on mitigations for PV installations. There was a research plan scoped in 2016, **Development of Fire Mitigations Solutions for PV Systems Installed on Building Roofs - Phase 1**. The Foundation is now working on implementing the test program outlined in this report starting this year. The proposed testing will use 20 PV arrays with targets to test potential mitigation solutions such as vertical barriers, noncombustible coverboard, aisles, and others as considered by the research team and the project technical panel. The baseline testing will be conducted in 2023 to determine the “worst case” scenario considering different roof membranes and PV orientations.

**Research Discussion**

There was a question about the use of polystyrene insulation on roofs in Europe and how to avoid risks from use of this material with PV installations. The researchers noted that based on testing conducted, these types of roofs will need an intervention and mitigation layers or will need to be renovated. It was pointed out that older roofs may likely need renovation before installing PVs. We should not install PVs, which have a 30-year life span, on roofs that will need to be renovated within the next decade.
It was highlighted that there is a need to collaborate with those that have conducted research like FM Global and others to build on what we know. It was pointed out that the Foundation testing will consider this previous research and will include many that have conducted recent testing on the technical panel to help advice the research direction.

It was noted that while significant testing is needed to develop guidance, a lot could be learned by testing and analyzing common roof types, PV installations, and mitigation options. There are only a select few mitigation solutions that are feasible for use because of other hazards (e.g., wind).

It was pointed out that UL is looking at developing a certification scheme and they are interested in talking more with insurers to get this set up. Can we map out scenarios that are insurable?

Insurance and Fire Service Perspective

Phil Smith (VP, Manager - Building Materials at FM Approvals, Steve Plummer, Operations Chief Engineer at FM Global)

Phil Smith from FM Global provided a perspective on product certification. For roof mounted PV, what are the required building requirements? This depends on perspective – life safety vs property protection. However, there is disagreement that PV is a construction element across the world. In North American it is treated as a construction element. In Europe it currently is not, but there is ongoing debate. In Asia it is analysis for structural loading only.

To meet sustainability goals, roof mounted PV needs to be resilient against fire, hail, and wind. Current standards are ASTM E108/UL 790, Standard Test Methods for Fire Tests of Roof Coverings and CEN/TS 1187 T1-T4, Test methods for external fire exposure to roofs. They all only evaluate fire on the roof, not presence of PV. Therefore, FM Approvals have developed an alternative method FM approval Standard 4478, Approval Standard for Rigid Photovoltaic Modules and some systems are certified to this (currently, 900 meet FM 4478). Have found that results with European fire tests show similar experience. Technology exists to meet the fire requirements but will is needed to implement these requirements.

Steve Plummer provided the risk engineering perspective. They take research, FM Approvals, loss experience and combine into property loss data sheets (FM Global DS 1-15, Roof Mounted Solar Photovoltaic Panels). He noted that good electrical installation practices are important as well as treating all components of the roof/PV installation as a system. This reduces the likelihood of loss, but losses continue to happen on new installations. There are some new buildings following FM global DS 1-15 and there are some solutions listed in FM Approvals tool RoofNav, but this is trickier for existing buildings. Those need to be analyzed case by case. We need to look at combustibility of materials among other factors to limit damage.

Loss prevention engineers consider building construction and materials; panel layout, aisle spaces, skylights; type of PV; and building load calculations to determine the loss exposure. FM Global want to support client’s green initiatives, but in a sustainable way. Compliance to building regulations may still result in an exposure to a facility, but there are ways to reduce risk. Based on loss experience, FM Global sees limited damage when using an FM Global approved PV panel/roof system or other risk-reduction measures such as glass backed panels, metal roof-top surface, or FM Approved or non-combustible insulation. They have seen large external fires with some water damage in the building with the combination of plastic-coated panels, PVC roof cover, and use of mineral wool or FM Approved PIR insulation. The experience has been a total loss of the building when plastic-
backed panels and combustible multi-ply roof cover combined with EPS insulation. Therefore, there is a need to consider assemblies that meet the current test, better configurations of systems, early notification of a fire, and emergency response planning with the fire service.

*Bart van Leeuwen (Watch Commander at Fire Department Amsterdam-Amstelland)*

In Amsterdam, they have created a fire tactics development group and are learning from near misses. This group also considers new problems and emerging issues. The operational concerns are really on energy transition as a whole.

Currently, there are no formal regulation for PV installations in The Netherlands. NEN 1010 exists for formal regulation on installation, expansion, and adaption of low voltage systems, but this is limited. For large installations, this is insurance guided and enforced, but the fire service does not have a role. For residential buildings, this is not insurance guided and for anything below 15 panels there are no regulations at all including no certification required.

The operational concerns from the fire service is that there is no reliable way to know if PV systems are installed (other than visual inspection). For retrofitted installations, there is no standard location for inverters and the fire department have even found them in escape routes. In terms of reignition, there are no guidelines on handover after event. And PV panels also create a barrier for operations on roof. Some of the secondary concerns are fallout from spread of burned remains (for example in a field), broken glass, and electrocution – there is no standard way to disable installation and upon arrival on a scene, it is unclear what electrical status of the building. There is a need for workforce education to keep firefighters up to date on technologies and there is a big need for education and training – today it is the wild west for fire fighters.

**Discussion**

Bart was asked about whether they have connected with the Dutch insurance industry about the concerns? There is some connection, but things are progressing so quickly that it is hard to keep up. It was pointed out that insurance companies in The Netherlands tend to work together – Scope12 is an example as an inspection standard for PV-installations. Getting legislation approved by the government is difficult and can take 5 years – this is way too slow for new technology, which is why the insurance industry works together and also with the fire service. There was agreement that unregulated small-scale installations are a real problem. There are no permitting requirements in The Netherlands for small installations. It was pointed out that in the US, there is a requirement to have a diagram on installs and batteries, etc. for emergency response.

It was asked that if building owners should have information on installation and could supply extinguishers, would this help? Having someone on scene is helpful for larger installations, but concern is still with the smaller installs.

There was a question relating to the FM data sheet 1-15 – do you consider business interruption when considering risk of PV installs? Yes, it is part of the exposure analysis and part of the calculation.

At this point, this group agreed that we expect to see more fires with the new mandate in Europe. How can the learnings from work done by others be transferred to guidance at EU level? This is a difficult question, most of the focus has been on industrial properties so far. There is not a lot of research or knowledge on other types of public buildings – schools, hospitals. Some of the member states are doing research – Italy and The Netherlands; however, it would be helpful to have some central knowledge sharing.
Summary and Wrap Up

Heikki Väänänen, Commission, DG Grow H.1 – Construction, was provided some time to talk about what follow up actions happening already in Europe. He discussed the Fire Information Exchange Platform (FIEP) – who hosted a webinar on PV panel fire issues. From a regulatory point of view, this will require coordination within the EU. Need to determine what can be done at the EU level and what can be done by the member states. Clear that EU responsible for products, member states responsible for safety of residents. However, not much else is clear. Currently, there is an EU project on developing a large-scale façade test. Maybe a similar approach could be applied to roofs with PV installations? This is a big challenge for all of us and needs to be done through open calls for research.

Birgitte Messerschmidt from NFPA wrapped up the event. The EU should be applauded for its ambitious plans to install more PV panels to boost uptake of renewable energy in Europe and its crisis response. However, as discussed during the workshop, implementing such radical changes does not come without challenges, and there are many concerns to be addressed and knowledge gaps to be filled.

The NFPA Fire and Life Safety Ecosystem™ provides a framework to describe the needs related to implementing a fire safe large-scale rollout of PV panel installations across Europe.
Government responsibility
When Government, whether at EU level or Member State level, mandate a change to the built environment that can impact fire safety they are responsible for ensuring that tools are available to mitigate the risk. There is some knowledge already and there is a need to get those with knowledge connected to those developing guidance.

Development and use of current codes
Research is critical, but there are some things that we know already. Is there a possibility of regulating this a bit more at the EU level? The construction product regulation is a performance-based regulation, and it is up to member states to set the specific requirements, the European Commission does not have the mandate to set any rules or regulations. However, as pointed out multiple times during the discussion, it would be best for at least a general guideline to come from one place and not to have every member state working with different guidance as they update their codes and regulations.

Referenced standards
There is a need for a comprehensive fire test that robustly tests fire spread of roof/PV panel combination to see how it acts as a system.

Investment in safety
A lot of the discussion focused around the critical need for more research. Researchers have started filling those gaps but we still have ways to go. In order to conduct this research, funding and resources are needed from the European Commission and European Parliament. There is a need specifically for neutral funding at a larger scale allowing multiple groups and organizations to collaborate. In addition, there is not a lot of research or knowledge on other types of public buildings – schools, hospitals. Some of the member states are doing research – Italy and The Netherlands; however, it would be helpful to have some central knowledge sharing.

Research needs to include a high-fidelity in-depth parametric system at different scales to understand the system. It was noted that while significant testing is needed to develop guidance, a lot could be learned by testing and analyzing common roof types, PV installations, and mitigation options to address the fire hazard of PV panels installed on existing roofs. Fire safety of PV modules on buildings needs further research now – a small investment needed for substantial gain.

Skilled workforce
There is a significant need for certification of PV installers as there is nothing in place currently. With such a large roll-out, it is imperative that the current installers and the new installers that will enter the market be educated and certified. Based on experience, one of the key factors to limit loss is good quality PV, good operation and maintenance routines and quality roofing.

Code compliance
Once developed, compliance with building regulations needs to be enforced. In addition, compliance with building regulations may still result in exposure to a facility, but there are ways to reduce risk. There is a need to understand the system and the priority of risk mitigation for all types of occupancies.

Preparedness and emergency response
One of the key factors to reducing loss is working with the fire service for larger installations. It is important that they have a contact at the facility to inform them on what is installed so that they can take appropriate, safe actions to put out the fire.
Informed public

It was noted that small installations are an issue in Europe and more regulation is needed. Education is also needed for homeowners on the risks that come with installing PVs and how to mitigate those risks as much as possible.

More Workshops like this are considered in the UK and US to continue the exchange of information and knowledge. Further collaborations on this issue are needed with all stakeholders involved. It is our sincere hope that the results of today’s discussions will help ensure that the Green Transition in the EU is also a Safe Transition.
Annex A: Workshop Participants and Attendees

The following were the workshop presenters on “Fire Safety and Photovoltaic Panels on Building Roofs”, held in Brussels, Belgium, on March 8, 2023.

<table>
<thead>
<tr>
<th>First Name</th>
<th>Last Name</th>
<th>Company</th>
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<tbody>
<tr>
<td>Tara</td>
<td>Bennett</td>
<td>The Hartford, Germany</td>
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<tr>
<td>Jan</td>
<td>te Bos</td>
<td>Eurima</td>
</tr>
<tr>
<td>Claus</td>
<td>Bugge Garn</td>
<td>VP ROCKWOOL Group</td>
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<tr>
<td>Ciaran</td>
<td>Cuffe</td>
<td>EU Parliament</td>
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<tr>
<td>Reginald</td>
<td>Degryse</td>
<td>AIG Europe S.A.</td>
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<tr>
<td>Susanne</td>
<td>Dyrbøl</td>
<td>ROCKWOOL Group</td>
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<tr>
<td>Witali</td>
<td>Engelhardt</td>
<td>FM Approvals</td>
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<tr>
<td>Charlotte</td>
<td>Epinay</td>
<td>Acumen</td>
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<tr>
<td>Christina</td>
<td>Francis</td>
<td>Tesla</td>
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<tr>
<td>Kirsten</td>
<td>Glennung</td>
<td>The Trade Council of Denmark</td>
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<tr>
<td>Grunde</td>
<td>Jomaas</td>
<td>FRISSBE</td>
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<tr>
<td>Rose</td>
<td>Hartwig-Peillon</td>
<td>EU Parliament</td>
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<tr>
<td>Diana</td>
<td>Horvat</td>
<td>Croatian Ministry of Construction</td>
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<tr>
<td>Oleksandra</td>
<td>Hrendey</td>
<td>Insurance Europe</td>
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<tr>
<td>Simon</td>
<td>Ince</td>
<td>UL</td>
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<td>Olof</td>
<td>Jonsdottir</td>
<td>ROCKWOOL UK</td>
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<tr>
<td>Giles</td>
<td>Keane</td>
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<tr>
<td>Amanda</td>
<td>Kimball</td>
<td>FPRF</td>
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<tr>
<td>Viktor</td>
<td>Kovačič</td>
<td>SBRA</td>
</tr>
<tr>
<td>Bart</td>
<td>van Leeuwen</td>
<td>Firefighter Amsterdam and owner of NETAGE</td>
</tr>
<tr>
<td>Bart</td>
<td>Merci</td>
<td>Ghent University</td>
</tr>
<tr>
<td>Birgitte</td>
<td>Messerschmidt</td>
<td>NFPA</td>
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<td>Stefan</td>
<td>Moser</td>
<td>EU Commission</td>
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<tr>
<td>Jan</td>
<td>Osenberg</td>
<td>SolarPower Europe</td>
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The following were the full list of workshop attendees on “Fire Safety and Photovoltaic Panels on Building Roofs”, held in Brussels, Belgium, on March 8, 2023.
<table>
<thead>
<tr>
<th></th>
<th>Name</th>
<th>Company/Title</th>
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<tbody>
<tr>
<td>25</td>
<td>Tom Pedersen</td>
<td>Ingka Real Estate</td>
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<td>26</td>
<td>Steven Plummer</td>
<td>FM Global</td>
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<td>27</td>
<td>Igor Rauschen</td>
<td>Centroplan GmbH</td>
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<td>Jan Willem van Rinsum</td>
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<td>29</td>
<td>Philip Smith</td>
<td>FM Approvals</td>
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<td>30</td>
<td>Georg Stockschläder</td>
<td>Zurich Resilience Solutions</td>
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<td>31</td>
<td>Steen Thorsted</td>
<td>The Permanent Representation of Denmark to the EU</td>
</tr>
<tr>
<td>32</td>
<td>Anđelka Toto Ormuž</td>
<td>ROCKWOOL LAT</td>
</tr>
<tr>
<td>33</td>
<td>Heikki Vaanänen</td>
<td>Commission, DG Grow H.1 – Construction</td>
</tr>
<tr>
<td>34</td>
<td>Richard Zammitt</td>
<td>FM Approvals</td>
</tr>
<tr>
<td>35</td>
<td>Dong Zeng</td>
<td>FM Global</td>
</tr>
</tbody>
</table>
Annex B: PowerPoint Slides

<table>
<thead>
<tr>
<th>Presentation Title</th>
<th>Presenter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire Safety and Photovoltaic Panels on Building Roofs</td>
<td>Grunde Jomaas, FRISSBE (ZAG) and the University of Primorska</td>
</tr>
<tr>
<td>Fire Hazard of Roof Mounted Solar PV Panels</td>
<td>Dong Zeng, Richard Davis, FM Global</td>
</tr>
<tr>
<td>Research Foundation Research on PV</td>
<td>Amanda Kimball, FPRF</td>
</tr>
<tr>
<td>Roof Top PV, Fire Safety &amp; Loss Prevention</td>
<td>Tom Pederson, Ingka Group</td>
</tr>
<tr>
<td>Insurer Perspective, FM Global</td>
<td>Philip Smith, FM Approvals and Steve Plummer, Benelux and Nordics</td>
</tr>
<tr>
<td>PV Panels and Fire Safety an Operational Perspective</td>
<td>Bart van Leeuwen, Brandweer</td>
</tr>
</tbody>
</table>

**Photovoltaic Fire Research, Grunde Jomaas**

**Slide 1**

Photo of solar panels on a building roof.

**Slide 2**

Photo of a solar panel installation on a building.

**Slide 3**

Photo of solar panels on a building with a text: “PV on All Buildings: Applauded by authorities and PV system providers.”

**Slide 4**

Photo of solar panels on a building with a text: “ASKO building, Norway 20 Million Euros loss”

**Slide 5**

Diagram showing the spread of fire from a solar panel with a text: “Massive stakeholder concerns related to PV fire safety.”

**Slide 6**

Photo of solar panels on a building with a text: “RepowerEU – PV on all new office buildings from 2025 and all new houses from 2029.”
ASKO fire (Norway) – 9000 m² damage

**Flame spread under photovoltaic module**

No panel: 80 min.

15 cm gap distance: 60 min.

**Influence of PV module**

- **Self-sustained flame spread?**
- **Type of PV module?**
- **Heating of Materials?**
- **Influence of inclination?**

**Parameter quantification**

- Flame front location
  - Critical gap height identified
- Flame front location
  - Identification of significant parameters

**Complexity increase**

- PVC-based roofing membrane (8000 m²).
- Stainless-steel board or PV module.
- Roof construction mock-up.

**Flame spread rate**

- Horizontal panels
- Inclined PV modules

**Flame spread length**

- More severe and faster spread for inclined panels.
Summary
- System analysis is key
- Testing of system 'as-built' is recommended, as standards are insufficient and lagging
- BAPV
  - Membranes that prevent spread without panels burn readily with PV modules present
  - A critical gap height appears to exist
  - Inclined PV modules result in faster spread
  - Mitigation layers are often needed for retrofits, and they should be constructed carefully

Outlook
- Numerous fires are expected – need to reduce the consequences and understand ‘all solutions’ (timber, bitumen, roofing material variations, insulation variations, geometry...)
- Fire safety of PV modules on buildings needs further research – NOW
- Very small investment needed for substantial gain, but nobody is funding it.
Research Foundation Research on Photovoltaics, Amanda Kimball

**Slide 1**

**Research Foundation Research on PV**
Workshop: Fire safety and photovoltaic panels on building roofs
8 March 2023, Amanda Kimball, Executive Director

**Slide 2**

**FPRF Process**

**Slide 3**

Previous research reports on PV (cont)
- **Property Insurance Research Group Forum on PV Panel Fire Risk: A Literature Review** (June 2014) – Roundtable discussion with property insurers, fire service representatives, and electrical specialists to discuss concerns and potential strategies related to fire risks of roof mounted PV panel installations.
- **Development of Fire Mitigation Solutions for PV Systems Installed on Building Roofs - Phase 1** (July 2016) – Identify features that mitigate fire spread between and within PV arrays installed on roof tops.

**Slide 4**

Previous research reports on PV
- **Fire Fighter Safety and Emergency Response for Solar Power Systems** (May 2010) – assemble and disseminate core principle and best practice information for first responders to assist in their decision making process at emergencies involving PV systems on buildings
- **Commercial Roof-Mounted Photovoltaic System Installation Best Practices Review and All Hazard Assessment** (Feb 2014) – Compiled information on a wide variety of hazards and damage potential created by the installation of photovoltaics (PV) systems on commercial roof structures.

**Slide 5**

**Fire Mitigation Solutions Research Overview**
- Reviewed
  - Selected fire incidents involving rooftop PV arrays
  - Relevant fire test data
- Developed a large-scale testing plan - future work is to implement this plan after updating with any relevant newer information

**Slide 6**

Relationship between NFPA and FPRF

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Roof Top Photovoltaics, Fire Safety & Loss Prevention, Tom Pedersen

**Ingka Group**

Roof Top PV, Fire Safety & Loss Prevention

Brussels 8. March 2023

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**Agenda**

1. Ingka Group
2. Rooftop PV at Ingka
3. Fire incidents
4. Mitigation and loss prevention

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**Ingka Group**

Main business areas
- Ingka Retail
- Ingka Centres
- Ingka Investments

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**Ingka Group**

Core business
- Ingka Retail
- Ingka Centres
- Ingka Investments
- 30 million square meter of buildings
- 140 stores in 15 countries
- 25,000,000 m² of buildings
Ingka Retail

Real Estate, Shops and planning Studios

Renewable Energy

- 150 Wind Turbines on and offshore
- 15 Solar PV Parks on 4 countries
- 560 Roof Top Projects & Corporations in 26 countries
- Several additional new energy projects are planned for 2020-2022

PV Procurement Strategy

- Focus on European supplier BCP
- Reliable partnerships, Procurement
- Turnkey delivery
- Operation & Maintenance for 25 years
- Performance guarantee

Fire Incidents

- First fire incident in 2001
- 46 fire incidents recorded to date
- Causality:
  - Post-occupancy
  - Contractor
  - Design
  - Storage during operations

Fire Prevention, Fire fighting & Loss Prevention

- Key Features
  - Identifying 4 fire plants
  - 24/7 remote monitoring system
  - Quick identification and minimal impact
  - Cooperation with fire prevention services

Thank you

tom.pedersen@ingka.ikea.com
Insurer Perspective, Steve Plummer, and Philip Smith

Slide 1

Slide 2

Slide 3

Slide 4

Slide 5

Slide 6

Slide 7

Slide 8

Slide 9

Slide 10

--- Page 23 of 26 ---
Current North American PV Fire Tests

- ASTM E108 (UL 790) - PV/roof systems generally fail to meet acceptance criteria – an alternative method was needed.
- Two different approaches to modify the tests:
  - FM Approvals Std 4478 uses a larger sample and ensures fire spread does not reach the array end.
- Some PV systems are certified to FM 4478
  - All aspects of the assembly are considered.

European PV Fire Tests

- Research results with European fire tests show a similar experience - PV systems generally cannot meet current acceptance criteria.
- It is expected that modification to existing tests or new methods are needed to fully evaluate these systems.

In Closing

- Technology exists to meet these fire requirements. The will is needed to implement these requirements.
- Over 900 specific PV/roof assemblies meet FM 4478:
  - Membrane
  - Metal panel
  - Composite sandwich panel
  - Includes manufacturers from USA and Europe.

Risk Engineering

- Research
- FM Approvals
- Loss Experience
- FM Global Data Sheet 1-15, Rooftop-mounted Solar Photovoltaic Panels
- Free of charge at FM Global Loss Prevention Data Sheets – FM Global.

Recent Loss Experience

- Good electrical installation practices (impacts probability of fire loss).
- Losses continue to happen on new installations.
- New Jersey, USA, 2020:
  - PV panel/roof system
- Netherlands, 2022:
  - PV panel/roof system, containerized, fire from hot work, fire spread to other containers.
- Fire can start a number of ways:
  - Electrical fires
  - Fire from hot work
  - Fire spreading from yard storage to the roof
  - Building contents landing on the roof and starting a fire

Existing Buildings

- Existing buildings are analyzed case-by-case.
- Fire is the key risk, but potential for increased risk of building collapse or damage from natural hazards.
- Loss prevention engineers analyze:
  - Building construction and materials
  - Panel layout, aisle spaces, and skylights
- Type of PV solar panels e.g., plastic-backed (glass-tint) or glass-backed (glass-glass)
- Building load calculations (snow, wind, rain)
- Determine the loss potential (exposure) to our client in a risk-based approach.
PV Panels and Fire Safety: An Operational Perspective, Bart van Leeuwen

**PV Panels and Fire Safety**

*An operational perspective*

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**Preparation – Dutch Situation**

- No formal regulation for installations
  - NEN 3010 – formal regulations for low-voltage systems in buildings
- Larger commercial / large residential buildings
  - Insurance guided, Scope12
- Residential buildings
  - 15 panels (0.55kwH)
  - Not insurance guided, no Scope12
- Wild West
  - No certification required to install small installations
  - No formal ‘delivery inspection’
---

**About me**

Bart van Leeuwen

- 27 years in Fire Service
- Company Officer /
  Watch Commander
  Brandweer Amsterdam-
  Amstelland
- Member of
  “Fire tactics development group”
- My Concerns...

---

**Operational concerns**

- No reliable indication if PV systems are installed
  - Other than visual indication, aesthetic panels hard to spot
- Retrofitted installations
  - Effect on fire behavior
  - No standard location for inverters
  - Escape routes
  - Re-ignition scenarios due to active panels
  - Physical barrier on roof for operations
  - Compartment spanning
Secondary concerns

Fallout
- Spread of burned remains
- Glass

Electrocution
- Non-affected panels remain active
- No standardized way to disable installation
- Unclear what electrical status of building is

Workforce education
- Requires ongoing effort to keep fire fighters up to date