

SCaFire

Fire dynamics of high-power electrical network and multi-scale smart risk evaluation model for new-energy buildings

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We set ambitious goals for modern engineering – sustainability, net-zero energy consumption, promotion of environmentally friendly modes of transport. So far, we have a solid idea on how to answer these needs with distributed energy generation, storage and smart grid, in something we call **new-energy buildings**. Yet, we do not recognise that we introduce a completely new threat to buildings with these ground-breaking innovation – the high-power energy cable fires.

Fires of energy cables are a well-known source of risk in large industrial facilities, such as eg. Nuclear Power Plants, or large scientific infrastructure such as particle accelerators. In these buildings, numerous mitigation strategies are put in place, and personnel training for a case of fire is enforced. We do not treat this threat lightly, as the consequences of such fires are usually severe – both in terms of economic loss and the imminent threat from the smoke generated from the combustion of plastic-heavy cables. However, in residential, commercial or parking buildings, we start to design similar electric infrastructure for megawatts of power that goes through corridors and open plan compartments. Instead of well-trained engineers, the occupants exposed are untrained civilians, unaware of the threat and unprepared for the escape. In our consortium, we have recognised this threat is significant, and this project aims to measure it and propose countermeasures. But to do this, we first need to understand the fundamentals of the combustion of cables...

Electrical cables are surprisingly complex products. Numerous bedding layers, sheeting and external envelope shield the metal cores (usually copper or aluminium). Each of the layers can be designed with different materials, having different flammability. Furthermore, one cable is rarely used alone – they are usually connected into bundles and distributed in the building on trays in vertical and horizontal arrangements. The combinations are endless and there does not exist a single model that could predict the cable sets' flammability. Similar issues emerge with relation to the batteries, energy storage or PV panels. We first want to integrate the existing body of knowledge, and support it with a ground-breaking in scale experimental programme on flammability to solve this. We will test the new-energy system components across the scales – from the microscale (the material properties), through small and intermediate scale (cables and bundles) to full-scale compartment fires. We expect the amount of data generated by this project will be too big for any human to comprehend so that we will resort to deep learning AI to reveal the relations between the cable structure and flammability.

Once we have identified the relations, we will build a surrogate model of fires. This model will have simple geometry but a complex engine based on fundamental physics and our experiments' results. These models will be placed in numerical models of actual compartments to analyse cable fires' outcomes in residential and commercial environments. We will also perform full-scale fire experiments to confirm these findings and validate the models. Many of the experiments planned will be the first time in the world that someone has tried recreating such fires. We want to know **how much** of the toxic products and heat do the cables add to common fire scenarios. We also wish to find **how often** such fires can happen. If we know the probability and consequences, we can estimate the **risk and** rank the solutions from the safest to the worst.

We have built a strong consortium of the most experienced Polish and Chinese fire scientist of the field. We are confident that we can tackle the ambitious goals set for this project and enable the safe development of new-energy buildings. We hope that we can enable the green revolution in civil engineering while reducing the risk that so far may seem unforeseen.