# The International FORUM of Fire Research Directors[1]
# A Position Paper on Sustainability and Fire Safety

Ulrich Krause[1], William Grosshandler[2] and Louis Gritzo[3]
[1]BAM Federal Institute for Materials Research and Testing, 12200 Berlin, Germany
[2]Engineering Laboratory, National Institute of Standards and Technology, Gaithersburg, MD 20899-7300, USA
[3]FM Global, 1151 Boston-Providence Highway, Norwood, MA 02062, USA

## 1. Introduction

As the earth's population approaches seven billion, not only the number of people who have to be provided with housing is growing, but also the demands on the quality of buildings and physical infrastructure are increasing /1/. In the developed countries buildings have to meet complex requirements according to structural integrity, safety, reliability, usability, comfort, aesthetics and affordability. In the developing countries there is still a strong need just to provide shelter fitting to minimum requirements for a large part of the society. Satisfying the needs of a growing human community means providing sustainable and efficient technical solutions at a level of safety that protects the occupants, first responders, and economic investments in our building stock, transportation systems and other infrastructure even in the event of an emergency.

Foreseeable shortage of natural resources, the need for reduction of pollution and wastes, increasing requirements to reduce the carbon footprint of buildings and our transportation systems, and protecting human health and the environment all contribute to the impetus for alternative construction materials, systems, and equipment /2/, /3/, /4/, /5/. New construction materials are being sought, developed and marketed with one or more of the following attributes:

- made from renewable resources,
- maintain desired properties over the whole life cycle,

[1] http://www.fireforum.org/ The International FORUM of Fire Research Directors (FORUM) was formed in 1991 with a goal to reduce the burden of fire (including the loss of life and property, and effects of fire on the environment and heritage) through international cooperation on fire research.

- fully recyclable.

An example is thermal building insulation made from renewable and/or "natural" materials. Systems include lightweight wood trusses for residential applications, more extensive use of glazing to maximize passive solar heating, and bridge and pier structural systems from polymer composites. New technologies have been introduced that claim to increase energy efficiency of building systems while not endangering the environment, such as hydrocarbon-based refrigerating and air-conditioning systems.

Transportation systems are also striving to make use of new materials and systems, not only for terminals but also for vehicles: automobiles, buses, light rail, trains, and airplanes /6/. Composites are highly desirable in these applications because they are lighter than the steel and aluminium materials they replace, creating the potential for significant fuel savings over the life of the vehicle. The anticipated exponential growth in fully electric vehicles is another trend to consider in our move toward sustainability.

While the twin goals of energy efficiency and environmental protection are laudable and the trends welcomed by most in society, those concerned with fire protection recognize that optimizing a product or system without fire performance as one of the parameters can lead to an increase in the risk of fire with serious consequences on human health, the environment and economic investment.

## 2. Fire safety issues

Possible fire safety issues that could arise in the move toward energy efficiency, environmental protection and sustainable design and construction are revealed when one considers how this move might impact (1) the flammability of materials (ignition, heat release rate, and flame spread), (2) the toxicity of the products of combustion, (3) automatic suppression approaches, (4) the materials resistance to fire (ability to maintain confinement and/or structural loading), and (5) fire fighting strategies (physical accessibility, fire fighter protection, hazards from electrically energized equipment such as photovoltaic panels and battery powered vehicles).

Natural materials from wood, cotton, and other bio-derived sources are flammable. To save on energy, extensive use is made of polymeric insulation materials like polystyrene even though these synthetic materials are not considered renewable. In addition, the traditional approach to reducing the fire risk from flammable bio-materials and polymers, the use of bromine and chlorine additives, is no longer considered acceptable. Many of these materials have been shown to bioaccumulate with undesirable consequences demonstrated in controlled animal studies when the fire retardant (or a daughter product) is present in sufficiently high concentrations. A number of these brominated materials are outright banned in many countries, and production has ceased or the applications significantly curtailed for other materials /7/. As industry, academia and governments search for alternatives to halogenated fire retardants, the potential for generating a different but equally problematic safety or environmental consequence during normal use and in the event of a fire must be carefully considered (e.g., the use of nano-materials to reduce the flammability of polymers).

The negative impact of hydrobromo- and hydrochloro-fluorocarbons on stratospheric ozone is well documented /8/, and the phase out of these materials from fire suppression systems and refrigeration and air-conditioning equipment over the past two decades has led to a reversal of the trend toward decreasing the ozone layer. Alternative fire suppressants that are absent of chlorine and bromine have entered the market, but their performance is much inferior to the old standards: halon 1301 and halon 1211. The alternative working fluids for air-conditioning and refrigerating equipment include highly flammable hydrocarbons.

Lightweight composite structural systems have many attractive attributes that lead to high performance under normal environmental conditions. However, the ability of these systems to maintain a load at elevated temperatures or to prevent penetration of a barrier by fire are often not considered, and may not be sufficiently evaluated during standard fire testing called out in building codes. Even new concrete materials in high-strength formulations using recycled fly ash can fail to carry a load at high temperatures more readily than standard concrete due to excessive spalling if appropriate measures are not taken.

Building passive houses as the probably most promising way of reducing the use of heat energy to a minimum is considered as one of the crucial developments for reducing carbon dioxide emissions. In such buildings heat dissipation is not only reduced by improved insulation of walls and windows, but also by actively controlled and fan-driven air ventilation systems. Safety concerns arise based on the following first experiences made with fires in such buildings:

- Due to reduced heat losses the time to flashover seems to decrease.
- Smoke is distributed through the entire building in short time by the ventilation system interconnecting all rooms.
- Fires are more difficult to notice from outside because, due to multiple layer glazing, the fire is contained inside the building until a more developed stage. Hence, alerting of rescue units happens when there is less chance to rescue residents.

Fire fighters are faced with new challenges when confronting a building with attractive environmental or energy-savings features such as: roof gardens, photo-voltaic solar panels, lightweight structural members, extra (flammable) thermal insulation, and furnishings and finishings made exclusively of natural materials and non-halogenated polymers. If the fires in these buildings spread faster, produce unfamiliar smoke and other effluents, and more quickly loose structural integrity, fire fighters will need to find new ways to gain access safely, to sufficiently protect themselves in a more hazardous fire environment, and to work more quickly /9/.

A number of specific questions arise whether the newly marketed, environmentally friendly products fit to the high level of fire safety achieved in the industrialised countries today. For instance, fire safety issues must be carefully considered in the following cases to avoid problems:

- performance in fire of formwork construction where renewable materials (cork grit, sheep wool, paper flakes etc.) are used for heat insulation,
- fire resistance of multi-storey timber structures, remaining bearing capacity,
- failure of nail bonders in timber constructions,
- resistance of roofing made of renewable materials (e.g. reed) to external fires,

- emissions from renewable materials with flame retardant additives under smouldering and flaming fire conditions,
- fire behaviour of latent heat storage systems (so called PCM devices, smartboards etc.) in fire-resistant structures, e.g. influence on time to flashover inside the fire room,
- endangering of fire fighters by creepage currents of photovoltaic panels..

Fires in electric and alternative fuel vehicles, whether on the open road or in garages and car parks, also require special treatment by the fire department. High voltages (>700 VDC) and batteries that can explode in a fire are a threat to life if appropriate measures are not taken when approaching an all electric vehicle fire. Hydrogen in storage and during fuel transfer operations has a unique set of concerns for fire fighters, and even relatively benign alternative liquid fuels such as 85 % ethanol require special training and equipment to properly suppress in the event of a vehicle fire.

Fire safe solutions can be found through research and product development. The overall functionality of materials, products, and structures, including fire safety aspects, is of major importance and must be considered early in development phases. The fire behaviour of novel product and system design solutions can be evaluated by performance-based methods, as an alternative to prescriptive requirements.

## 3. FORUM Position

It is the FORUM's position that:

- construction of sustainable, energy efficient buildings, infrastructure and transportation systems is a worthwhile and necessary goal to address critical worldwide environmental and energy concerns;
- the safety of the public and the protection of property against losses due to fire should not, and need not, be compromised while pursing the goal of sustainable, energy efficient construction and infrastructure;

- fire safety consideration should form an unrenouncable part of any new product or technology developed to promote sustainable construction;
- acceptable solutions to acute fire safety concerns must not pose a threat to the long term health of workers, fire fighters or the general public; and
- a robust and extensive international research program on sustainable infrastructure materials, advanced fire protection technologies, the environmental and health impacts of fire and fire safety practices, and suitable economic metrics for assessing alternative approaches is prerequisite to attaining sustainable buildings, infrastructure and transportation systems..

Hence, a knowledge-based integrated approach is needed to assess pros and cons of the application of renewable infrastructure materials, sustainable construction technologies, and new energy technologies for buildings and transportation systems that preserve fire safety. FORUM members are committed to furthering this knowledge-based approach and documenting progress on collaborative and individual efforts to meet the increasing demand to lower the environmental impact and carbon footprint of constructed facilities while maintaining the fire safety and the health of building occupants, fire fighters, and the communities within which these structures and systems reside.

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