



# Meeting Sustainability Goals Without Sacrificing Fire Safety

## — A Delicate Balancing Act

By Tim Earl

Figure 1 – An example of a building-integrated photovoltaic (BIPV) system with solar shingles. Image courtesy of Tai Viinikka, Creative Commons.

### INTRODUCTION

The increased focus on sustainability in the built environment has led to the introduction of many new materials and construction practices into the marketplace. These situations may not be addressed in the building or fire code; or worse, they may be prohibited, leading some sustainability advocates to propose revisions to the codes.

While technological advancements can happen very quickly, the regulatory process is slow and methodical, based on research and statistics. New technologies and construction methods cannot be adequately assessed in a short period of time with little or no performance history. Advocates of these new systems are understandably enthusiastic about implementing them, and in their zeal may want to shorten the period between development of a new system and approval for use in the built environment.

This article will discuss how organizations can work towards achieving their sustainability goals without compromising fire safety.

### SUSTAINABILITY TECHNOLOGIES, THEIR IMPLEMENTATION, AND THEIR EFFECT ON FIRE SAFETY

#### Vegetative Roofs

Vegetative roofs have become popular for their pleasant aesthetics and the environmental benefits of increased plant life, even though a recent report concluded that, by reflecting more sunlight, “White roofs are three times more effective at countering climate change than green roofs.”<sup>1</sup>

ASTM E108, *Standard Test Methods for Fire Tests of Roof Coverings*, is the fire test required for all roofs in the International Code Council (ICC) codes. Based on the test results, roof materials or systems are classified as Class A, B, or C, with Class A being the highest level of fire performance.

Because ASTM E108 is not appropriate for vegetative roofs, the Single Ply Roofing Industry (SPRI) spearheaded the development of an American National Standards Institute (ANSI) standard governing external fire design for vegetative roofs, ANSI/SPRI VF-1, which was published in 2010. The general approach used by this standard is to design

in fire breaks for large roof areas, around rooftop equipment and penetrations, and next to adjacent walls. As such, it requires nonvegetative portions of the rooftop to be classified ASTM E108 Class A, and it mandates a minimum 6-ft.-wide Class A continuous border around rooftop structures. The standard claims that data support a Class A rating for succulent-based roof systems, but no such data are actually referenced.

FM Global publishes FM 4477, *Approval Standard for Vegetative Roof Systems*. This standard requires testing to ASTM E108 for combustibility from above the roof deck and heat release testing with the FM Global Fire Propagation Apparatus (FPA) for combustibility from below the roof deck.

ASTM Committee D08 on Roofing and Waterproofing maintains several standards related to vegetative roofs.

A search conducted for this work found no published news articles on a fire incident where a vegetative roof was involved. Given the increasing use of these systems, it is possible that such fires have occurred but were not widely reported, or that no

connection between the roof system and the fire was suspected or reported.

It is also notable that the stakeholders in the vegetative roofing and single-ply roofing industries worked together to develop proper fire safety requirements for vegetative roofs, and their adherence to these requirements helps minimize fire losses.

### Rooftop Photovoltaic Systems

The addition of photovoltaic modules (solar panels) to a roof structure affects fire safety in two ways:

- 1) Added material which may alter the level of safety assumed by the fire classification of the roof
- 2) Added electrical hazard for firefighters

Issue 1 was well addressed by proponents of photovoltaic (PV) systems from the very beginning. Rooftop arrays are divided into two categories: building-integrated photovoltaics (BIPVs) and rack-mounted systems. BIPVs, described as “modules or panels intended for installation integral with or forming a part of the building’s roof structure,” are tested in the same manner as any other roof covering, with the same requirements as those coverings (*Figure 1*).

Existing fire tests were adapted for rack-mounted PV systems, for both spread of flame on the top surface and burning brand ignition. These results are used to assign a classification for the entire system.

The second issue listed above came to light only after adoption. The key issue with PV systems and firefighter safety is the inability to completely de-energize the system. Standard firefighting procedures call for power to be disconnected, but this is not so simple with a PV system. As long as there is a source of light, the panels will continue to produce electricity. Even at night, there may still be power stored in batteries. It is important to note that, despite the vastly increased electrocution risk, there have been no reports of firefighter deaths by electrocution from a PV system to date in the U.S.

Most of the effort in protecting firefighters from electrical shock related to PV systems has focused on training. However, the codes do attempt to address the hazard in a limited fashion. Section 690 of the National Electrical Code (NEC) specifies wiring requirements for PV systems, which include labels stating “Photovoltaic Power Source” where appropriate. The 2012

International Fire Code (IFC) contains similar labeling requirements, but some of these have been removed in the 2015 edition, as the IFC already references the NEC.

In order to allow firefighters to ventilate a structure without inadvertently severing live PV power wiring, the IFC requires conduit for PV wiring to be run along the bottom of load-bearing members.

As a result of the electrocution hazard, the most common practice among fire departments today is to disengage when PV systems are present. An example of this occurred in Delanco, NJ, in September 2013, when the local fire chief refused to send firefighters onto the roof of a 300,000-sq.-ft. warehouse that was covered in over 7,000 solar panels. The structure was a complete loss, and the acting New Jersey State Fire Marshall stated after the incident that “We may very well not be able to save buildings that have alternative energy.”<sup>2</sup>

Partly as a result of this incident, in January 2014, the state of New Jersey passed a law to address firefighter safety when combatting fires involving rooftop PV systems. The law requires external shut-off mechanisms and the posting of an emblem identifying buildings containing or served by PV systems. It also requires that the specifications of the PV system be filed with the local fire department, so they have quick access to information regarding the system in an emergency.<sup>3</sup>

In summary, as far as rooftop PV systems are concerned, the codes have done an effective job of addressing the material flammability challenge, but much more work is needed to address firefighter safety. In the meantime, the presence of rooftop PVs creates a risk for the building owner, as it may have a detrimental effect on firefighter response.

This has recently become even more complicated with the proliferation of energy storage systems (ESSs). These are large bat-

tery systems, often installed in conjunction with PV systems (*Figure 2*). A large percentage of ESSs use lithium-ion batteries, which have been associated with many fires over the years. While most systems are located in garages, basements, or outdoors, there are provisions for installing them inside a residence, mostly to accommodate people who live in townhomes, do not have basements, or have strict homeowner association rules that do not permit outdoor installations.

The 2021 editions of the International Building Code (IBC), the IFC, and the International Residential Code (IRC) will regulate these systems, in large part by referencing a new UL standard, UL 9540, *Standard for Energy Storage Systems and Equipment*. Additional restrictions on location were added to the IRC to protect the occupants. For instance, they cannot be located in sleeping rooms or rooms that open into them (like bedroom closets), and the walls have to be finished with gypsum wallboard.



*Figure 2 – Typical ESS installed in residential garage. Image courtesy of GBH International.*

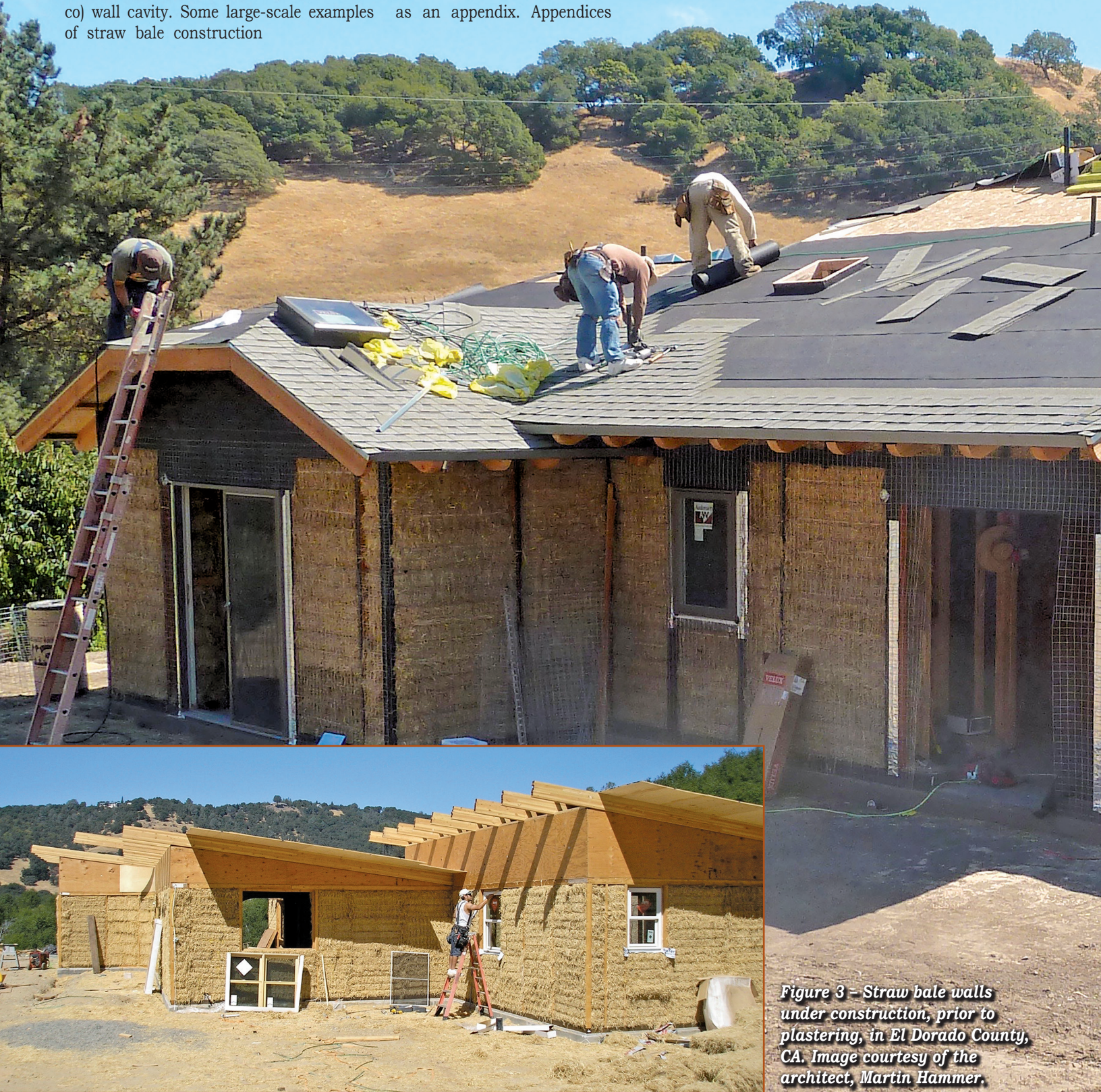
### Straw Bale Construction

Straw bale construction is another popular green construction technology. From an environmental perspective, it has several advantages, as the straw requires no further processing, traps carbon, and can often be sourced locally. It is simply baled, tightly compacted, and placed in a (usually stucco) wall cavity. Some large-scale examples of straw bale construction

include a hotel in Switzerland<sup>4</sup> and a luxury resort in South Africa.<sup>5</sup> (See *Figures 3-5*.)

The story of straw bale construction's introduction into the ICC codes is a mixed bag of good intentions and poor execution. A proposal was submitted to add a section on straw bale construction to the 2015 IRC. The proponents wisely drafted this new section as an appendix. Appendices

in the ICC codes contain mandatory provisions, but they are only implemented if the jurisdiction includes them when adopting the code. This allows each jurisdiction to decide whether they want to allow the construction type or system described in the appendix. With this in mind, many new materials are



*Figure 3 – Straw bale walls under construction, prior to plastering, in El Dorado County, CA. Image courtesy of the architect, Martin Hammer.*

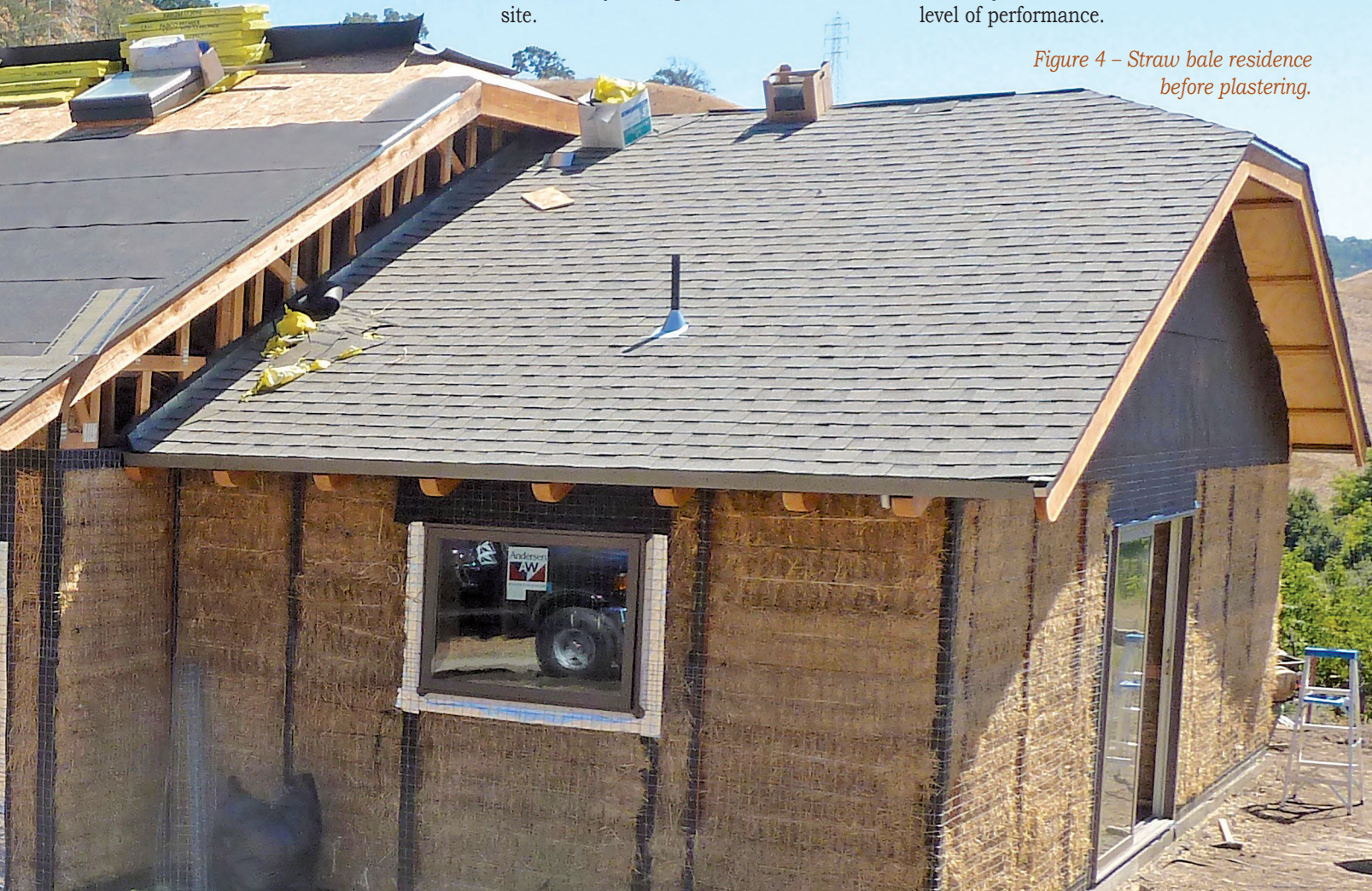
first introduced via an appendix, and then, after a few cycles have passed to establish a satisfactory safety record, a proposal is submitted to move them to the body of the code. This straw bale proposal was therefore an appropriate use of an appendix, and it was approved by the committee.

The appendix includes a section on fire safety, but it has some issues. It contains two sections describing how to construct walls and then states that walls constructed in accordance

with those sections shall be considered one-hour or two-hour fire-resistance-rated walls. In support of this proposal, the proponents provided one test report each for wall assemblies built in accordance with those sections. However, the straw bale walls described are essentially handmade on site, and without observing the entire process, there is no way for an authority having jurisdiction (AHJ) to verify whether the procedure was followed in its entirety. As opposed to a manufactured product, the fire test may not represent what is built on site.

In addition, the assemblies described in the appendix do not match the assemblies tested. The tested bales were of a higher density than required by the code. This oversight was corrected for the 2018 IRC, with the appendix revised to match the assemblies tested. However, this only occurred because a fire testing professional noticed the discrepancy and submitted a proposal. The proponents submitted, and the committee approved, language which assigned a fire resistance rating to an assembly which had not demonstrated that level of performance.

*Figure 4 – Straw bale residence before plastering.*



*Figure 5 – Completed residence in Martinez, CA, from Figure 4.*



## THE PERILS OF NOT CONSIDERING FIRE SAFETY

### Organic Valley Office Building Fire

On May 14, 2013, a fire occurred in the offices of Organic Valley, an organic dairy cooperative in Lafarge, IN (Figure 6).<sup>6</sup> The building had several “green” and “sustainable” features which contributed to the fire, including:

- Rooftop PV arrays
- Lightweight construction
- Natural fiber insulation



Figure 6 – PV panels burning on roof of Organic Valley Dairy headquarters, by WXOW News.

### Rooftop PV

The local fire department was aware of the PV arrays and made the decision not to put firefighters on the roof. Eventually, when the local utility company arrived, they discovered that the roof deck itself was energized through contact between the PV arrays and metal roof panels. Without firefighters on the roof, vertical ventilation was not attempted.

### Lightweight Construction

While lightweight construction is not entirely a green phenomenon, it has been embraced by sustainability advocates for its use of less lumber. Firefighters have been very vocal in their opposition to lightweight construction, as this type of construction has been associated with multiple cases of firefighter injuries and fatalities. In this case, the lightweight roof trusses did collapse. Due to the PV array, no firefighters were on the roof, but the collapsed trusses broke the attic sprinkler piping, which created a large demand on the water supply during firefighting efforts.

### Natural Fiber Insulation

The insulation used in the building was a nonwoven unfaced batt insulation consisting of post-industrial recycled denim and cotton fibers treated with a borate solution, with a published R-value of 3.94, similar to polystyrene board insulation. The manufacturer’s literature lists the flame spread index as 5 (to ASTM E84) and the smoke developed index as 35 (to UL 723). It is believed that the insulation contributed to the rapid vertical spread of the fire within the walls of the building.

The Organic Valley fire burned for nearly 18 hours and resulted in an estimated \$13 million in property damage and related losses. A reported 116 firefighters and emergency medical personnel responded from

10 different communities. The January/February issue of *NFPA Journal* called this “a cautionary tale in the use of ‘green’ or ‘sustainable’ construction materials and what they can mean to firefighting efforts.” Some in the green movement have questioned this assessment,<sup>7</sup> but only time will tell whether this is an isolated incident or a harbinger of things to come.

## CONCLUSIONS

When considering the effects of sustainability improvements on fire safety, the following factors must be considered.

### Don’t Overreach

It is impossible to predict all of the unintended consequences of any change in building design or codes. When introducing a new material or construction method into the code, consider starting with an appendix. Many current code provisions started as appendices. Committee members are generally more receptive to appendix proposals, to allow time to see how the code change works out in practice. Recent appendices for sustainability-related issues include straw bale construction and tiny houses.

### Look at the Existing Code Provisions and Their History

If your proposal requires a relaxation or elimination of an existing code requirement, committee members and safety advocates will question the need for that. All too often, proponents of change dismiss these concerns and try to declare existing provisions “outdated” and “unnecessary.” But it’s important to recognize that the code is generally reactionary, and that those provisions were likely added in response to serious incidents that involved injuries and/or fatalities. Learn the history of the sections

that conflict with your proposal and look for ways to retain current safety provisions.

### Identify New Hazards


Although it is impossible to foresee every conceivable situation that could arise with the use of a new technology, it is essential to make some effort to identify likely hazards that may be created. Rooftop photovoltaic systems provide an example of this. The inability to completely de-energize the system presents a serious life safety risk for first responders—one which should have been apparent to designers and building owners.

### Run (Standardized) Tests

Code change proposals must include a technical justification. If a new product or construction method can meet existing fire test requirements, actual fire test data should be provided. When a product fails existing tests, proponents may be tempted to develop alternative tests. These proposals will justifiably be met with much skepticism, especially if proposed new tests are ad hoc or “homemade” tests not published by a standards development organization (SDO) via a consensus process. This is not to say new tests may not be appropriate, because sometimes modifications may be needed. For instance, ASTM E84 (the Steiner Tunnel test) is outdated and not ideal for some modern materials. Manufacturers have helped develop mounting methods for some products which specify exactly how to test a certain material in the tunnel. Because these mounting methods are published as ASTM standards after approval by Committee E05 on Fire Standards, they are considered credible.

Green construction is becoming more and more prevalent in the United States. While there is nothing inherently unsafe about green construction, it presents many challenges—some old and some new—to fire safety. The proponents of green construction are, in many cases, not intimately familiar with the requirements that currently exist in building codes and the reasons for them. Fire safety is not the primary consideration in green construction, so the proper questions are not always asked by stakeholders. It could be said that in the U.S., fire safety is a victim of its own success, as decades of work have had a substantial impact on life safety and property protection. But with fewer large

fire incidents, many people are unaware of the work that goes into developing technologies that improve fire safety and writing them into building codes and regulations.

Green construction advocates must continue to engage with fire scientists and fire safety professionals to ensure that these new construction techniques do not adversely affect fire safety. 

## REFERENCES

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# Construction-Related Events Rescheduled Due to COVID-19

Photo Credit: © Can Stock Photo / feelartphoto

Scores of construction-related conventions, meetings, and conferences have been postponed or even canceled due to the worldwide novel coronavirus pandemic (COVID-19). These include, of course, the International Institute of Building Enclosure Consultants' (IIBEC's) 2020 Convention and Trade Show, which was to have occurred in March. By now, interested parties know that IIBEC convention papers will be presented virtually on June 12-14 (registrants can enjoy the content until July 15). IIBEC also relocated its 2020 Building Enclosure Symposium, which was to have taken place November 5-6 in Orlando, FL, to November 20-22 in Houston, TX. The newly scheduled event (dubbed BES+) will include many additional events that would have taken place at the March convention.

The 2020 International Conference on Building Envelope Systems and Technologies (ICBEST), cosponsored by IIBEC and the National Research Council of Canada (NRC), was still scheduled at this writing for Vancouver, BC, on August 31.

For rescheduled IIBEC educational classes and meetings, keep an eye on IIBEC's calendar at [iibec.org](http://iibec.org).

Other industry events of interest to IIBEC's readership are listed below.

The Roofing Day in D.C. 2020, sponsored by the National Roofing Contractors Association (NRCA), and historically participated in by many IIBEC members, has been canceled. It was

to have been held April 22. Roofing Day in D.C. 2021 will be held March 23-24, 2021.

The Canadian Roofing Contractors Association's (CRCA's) annual conference and annual general meeting, scheduled for May 1-3 in Edmonton, AB, have been canceled.

The Building Innovation Conference (BI2020) sponsored by the National Institute of Building Sciences (NIBS) has been rescheduled from April 6-9 to August 16-19 at the Renaissance Arlington Capital View Hotel in Arlington, VA. To learn more: [https://www.youtube.com/watch?time\\_continue=16&v=ijkYpE0Tzu0](https://www.youtube.com/watch?time_continue=16&v=ijkYpE0Tzu0).

The Facilities Management Conference (NFMT 2020), originally scheduled for Baltimore March 17-19, has been rescheduled to August 11-13 at the Baltimore Convention Center. See <https://www.nfmt.com/baltimore/>.

Associated Builders and Contractors Inc. (ABC) moved its March 23-27 convention to August 17-19 at the Music City Center in Nashville, TN. See <http://abcconvention.abc.org>.

BOMA 2020 Southern Regional Conference, put on by the Building Owners and Managers Association International (BOMA International), scheduled for April 2-4, 2020, in Orlando, FL, was canceled. Its Southwest Regional Conference, scheduled for April 16-18, 2020, in Oklahoma City, OK, has been canceled. Its Middle Atlantic Regional Conference for Albany, NY, scheduled for April 22-23, 2020, has been postponed. As of this writing, the 2020 BOMA International Annual Conference & Expo, scheduled for June 27-30, 2020, in Philadelphia, PA, was still on. Visit [https://www.boma.org/BOMA/Education-Events/BOMA/for\\_updates](https://www.boma.org/BOMA/Education-Events/BOMA/for_updates).

The Western Roofing Expo 2020, presented by the Western States Roofing Contractors Association (WSRCA), scheduled for June 7-9, 2020, in Las Vegas, NV, was still on as of this writing. See <https://westernroofingexpo.com>.

The 2020 Southeast Building Conference, scheduled for July 30-31, 2020, in Kissimmee, FL, was also still on hold. Visit [sebcshow.com](http://sebcshow.com) for updates.