

Chapter 2

Information Search

Various searches and inquiries have been undertaken by the project team with the aim to identify fire incident reports, news reports, fire investigation reports, and research reports related to fires in green buildings and fires involving green building elements. These include web-based searches using generic search platforms (e.g., Google), targeted searches supported by WPI library staff (e.g., LEXIS/NEXIS), and searches of research and academic institution holdings (e.g., NIST, NRCC, BRANZ, WPI, etc.). The searches by the project team were supplemented by searches conducted by NFPA Research staff, inquiries sent to the Technical Panel for this project, and inquiries sent to the FPRF Property Insurance Research Group which sponsored this project. In addition, targeted inquiries were made via the IRCC (a group of 14 building regulatory agencies in 12 countries, www.irccbldgbuildingregulations.org) and the Fire FORUM (an international group of fire research laboratory directors, <http://www.fireforum.org/>). Representative findings are provided below, with additional information in the appendices.

2.1 Representative Fire Incidents

In order to identify as many fire incidents involving green buildings and building elements as practicable, the project team reached out to several entities in the USA and internationally, including building regulatory agencies, fire service entities, insurance companies and research entities. The first stage involved web-based searches and requests via NFPA for fire incident data base searches. As a result of these searches a few dozen incidents were identified. A representative selection of incidents is presented in Table 2.1. While relatively small in number when compared to all fires, these incidents reflect a diverse set of fire and green building/element related issues, and helped form the basis of attributes identified and considered in Table 3.1 (Chap. 3) and Table 4.1 (Chap. 4).

Table 2.1 Representative fire incidents

Commercial photovoltaic panel fire	
383 kW roof PV system fire, Target Store, Bakersfield, CA, April 2009	http://nfpa.typepad.com/files/target-fire-report-09apr29.pdf (last accessed 10/21/12)
PV roof fire, France warehouse, January 2010	http://www.aria.developpement-durable.gouv.fr/ressources/fd_37736_valdreuil_jfm_en.pdf (last accessed 10/21/12)
Roof PV system in Goch, Germany, April 2012	http://www.feuerwehr-goeh.de/index.php?id=22&tx_ttnews%5D=596&cHash=982afcd5c431b7299f67de4af397cc43 (last accessed 10/21/12)
1,208 kW roof PV system, Mt. Holly, NC, April 2011	http://www.solarabcs.org/about/publications/meeting_presentations_minutes/2011/12/pdfs/Duke-Webinar-Dec2011.pdf (last accessed 10/21/12)
PV roof fire, Trenton, NJ, March 2012	http://blog.nj.com/centraljersey_impact/print.html?entry=/2012/03/trenton_firefighters_battle_ro.html (last accessed 10/21/12)
<i>Residential photovoltaic panel fire</i>	
PV Fire: Experience and Studies, UL, 2009	http://www.solarabcs.org/about/publications/meeting_presentations_minutes/2011/02/pdfs/Arc-PV_Fire_sm.pdf (last accessed 10/21/12)
PV fires, FPRF report, 2010	http://www.nfpa.org/assets/files/pdf/research/ffrtacticsolarpower.pdf (last accessed 10/21/12)
PV fire, San Diego, CA, April 2010	http://www.ntimes.com/article_8a32fb03-9e3f-58ca-b860-9c7fe1e28c7e.html (last accessed 10/21/12)
PV fire, Stittingbourne, UK, March 2012	http://www.kentonline.co.uk/kentonline/news/2012/march/30/solar_panels.aspx (last accessed 10/21/12)
<i>Battery storage and UPS fire</i>	
Battery fire, Data Center, Taiwan, February 2009	http://indico.cern.ch/getFile.py/access?sessionId=8&resId=1&materialId=0&confId=45473 (last accessed 10/21/12)
<i>Residential spray foam insulation fire</i>	
Foam insulation home fire, North Falmouth, MA, May 2008	http://www.capecodonline.com/apps/pbcs.dll/article?AID=/20080520/NEWS/805200318/-1/rss01 (last accessed 10/21/12)
	http://www.greenbuildingadvisor.com/blogs/dept/green-building-news/three-massachusetts-home-fires-linked-spray-foam-installation (last accessed 10/21/12)
Foam insulation, Woods Hole, MA, February 2011	http://www.capecodonline.com/apps/pbcs.dll/article?AID=/20110211/NEWS/102110323 (last accessed 10/21/12)

(continued)

Table 2.1 (continued)

Commercial photovoltaic panel fire	
Foam insulation fire, Quebec, May 2010	http://www.greenbuildingadvisor.com/blog/dept/green-building-news/nze-project-tragic-fire-and-will-rebuild (last accessed 10/21/12)
<i>Residential foil insulation, fire/shock hazards</i>	
Home insulation program (Australia)	http://www.climatechange.gov.au/government/initiatives/hisp/key-statistics.aspx (last accessed 10/21/12) http://www.productsafety.gov.au/content/index.phtml/itemId/974027/ (last accessed 10/21/12) http://www.wsws.org/articles/2010/feb2010/insu-f22.shtml (last accessed 10/21/12) http://www.theaustralian.com.au/news/garretts-roofing-fire-admission/story-e6frg6n6-1225829880090 (last accessed 10/21/12)
<i>Exterior finish and insulation systems fire</i>	
The Monte Carlo Exterior Façade Fire (2008)	http://usatoday30.usatoday.com/news/nation/2008-01-25-vegas-fire_N.htm (last accessed 10/21/12) http://magazine.sfpd.org/fire-investigation/monte-carlo-exterior-facade-fire (last accessed 10/21/12)
<i>Sandwich panels/structural integrated panel (SIP) with combustible foam insulation or coating</i>	
Borgata Casino, Atlantic City, NJ, Façade Fire (2007)	http://www.fireengineering.com/articles/2010/05/modern-building-materials-are-factors-in-atlantic-city-fires.html (last accessed 10/21/12)
Apartment Façade Fire, Busan, Korea	http://koreabridge.net/post/haeundae-highrise-fire-busan-marine-city-burns (last accessed 10/21/12)
Apartment Façade and Scaffold Fire, Shanghai, China	http://view.koreaherald.com/kh/view.php?ud=20101001000621&cpv=0 (last accessed 10/21/12) http://www.boston.com/bigpicture/2010/11/shanghai_apartment_fire.html (last accessed 10/21/12) http://www.bbc.co.uk/news/world-asia-pacific-11760467 (last accessed 10/21/12)
High-Rise Façade Fires, UAE	http://gulfnws.com/news/gulf/uae/emergencies/fire-breaks-out-at-sharjah-tower-1.1014750 (last accessed 10/21/12) http://www.emirates247.com/news/emirates/dh50-000-fine-for-fire-safety-violation-in-high-rises-2012-05-07-1.457534 (last accessed 10/21/12) http://article.wn.com/view/2012/05/02/Municipality_moves_to_ban_flammable_tiles/ (last accessed 10/21/12)
Façade Fire, Beijing, China	http://article.wn.com/view/2012/05/02/Tower_cladding_in_UAE_fuels_fire/ (last accessed 10/21/12) http://article.wn.com/view/2012/05/01/Experts_shed_light_on_how_fires_spread_in_towers/ (last accessed 10/21/12) http://www.nytimes.com/2009/02/10/world/asia/10beijing.html?_r=1 (last accessed 10/21/12)

2.2 Selected Resources Related to Fire and Green Building Concerns

In addition to identifying fire incidents, the project team was also interested in identifying fire-related concerns with green buildings and building elements. The starting point for this search was also web-based searches, considering general media, trade publications, peer review articles, and research reports. Much like the incident data, the number of publications/resources identified is somewhat low. This is in part due to challenges associated with web searches, limited responses to inquiries (see survey section), and general lack of efforts on fire and green building issues *defined as such*. This latter point is important, as some of the research identified by the project team has been attributed by the team as being related to green building issues, but might not have been by entities which conducted research that is cited (e.g., UL investigation into LEL and structural stability concerns, which was more closely identified as a fire fighter safety issue). This type of confounding representation likely means more research is available, but requires more effort to identify. Nonetheless, Table 2.2 contains a representation of the types of articles, reports and studies related to fire and green building concerns.

While details can be found via the links provided, selected incidents, test programs and mitigation approaches are summarized in Appendix B. In addition, the following resources provide significant discussion relative to the project focus, and are highly recommended as key sources of information on the topic of green buildings and fire:

- The BRANZ study, *Building Sustainability and Fire-Safety Design Interactions*, http://www.branz.co.nz/cms_show_download.php?id=716733515027fe4626188881f674635d51e3cfb0 (last accessed 10/21/12)
- The BRE study, *Impact of Fire on the Environment and Building Sustainability*, <http://www.communities.gov.uk/documents/planningandbuilding/pdf/1795639.pdf> (last accessed 10/21/12)
- The NASFM Green Buildings and Fire Safety Project (report and web links), <http://www.firemarshals.org/programs/greenbuildingsandfiresafetyprojects.html> (last accessed 10/21/12)

In addition, it is worth noting that two of the above studies, those by BRE and BRANZ, also address the contribution of fire protection measures to sustainability. While this effort did not consider this topic, it is an area that should be considered in the overall assessment of building fire safety and sustainability. In this regard, studies undertaken by FMGlobal contribute significantly in this area as well:

- *The Influence of Risk Factors on Sustainable Development*—<http://www.fmglob.al.com/assets/pdf/P09104a.pdf> (last accessed 10/21/12)
- *Environmental Impact of Fire Sprinklers*—<http://www.fmglobal.com/assets/pdf/P10062.pdf> (last accessed on 10/21/12—registration may be necessary)

Table 2.2 Fire safety concerns in green buildings: Selected resources

Overall concerns	
BRANZ—Building sustainability and fire-safety design interactions (2012)	http://www.branz.co.nz/cms_show_download.php?id=716733515027fe4626188881f674635d51e3cfb0 (last accessed 10/21/12)
BRE—Impact of fire on the environment and building sustainability (2010)	http://www.communities.gov.uk/documents/planningandbuilding/pdf/1795639.pdf (last accessed 10/21/12)
Green fire initiatives—Links to related studies, National Association of State Fire Marshals (2010)	http://www.firemarshals.org/greenbuilding/greenfireinitiatives.html#greenroofs (last accessed 10/21/12)
Bridging the gap: Fire safety and green buildings, NASFM 2010	http://firemarshals.org/greenbuilding/bridgingthegap.html (last accessed 10/21/12)
Fire safety green buildings, an IQP project by Joyce, Miller, Wamakima (WPI 2008)	http://www.wpi.edu/Pubs/E-project/Available/E-project-121908-111921/unrestricted/Final_IQP_Report.pdf (last accessed 10/21/12)
<i>Photovoltaic/energy systems</i>	
Fire operations for photovoltaic emergencies, CAL fire-office State fire Marshal, 2010	http://osfm.fire.ca.gov/fromthechief/pdf/sfmreportnov10.pdf (last accessed 10/21/12)
Fire fighter safety and emergency response for solar power systems	http://www.nfpa.org/assets/files/pdf/research/ffitacticssolarpower.pdf (last accessed 10/21/12)
Firefighter safety and photovoltaic installations research project, UL 2011	http://www.ul.com/global/documents/offers/industries/buildingmaterials/fireservice/PV-FF_SafetyFinalReport.pdf (last accessed 10/21/12)
The ground-fault protection blind spot: A safety concern for larger photovoltaic systems	http://www.solarabcs.org/about/publications/reports/blindspot/pdfs/BlindSpot.pdf (last accessed 10/21/12)
<i>Lightweight wood structures</i>	
Lightweight structure fire, NFPA	http://www.nfpa.org/publicJournalDetail.asp?categoryID=1857&itemID=43878&src=NFPAJournal&cookie%5Ftest=1 (last accessed 10/21/12)
Structural collapse under fire conditions, Toomey 2008	http://www.fireengineering.com/articles/print/volume-161/issue-5/departments/training-notebook/structural-collapse-under-fire-conditions.html (last accessed 10/21/12)
Improving fire safety by understanding the fire performance of engineered floor systems and providing the fire service with information for tactical decision making, UL 2012	http://www.ul.com/global/documents/offers/industries/buildingmaterials/fireservice/basementfires/2009_NIST_ARRA_Compilation_Report.pdf (last accessed 10/21/12)

(continued)

Table 2.2 (continued)

Overall concerns	
Structural collapse: the hidden dangers of residential fires (Dalton)	http://www.fireengineering.com/articles/print/volume-162/issue-10/features/structural-collapse.html (last accessed 10/21/12)
<i>Architectural</i>	
Fire safety concern on well-sealed green buildings with low OTTV's (Chow 2010)	http://docs.lib.purdue.edu/cgi/viewcontent.cgi?article=1000&context=ihpbc (last accessed 10/21/12)
A short note on fire safety for new architectural features (Chow 2004)	http://www.bse.polyu.edu.hk/researchCentre/Fire_Engineering/summary_of_output_journal/IJAS/V5p.1-4.pdf (last accessed 10/21/12)
<i>Architectural</i>	
Performance of double-skin façade	http://www.bse.polyu.edu.hk/researchCentre/Fire_Engineering/summary_of_output_journal/IJEPBFC/V6p.155-167.pdf (last accessed 10/21/12)
Window reflecting melting vinyl siding	http://www.greenbuildingadvisor.com/blogs/dept/musings/window-reflections-can-melt-vinyl-siding (last accessed 10/21/12)
<i>Fire hazards of foam insulation</i>	
Exterior walls, foam insulating materials, and property risk considerations (2007)	http://www.risklogic.com/articles/may2007.html (last accessed 10/21/12)
Panelized Construction problems	http://www.njeifs.com/lawyer-attorney-1513025.html (last accessed 10/21/12)
<i>Toxicity of flame retardants in foam insulation and other products</i>	
Brominated flame retardants and health concerns	http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1241790/ (last accessed 10/21/12)
PBDE flame retardants/potential adverse health effects	http://www.actabiomedica.it/data/2008/3_2008/costa.pdf (last accessed 10/21/12)
Toxicity of flame retardants and impact on fire fighters	http://www.nist.gov/el/fire_research/upload/4-Purser.pdf (last accessed 10/21/12)
<i>Industrialized roof farming</i>	
Rooftops take urban farming to the skies	http://today.msnbc.msn.com/id/32643514/ns/today-green/t/rooftops-take-urban-farming-skies (last accessed 10/21/12)
<i>Wind farm</i>	
Dark side of green wind turbine accidents	http://eastcountymagazine.org/print/9238 (last accessed 10/21/12)

It is recommended that future research into the interactions of fire protection and building sustainability include consideration of the potential benefits of fire protection to sustainability as well as the potential detriments of green construction to fire and life safety.

2.3 International Survey and Responses

In addition to the web-based searches, a number of targeted inquiries were sent out, including requests for information sent to the NFPA Research Division, the FPRF panel members and their organizations, member countries of the Inter-jurisdictional Regulatory Collaboration Committee (IRCC) and associated organizations in their countries (i.e., fire service, research or insurance entities to which they forwarded requests and/or provided contact information), and members of the International FORUM of Fire Research Directors (the FORUM). Response was reasonable (e.g., NFPA, several FPRF panel members and 8 of 14 IRCC members responded); however, data were limited, since in all cases it was reported that data specific to fire in green buildings is not being tracked, as this criterion is not including in existing fire incident reporting systems (including NFIRS in the USA). That challenge aside, some data on fires involving green building elements was provided, such as by the New South Wales Fire Brigade (Australia) as reflected in Table 2.3 (see Appendix C for complete survey responses).

2.4 Review of Representative Green Building Rating Schemes for Fire Considerations

The problem statement for this project noted the proliferation of rating schemes for green buildings and the development of green building and construction codes which promote the use of green materials and systems, but which perhaps do not consider fire safety concerns, and that “a systematic method needs to be developed for implementation in the certification process that integrates the consideration of fire as well as other hazard risk factors as part of design performance metrics.” In order to make progress on this, not only is it required to understand what constitutes green buildings and elements, and what fire hazards or risks they might pose, it is important to understand in which areas the existing rating schemes and codes might be imposing unintended fire safety consequences.

The information search revealed that globally there more than two dozen green building rating schemes available (e.g., see http://www.gsa.gov/graphics/ogp/sustainable_bldg_rating_systems.pdf, last accessed on 10/29/12). In addition, several systems have multiple schemes by building use, such as retail, school, residential, office, etc., and some include separate schemes for new and existing buildings. Likewise, there are a number of green building codes world-wide, including the

Table 2.3 Survey responses from New South Wales fire brigade

Country/entity	Fire Incident experience/tracking in green buildings	Fire Incident experience/tracking Involving green building elements	Risk-based assessment of green building elements
<i>Australia</i>			
New South Wales Fire Brigade	<p>The structures that subscribe to the National Built Environment Rating System (NABERS) are usually commercial or government buildings. In most cases they are relatively new and range from modern high rise premises in the city (e.g., No. 1 Bligh St.) to restored and renovated federation style buildings (e.g., 39 Hunter St.)</p> <p>The building codes also provide for prescribed or engineered fire safety solutions. There are no specific AIRS codes for “Green” buildings therefore it is very difficult to determine if there have been any fires or dominant fire causes in these buildings</p>	<p><i>Ceiling Insulation:</i> FIRU have experienced major concerns with this issue particularly in residential, nursing homes and aged care facilities. Cellulose fibre insulation in close proximity to down lights and insulation batts including non-compliance with electrical wiring rules have been the dominant concerns. AIRS analysis for insulation fires 29/02/2008 to 22/06/2011. Data provided by SIS: The data includes 102 incidents that occurred in metropolitan, regional and country areas. Of these incidents 75 were directly related to down lights and their associated transformers in close proximity to ceiling insulation. Some of the fires resulted in substantial property damage. <i>Insulated Sandwich Panels:</i> No specific AIRS codes for Insulated Sandwich Panels. FIRU have reports of residential structures constructed of insulated sandwich panels in locations ranging from Broken Hill to Thredbo. <i>Laminated Timber I-Beams:</i> No specific AIRS codes for Laminated Timber I-Beams. A combination of open plan living and modern furnishings (e.g. polyurethane foam seattees, etc.) can create fuel packages that will reach temperatures of 1,000–1,200 °C that can rapidly weaken structural elements. <i>Photovoltaic Solar Installations:</i> No specific AIRS codes for PV solar installations. It is estimated that NSW has about 150,000 PV solar installations. Predominant causes include faulty components and incorrect installation. (2010 to August 2012 = nine reported incidents) FIRU research indicates major problems with PV solar installations. No remote solar isolation switching, no DC rest device for Firefighters and no 24/7 availability of qualified PV solar electricians. This has been reflected in reports from around Australia, Germany and the US. From FIRU research it appears that major fire services throughout Australasia, United Kingdom, Germany and the United States have experienced concerns with “Green” building elements. When attending fire calls operational Firefighters are unable to readily determine if it is a “Green” building or one with “Green” building elements</p>	<p>FRNSW has a Risk Based Approach for all incidents, including all types of structures. This is supported by a broad range of Standard Operational Guidelines (SOGs), Safety Bulletins and Operations Bulletins. No specific effort related to green buildings</p>

IgCC, the Code for Sustainable Homes in England (http://www.planningportal.gov.uk/uploads/code_for_sust_homes.pdf, last accessed on 10/29/12) and others.

Only a small subset of the available green rating systems was able to be reviewed within the bounds and scope of this project. The sample of green rating schemes selected for this project was determined based on freely available information. The sample ultimately included LEED (residential and retail), BREEAM (new buildings), GREEN MARK (residential and nonresidential), and the IgCC. More discussion on the review and findings relative to these schemes can be found in [Chap. 5](#) and Appendix G.

Review of this sample of green building rating schemes and the IgCC indicated that fire safety objectives are not explicitly considered in these systems. This is not unexpected, however, since the focus is principally on resource efficiency (e.g., energy, water, materials) and not on safety. In the case of BREEAM, a study by BRE (BRE BD2709 2010, p 45) notes that “fire safety and fire protection are not included in most BREEAM schemes since most BREEAM schemes assess new buildings and the BREEAM assessment takes for granted that the building will satisfy the Building Regulations; the BREEAM assessment relates to *additional* sustainability features.”

Although no specific references regarding fire safety objectives were identified in LEED and GREEN MARK documentation, it is hypothesized that similar rationale applies as with BREEAM. With a voluntary system, which aims to encourage sustainable practices, it is anticipated that basic building code requirements, including fire safety, are met via code compliance. This is also the case with the IgCC, which is intended to work along with the International Building Code (IBC) and relevant codes and standards. If one then assumed that the risks or hazards associated with green building elements and features are addressed adequately by building codes and standards, one could assume that no additional risk or hazards exist. However, it can be that current fire tests, which have been determined as adequate for conventional construction, may not yet be fully vetted for innovative and green construction with respect to performance in use (e.g., LEL). Further study is recommended in this area.

Although none of the green building rating schemes that were reviewed during this project included fire safety objectives, it was found that the scheme of the German Sustainable Building Council (DGNB) includes criteria for fire prevention (<http://www.dgnb-system.de/dgnb-system/en/system/criteria/>, accessed last on 10/29/12). Although detail on the weights of fire prevention attributes relative to the green attributes was not able to be verified it is understood that some credit is given for fire protection features such as smoke extract, automatic sprinklers, and structural fire protection.

Likewise, it was determined that BREEAM-in-USE (<http://www.breeam.org/page.jsp?id=373>, last accessed on 10/29/12), a recent BRE scheme to help building managers reduce the running costs and improve the environmental performance of existing buildings, incorporates fire risk reduction attributes (BRE 2010). The fire risk reduction attributes related to such issues as whether a fire risk assessment has been conducted, are emergency plans in place, and so forth. No indication of consideration of fire protection systems was identified.

Fire Safety Challenges of Green Buildings

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