Fire Safety Challenges of Green Buildings

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Overview

- Research problem aims and objectives
- Potential fire concerns with green buildings
- Overview of information search
- Categorization of green elements and attributes and potential fire concerns
- Presentation of relative risk/hazard/concern
- Fire and green rating schemes
- Conclusions and recommendations

Aims and Objectives

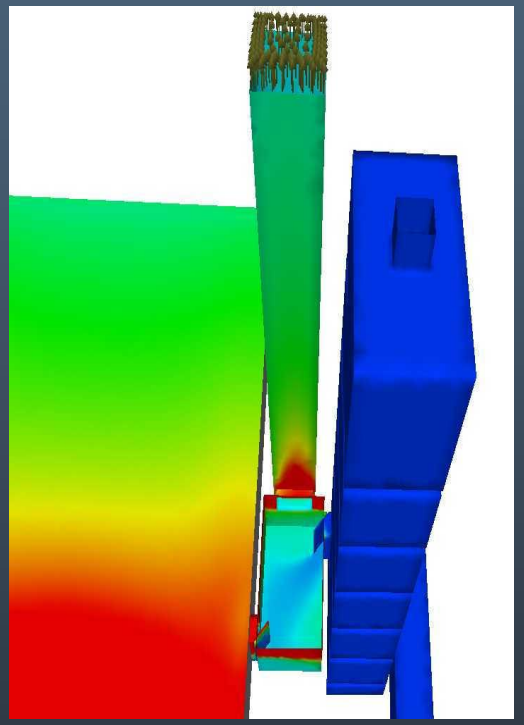
- Green buildings are a global focus. Several green building rating schemes and green building codes exist; however, the extent to which fire safety considerations are addressed within theses systems, and whether potential fire hazards may be created by green building elements and features, has not been systematically studied.

Aims and Objectives

- Identify documented fire incidents in the built inventory of green buildings,
- Define a specific set of elements in green building design, including configuration and materials, which, without mitigating strategies, increase fire risk, decrease safety or decrease building performance in comparison with conventional construction,

Aims and Objectives

- Identify and summarize existing best practice case studies in which the risk introduced by specific green building design elements has been explicitly addressed,
- Compile research studies related to incorporating building safety, life safety and fire safety as an explicit element in green building indices, identifying gaps and specific needed research areas.



http://projects.bre.co.uk/frsdiv/smokeshafts/

Approach

- Global information search – web & surveys
  - Incidents, research studies, best practice case studies, related efforts
- Identify green building elements / attributes
- Identify risk / hazard / performance factors
- Consider how fire addressed in green building rating schemes
- Present ways to communicate concerns

Incidents

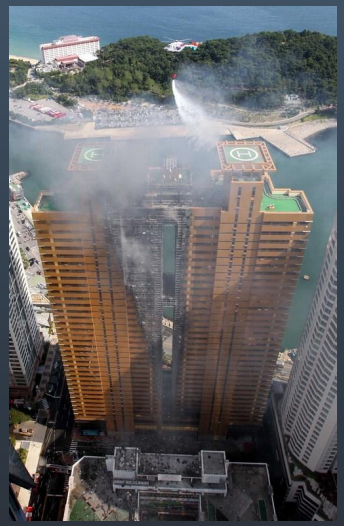
Table 1. Representative Fire Incidents	
Commercial Photovoltaic Panel Fire	
383 kW roof PV system fire, Target Store, Bakersfield, CA, April 2009	http://nfpa.typepad.com/files/target-fire-report-09apr29.pdf (last accessed 10/21/12)
PV roof fire, France warehouse, January 2010	http://www.aria.developpement-durable.gouv.fr/ressources/fd_37736_valdereuil_jfm_en.pdf (last accessed 10/21/12)
Roof PV system in Goch, Germany, April 2012.	http://www.feuerwehr-goch.de/index.php?id=22&tx_ttnews%5Btt_news%5D=596&cHash=982afcd5c431b7299f67de4af397cc43 (last accessed 10/21/12)
1,208kW 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)
	http://www.nj.com/mercer/index.ssf/2012/03/solar_panels_source_of_fire_at.html (last accessed 10/21/12)
Residential Photovoltaic Panel Fire	
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/fftacticssolarpower.pdf (last accessed 10/21/12)
PV fire, San Diego, CA, April 2010	http://www.nctimes.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)
Battery Storage and UPS Fire	
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)

https://solarjuice.com/blog/buildings-and-pv/solar-panels-and-fire/

http://www.coffscoastadvocate.com.au/news/warning-solar-panel-owners/1256986/

Incidents

http://www.greenbuildingadvisor.com/blogs/dept/green-building-news/three-massachusetts-home-fires-linked-spray-foam-installation

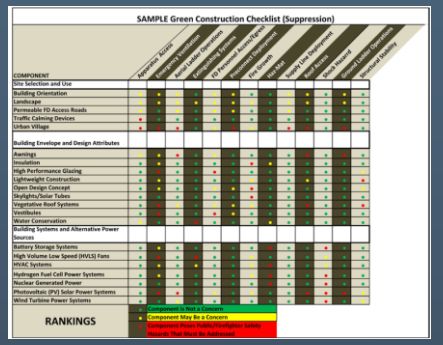


http://koreabridge.net/post/haeundae-highrise-fire-busan-marine-city-burns

Table 1. Representative Fire Incidents	
Residential Spray Foam Insulation Fire	
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)
Foam insulation fire, Quebec, May 2010	http://www.greenbuildingadvisor.com/blogs/dept/green-building-news/nze-project-tragic-fire-and-will-rebuild (last accessed 10/21/12)
Residential Foil Insulation, Fire / Shock Hazards	
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)
Sandwich Panels / Structural Integrated Panel (SIP) with Combustible Foam Insulation or Coating	
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)
	http://view.koreaherald.com/kh/view.php?ud=20101001000621&cpv=0 (last accessed 10/21/12)
Apartment Façade and Scaffold Fire, Shaghai, China	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://gulfnews.com/news/gulf/uae/emergencies/fire-breaks-out-at-sharjah-tower-1.1014750 (last accessed 10/21/12)
	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)

Research Studies

Table 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)
Bridging the Gap: Fire Safety and Green Buildings, NASFM 2010	http://firemarshals.org/greenbuilding/bridgingthegap.html (last accessed 10/21/12)
Photovoltaic / Energy systems	
Fire Fighter Safety and Emergency Response for Solar Power Systems	http://www.nfpa.org/assets/files/pdf/research/fftacticssolarpower.pdf (last accessed 10/21/12)
Firefighter Safety and Photovoltaic Installations Research Project, UL 2011	http://www.ul.com/global/documents/offerings/industries/buildingmaterials/fireservice/PV-FF_SafetyFinalReport.pdf (last accessed 10/21/12)
Lightweight Wood Structures	
Lightweight structure fire, NFPA	http://www.nfpa.org/publicJournalDetail.asp?categoryID=1857&itemID=43878&src=NFPAJournal&cookie%5Ftest=1 (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/offerings/industries/buildingmaterials/fireservice/basementfires/2009 NIST ARRA Compilation Report.pdf (last accessed 10/21/12)
Architectural	
Performance of double-skin façade	http://www.bse.polyu.edu.hk/researchCentre/Fire_Engineering/summary_of_output/journal/IJEPBFC/V6/p.155-167.pdf (last accessed 10/21/12)
Fire Hazards of Foam Insulation	
Toxicity of Flame Retardants in Foam Insulation and Other Products	
Brominated flame retardants and health concerns	http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1241790/ (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)



http://firemarshals.org/greenbuilding/bridgingthegap.html

http://www.ul.com/global/eng/pages/offerings/industries/buildingmaterials/fire/fireservice/lightweight/

Possible Concerns

- Green / Sustainability Objectives
  - Limit impact on environment
    - Limit impact to environment due to toxic releases into air, water and soil
    - Lower overall carbon emissions
    - Slow pace of climate change
    - Better utilize natural resources
  - Promote new technologies, materials and methods to facilitate the above

Possible Concerns

- Green / sustainability objectives are driving changes in building design and technology
  - New façade material, façade with louvers for shading, double-wall façade for HVAC, …
  - New insulation materials, construction, …
  - Green roofs, green interior spaces, …
  - Photovoltaic panels, wind turbines, cogeneration, hydrogen fuel cells, …
  - More natural lighting, natural ventilation, …

Competing Objectives?

- Material properties
  - High thermal insulation vs. flammability
    - New materials as interior lining, façade, insulation, within sandwich panel and more – increased fuel load, distribution, flame spread, smoke spread…
    - High thermal insulation vs. effect on compartment temperatures in a fire

http://koreabridge.net/post/haeundae-highrise-fire-busan-marine-city-burns

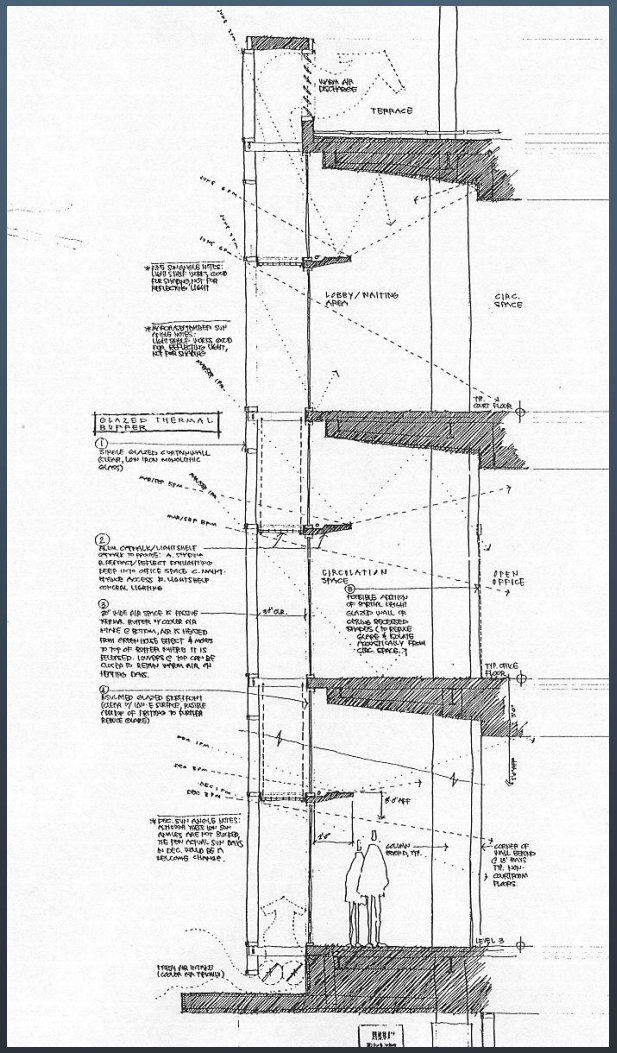
http://www.greenbuildingadvisor.com/blogs/dept/green-building-news/three-massachusetts-home-fires-linked-spray-foam-installation

Competing Objectives?

Seattle Justice Center

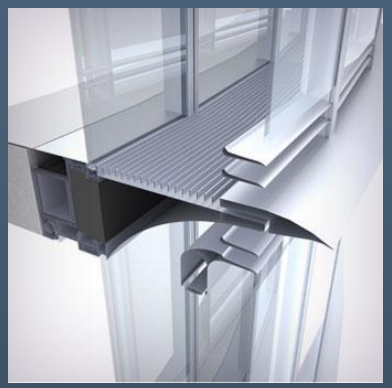
Naturally vented double skin façade, composed of two separate planes of glass separated by a 76 cm (30-inch) air space

http://gaia.lbl.gov/hpbf/design_g4.htm



Competing Objectives?

- Natural ventilation vs. smoke management
  - 1 Bligh Street, Sydney



https://www.asme.org/kb/news---articles/articles/energy-efficiency/down-under-a-highly-sustainable-high-rise

Competing Objectives?

- Material properties
  - Toxicity (IAQ) vs. fire retardant qualities
    - Chemical additives in foam insulation and other materials – toxicity under fire and non-fire conditions?
      - Polystyrene foam insulation used in building insulation (both XPS, such as Styrofoam, and EPS) is treated with hexabromocyclododecane, (HBCD), a persistent, bioaccumulating, and toxic fire retardant

http://www.hoffmaninsulation.com/Products.html

http://www.noburn.com/intumescent-paints-fire-retardant-coatings

Competing Objectives?

- Reduced and/or natural material vs. reduced strength or fire protection
  - Lightweight engineered lumber
  - High strength concrete
  - Combustible interior finishes

http://www.ul.com/global/eng/pages/offerings/industries/buildingmaterials/fire/fireservice/lightweight/

Courtesy MSU

http://www.nhit-shis.org/bamboo-wall-interior-design-by-kengo-kuma-associates/02-great-bamboo-wall-interior-design/

Competing Objectives?

- Green exterior vs. fuel load and FF access

http://inhabitat.com/flower-tower-380-potted-plants-line-parisian-apartment-facade/

Competing Objectives?

- Green exterior / interiors vs. fuel load

http://directory.leadmaverick.com/Southern-Botanical-Inc/DallasFort-WorthArlington/TX/10/15993/index.aspx

Competing Objectives?

- Green / alternate energy roof vs. fire fighter access

Competing Objectives?

- PV panels on roof vs. fire hazard

https://solarjuice.com/blog/buildings-and-pv/solar-panels-and-fire/

http://www.feuerwehr-goch.de/index.php?id=22&tx_ttnews%5Btt_news%5D=596&cHash=982afcd5c431b7299f67de4af397cc43

http://www.youtube.com/watch?v=4aDrmtur6fw

Green Elements / Attributes

Structural Materials and Systems	Interior Materials and Finishes	Alternative Energy Systems	Interior Space Attributes
- Lightweight engineered lumber	- FRP walls / finishes	- PV roof panels	- Tighter construction
- Lightweight concrete	- Bio-polymer wall / finishes	- Oil-filled PV panels	- Higher insulation values
- Fiber reinforced polymer (FRP) elements	- Bamboo walls / finishes	- Wind turbines	- More enclosed spaces
- Plastic lumber	- Wood panel walls / finishes	- Hydrogen fuel cells	- More open space (horizontal)
- Bio-polymer lumber	- Bio-filtration walls	- Battery storage systems	- More open space (vertical)
- Bamboo	- Glass walls	- Cogeneration systems	- Interior vegetation
- Phase-change materials	- FRP flooring	- Wood pellet systems	- Skylights
- Nano materials	- Bio-polymer flooring	- Electric vehicle charging station	- Solar tubes
- Extended solar roof panels	- Bamboo flooring	- Tankless water heaters	- Increased acoustic insulation
Exterior Materials and Systems	**Building Systems & Issues**	**Site Issues**	**Façade Attributes**
- Structural integrated panel (SIP)	- Natural ventilation	- Permeable concrete systems	- Area of glazing
- Exterior insulation & finish (EFIS)	- High volume low speed fans	- Permeable asphalt paving	- Area of combustible material
- Rigid foam insulation	- Refrigerant materials	- Use of pavers	- Awnings
- Spray-applied foam insulation	- Grey-water for suppression	- Extent (area) of lawn	- Exterior vegetative covering
- Foil insulation systems	- Rain-water for suppression	- Water catchment / features	
- High-performance glazing	- On-site water treatment	- Vegetation for shading	
- Low-emissivity & reflective coating	- On-site waste treatment	- Building orientation	
- Double-skin façade / cavity walls	- On-site cogeneration	- Increased building density	
- Bamboo, other cellulosic	- High reliance on natural lighting	- Localized energy production	
- Bio-polymers, FRPs	- PV exit lighting	- Localized water treatment	
- Vegetative roof systems	- Reduced water suppression systems	- Localized waste treatment	
- PVC rainwater catchment		- Reduced water supply	
- Exterior cable / cable trays		- Hydrogen infrastructure	
		- Community charging stations	

Fire Risk / Hazards

Poses potential ignition hazard
Poses potential shock hazard
Poses potential explosion hazard
Poses potential toxicity hazard
Readily ignitable
Burns readily once ignited
Contributes more fuel / increased heat release rate (HRR)
Material affects burning characteristics
Fast(er) fire growth rate
Significant smoke production/hazard
Potential for shorter time to failure
Failure affects burning characteristics
Failure presents smoke spread concern
Failure presents flame spread concern
Material presents flame spread concern
May impact smoke/heat venting
May impact occupant evacuation
May impact fire-fighter (FF) water availability
May impact suppression effectiveness
May impact fire apparatus access
May impact fire-fighter (FF) access and operations
May impact containment of runoff

Green Element / Hazard Matrix

	Poses potential ignition hazard	Poses potential shock hazard	Potential explosion hazard	Poses potential toxicity hazard	Readily ignitable	Burns readily once ignited	Contributes more fuel / increased HRR	Material affects burning characteristics	Fast(er) fire growth rate	Significant smoke production/hazard	Potential for shorter time to failure	Failure affects burning characteristics	Failure presents stability concern	Failure presents smoke spread concern	Failure presents flame spread concern	Material presents flame spread concern	May impact smoke/heat venting	May impact occupant evacuation	May impact FF water availability	May impact suppression effectiveness	May impact fire apparatus access	May impact FF access and operations	May impact containment of runoff
Exterior Materials and Systems																							
- Structural integrated panel (SIP)																							
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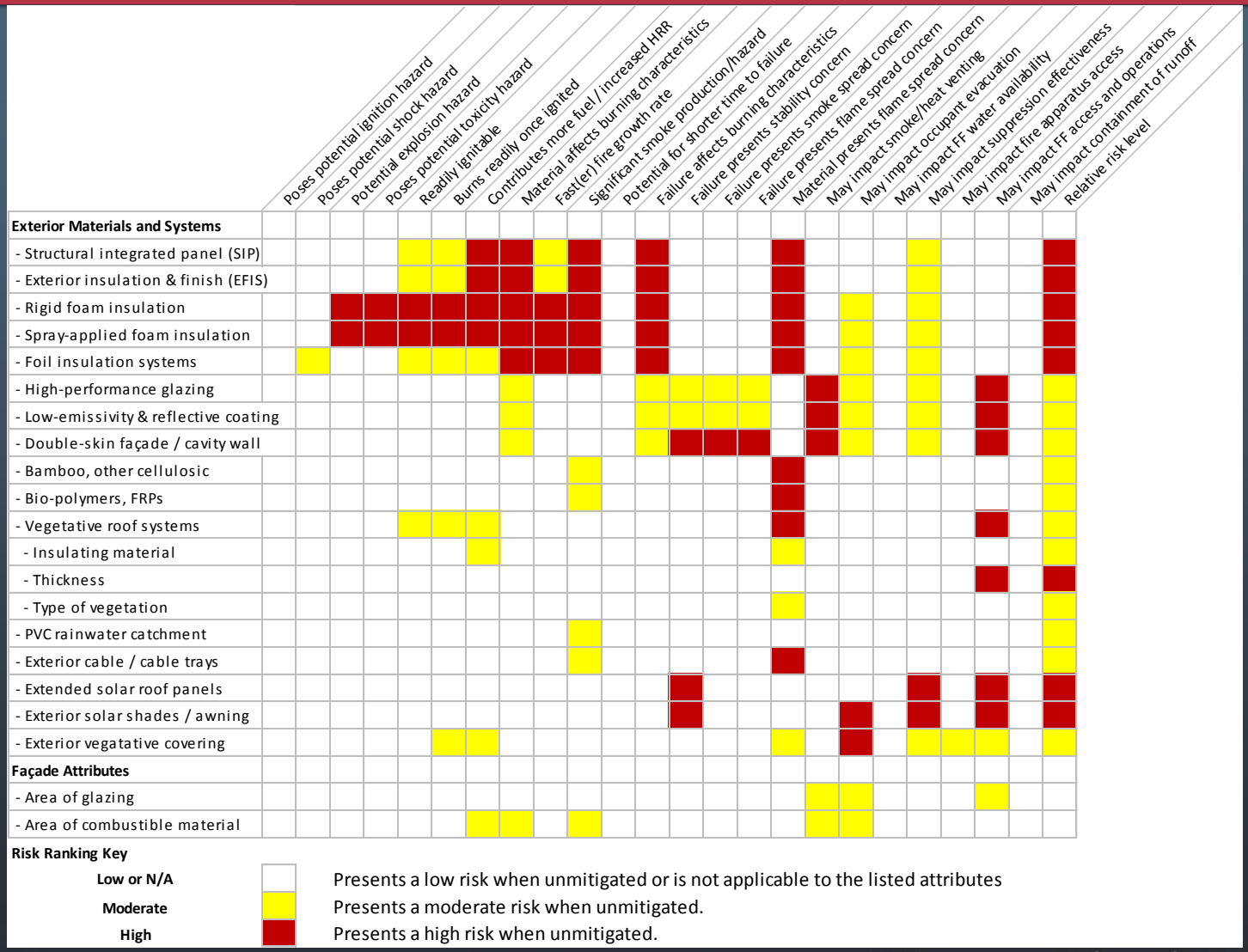
- Double-skin façade / cavity wall																							
- Bamboo, other cellulosic																							
- Bio-polymers, FRPs																							
- Vegetative roof systems																							
- Insulating material																							
- Thickness																							
- Type of vegetation																							
- PVC rainwater catchment																							
- Exterior cable / cable trays																							
- Extended solar roof panels																							
- Awnings / exterior solar shades																							
- Exterior vegetative covering																							
Façade Attributes																							
- Area of glazing																							
- Area of combustible material																							

Green Element / Hazard Matrix



Element/Concern/Mitigation

Material / System / Attribute	Hazard	Concern Level	Potential Mitigation Stratgies
Exterior Materials and Systems			
- Structural integrated panel (SIP)	If fail, insulation can contribute to flame spread, smoke production and fuel load.	High	Approved / listed materials. Assure proper sealing of panels. Take care during installation, including retrofits, relative to potential sources of ignition.
- Exterior insulation & finish (EFIS)	If fail, insulation can contribute to flame spread, smoke production and fuel load.	High	Approved / listed materials. Assure proper sealing of panels. Take care during installation, including retrofits, relative to potential sources of ignition.
- Rigid foam insulation	Can contribute to flame spread, smoke and toxic product development and fuel load.	High	Fire resistive barrier (e.g., fire rated gypsum). Approved / listed materials. Flame retardants. Sprinklers.
- Spray-applied foam insulation	Can contribute to flame spread, smoke and toxic product development and fuel load.	High	Fire resistive barrier (e.g., fire rated gypsum). Approved / listed materials. Flame retardants. Sprinklers.
- Foil insulation systems	Can contribute to shock hazard for installers. Can contribute to flame spread and fuel load.	High	Fire resistive barrier (e.g., fire rated gypsum). Approved / listed materials. Sprinklers.
- High-performance glazing	Can change thermal characteristics of compartment for burning. Can impact FF access.	Moderate	Sprinklers. Assure adequate FD access. Assure mechanism for FD smoke/heat venting. Approved / listed materials.
- Low-emissivity & reflective coating	Can change thermal characteristics of compartment for burning. Can impact FF access.	Moderate	Sprinklers. Assure adequate FD access. Assure mechanism for FD smoke/heat venting. Approved / listed materials.
- Double-skin façade	Can change thermal characteristics of compartment for burning. Can impact FF access. Can present 'chimney' for vertical smoke and flame spread if not properly fire stopped.	Moderate	Appropriate fire stop between floors. Sprinklers may have some benefit (sprinklered building). Assure mechanism for FD smoke/heat venting. Approved / listed materials.
- Bamboo, other cellulosic	Can contribute to flame spread, smoke development and fuel load.	Moderate	Approved / listed materials. Flame retardant treatments. Sprinklers.
- Bio-polymers, FRPs	Can contribute to flame spread, smoke development and fuel load.	Low	Approved / listed materials. Flame retardant treatments. Sprinklers.
- Vegetative roof systems	Can contribute to fire load, spread of fire, impact FF operations, impact smoke and heat venting, contribute to stability issues.	Moderate	Manage fire risk of vegetation. Assure use of fire tested components. Provide adequate area for FD acces, smoke/heat venting, and other operations.Approved / listed materials.
- PVC rainwater catchment	Can contribute additional fuel load.	Low	Limit volume.
- Exterior cable / cable trays	Can contribute additional fuel load.	Low	Limit volume.Approved / listed materials.
Façade Attributes			
- Area of glazing	Can present more opportunity for breakage and subsequent fire spread and/or barrier to FF access depending on type.	Moderate	
- Area of combustible material	Larger area (volume) provides increased fuel load.	High	Limit volume.
- Awnings	Impacts FF access.	Low	
- Exterior vegetative covering	Can impact FF access and present WUI issue.	Low	Limit volume.

Review of Rating Schemes

- More than 2 dozen schemes and codes available world-wide
  - Primarily voluntary
- Looked at subset
  - LEED (homes, retail)
  - BREEAM (new buildings)
  - GREEN MARK (residential, non-residential)
  - IgCC

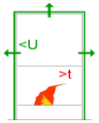
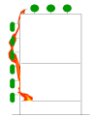
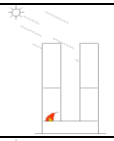
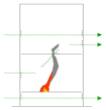
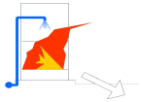
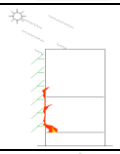
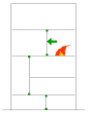
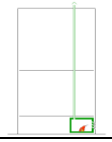
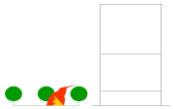
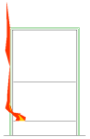
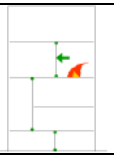
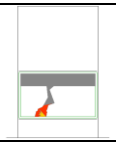
Review of Rating Schemes

- Do green building rating schemes include fire safety objectives?
- Are there benefits for green points which could result in fire concern?
- How best to illustrate outcomes for a wide ranging audience?

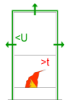
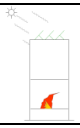
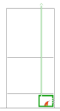
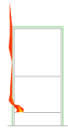
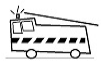
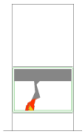
Review of Rating Schemes

- None of the schemes or IgCC were found to have explicit fire safety objectives
  - Schemes voluntary: assume fire safety addressed by mandatory code requirements
- Two schemes with some fire objectives
  - Fire protection benefit in German Sustainable Building Council (DGNB) (http://www.dgnb-system.de/dgnb-system/en/system/criteria/)
  - Fire risk reduction attributes in BREEAM-in-USE (http://www.breeam.org/page.jsp?id=373)

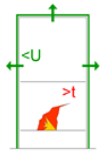
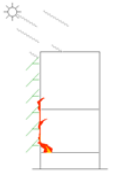
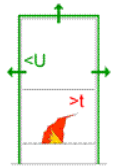
Schematic Representation

	Schematic Depiction of Interaction	Hazard Description		Schematic Depiction of Interaction	Hazard Description
1		Insulation increases interior temperature	8		The use of greenery systems on the envelope invades the surface with combustible material (dry and local species required)
2		Natural lighting and ventilation requires a non-compact building form	9		Natural ventilation requires connecting the exterior with the interior building parts
3		Renewable energy systems require invading part of the building envelope	10		Water consumption reduction influences the election of fire suppression systems
4		Daylight control devices require invading part of the building envelope	11		Noise reduction strategies require the use of non-rigid (elastic) joints
5		Disposal of rooms for waste or recyclable materials increases fire loads	12		Vegetation protection and use of greenery to reduce heat island effect influence the building surroundings conditions (may affect fire conditions)
6		Specific facade materials and systems reduce the election for optimal performance and may affect fire conditions	13		Structural materials prone to quicker failure.
7		Specific interior materials and systems reduce the election for optimal performance and may affect fire conditions	14		Adds additional fuel load to building

Schematic Representation

	Schematic Depiction of Interaction	Hazard Description	Primary Issues Associated with Fire Interaction with Green Elements					
			Interior Spread	Exterior Spread	Evacuation	FP Systems	Fire Service	Structure
1		Insulation increases interior temperature						
2		Natural lighting and ventilation requires a non-compact building form						
3		Renewable energy systems require invading part of the building envelope						
4		Daylight control devices require invading part of the building envelope						
5		Disposal of rooms for waste or recyclable materials increases fire loads						
6		Specific facade materials and systems reduce the election for optimal performance and may affect fire conditions						
7		Specific interior materials and systems reduce the election for optimal performance and may affect fire conditions						

Review of Rating Schemes

Categories / Chapter	Section / Assessment Issues	Aims	Credits / Scores	Requirements / Criteria	Procedures	Fire Hazard Primary (P) & Secondary (S)	Summary
Energy Efficiency (116 p. max.)	NRB 1-1 Thermal performance of Building Envelope- ETTV Enhance the overall thermal performance of the building envelope to minimize heat gain thus reducing the overall cooling load requirement		12	Maximum ETTV = 50 W/m2	Increase envelope insulation	(P) Increasing insulation (diminishing ETTV value) will increase interior temperature under fire (S) Can affect compartmentalization, the structure time resistance or evacuation	
				Use sun control devices		(P) May influence fire exterior spread (S) May disturb fire brigade intervention	
	NRB 1-2 Air-Conditioning System Encourage the use of better energy efficient air-conditioned equipment to minimize energy consumption		30	(a) Water-Cooled Chilled-Water Plant (b) Air Cooled Chilled-Water Plant/Unitary Air-Conditioners			
	NRB 1-3 Building Envelope-Design/Thermal Parameter Enhance the overall thermal performance of building envelope to minimize heat gain		35	(a) Minimum direct west facing façade through building design orientation (b) (i) Minimum west facing window openings (ii) Effective sunshading provision for windows on the west façade with minimum shading of 30% (c) Better thermal transmittance (U-value) of external west facing walls (≤ 2 W/m2K) (d) Better thermal transmittance (U-value) of roof	Increase envelope insulation	(P) Increasing insulation (diminishing ETTV value) will increase interior temperature under fire (S) Can affect compartmentalization, the structure time resistance or evacuation	

Conclusions

- There are currently no fire incident reporting systems in the United States or other countries surveyed which specifically collect and track data on fire incidents in green buildings or on items labeled as green building elements or features. Unless changes are made to reporting systems such as NFIRS, it will be difficult to track such fire incident data.

Conclusions

- Fires associated with photovoltaic (PV) panels and roof materials, fire and safety hazards attributed to increased energy efficiency aims in residential buildings (primarily insulation related), fire involving insulating materials, fires associated with exterior cladding that contains combustible insulation materials or coatings, and fire performance of timber frame buildings with lightweight engineered lumber (LEL).

Conclusions

- Moving toward a risk analysis approach
  - A comprehensive list of green building site and design features / elements / attributes has been compiled
  - A list of fire-related hazards and risk factors, associated with green building elements, has been compiled
  - A set of matrices relating green attributes and potential fire risks / hazards was developed

Conclusions

- Moving toward a risk analysis approach
  - An approach for illustrating the relative fire risk or hazard, or decreased fire performance, associated with green building elements, was developed
  - Potential mitigation strategies for addressing the relative increase in fire risk or hazard associated with the green building elements and features have been identified

Conclusions

- None of the schemes reviewed were found to have explicit fire safety objectives
- Two schemes with some fire objectives
  - Fire protection benefit in German Sustainable Building Council (DGNB) (http://www.dgnb-system.de/dgnb-system/en/system/criteria/)
  - Fire risk reduction attributes in BREEAM-in-USE (http://www.breeam.org/page.jsp?id=373)

Recommendations

- To address the lack of reported fire experience with green buildings and green building elements, especially in buildings which have a green rating or certification, a modification is required to fire incident data reporting systems as NFIRS.

Recommendations

- To address the lack of analysis on fire ‘risk’ associated with green building elements, it is suggested that a more extensive research project is needed to review existing studies and reports on fire performance of green building elements, even if not explicitly identified as such (e.g., LEL).

Recommendations

- Research is needed to
  - develop a clear set of comparative performance data between green & ‘conventional’ methods,
  - develop an approach to convert the relative performance data into relative risk or hazard measures, and
  - conduct a risk (or hazard) characterization and ranking exercise, with a representative group of stakeholders, to develop agreed risk/hazard/performance levels.

Recommendations

- To explore the extent to which current standard test methods are appropriate for evaluating both green and fire safety criteria, and result in adequate mitigation of fire risk / hazard concerns, investigation into level of fire performance delivered by current standard test methods and into the *in situ* fire performance of green building elements is recommended.

Recommendations

- To address the lack of published case studies in which increased fire risk or hazards associated with green building elements have been specifically addressed, groups such as SFPE, NFPA, AIA and the USGBC can be encouraged to hold symposia on these topics and encourage publication of case studies in proceedings and associated journals.

Recommendations

- To address the lack of studies which have investigated incorporating building safety, life safety and fire safety as explicit elements in green building indices, joint research efforts between the FPRF and the USGBC and other promulgators of such indices could be explored with the aim to incorporate fire and life safety objectives as fundamental elements in green rating schemes and codes.

Recommendations

- To facilitate better collection of relevant data on fire safety challenges with green buildings in the future, a fire & green building data repository could be set up. This could build on an existing effort (e.g., http://www.firemarshals.org/programs/greenbuildingsandfiresafetyprojects.html) or be supported by the FPRF and/or other organizations.

Acknowledgments

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Thank you for your kind attention!

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