Fire Safety and Sustainability of Buildings

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Overview

- Building objectives related to green buildings, sustainability and climate change
- Building objectives related to fire and life safety
- Potential for competing objectives
- Challenges and opportunities for fire safety as being a sustainable objective
Green / Sustainable Objectives

Primary Energy Consumption in Residential and Commercial Buildings, 2002

**Residential Buildings (Total Quads: 20.9)**
- Space Heating (30%)
- Space Cooling (11%)
- Lighting (12%)
- Water Heating (12%)
- Other Uses (15%)
- Refrigeration (7%)
- Clothes Dryers (4%)
- Cooking (2%)
- Freezers (2%)
- Other Electric Uses (5%)
  - Clothes Washers (0.5%)
  - Dishwashers (0.5%)
  - Color Televisions (2.0%)
  - Personal Computers (1.0%)
  - Furnace Fans (1.0%)

**Commercial Buildings (Total Quads: 17.4)**
- Space Heating (12%)
- Lighting Uses (21%)
- Other Uses (35%)
- Refrigeration (4%)
  - Water Heating (6%)
  - Office Equipment (8%)
  - Ventilation (3%)
  - Cooking (2%)

Note: Other energy uses in the residential sector includes small electric devices, heating elements, and motors; such appliances as swimming pool and hot tub heaters, outdoor grills, and outdoor lighting (natural gas); wood used for primary and secondary heating in wood stoves or fireplaces; and kerosene and coal.

Note: Other energy uses in commercial buildings include service station equipment, automated teller machines, telecommunications equipment, medical equipment, pumps, emergency electric generators, combined heat and power in commercial buildings, and manufacturing performed in commercial buildings.


http://www.pewclimate.org/global-warming-in-depth/all_reports/buildings
Green / Sustainable Objectives

- Lower carbon footprint
  - Construction materials
    - Structure
    - Façade
    - Interior finish
  - Operational energy usage
    - Lighting
    - Heating, cooling, ventilation

http://www.pewclimate.org/global-warming-in-depth/all_reports/buildings
Green / Sustainable Objectives

http://www.dailymail.co.uk/news/article-488982/One-million-terrified-residents-flee-ravaged-Malibu.html

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Green / Sustainable Objectives

http://www.herts.police.uk/about/buncefield_incident.htm

Windsor Building, Madrid, Spain

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

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Green / Sustainable 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
  – Provide better, more secure environment for people in the future

• Promote new technologies, materials and methods to facilitate the above
• 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, …
Fire & Life Safety Objectives

- Protect people
  - Building occupants, fire fighters, neighbors
- Protect property
  - Fire within, between and external to buildings
- Protect business operations
- Protect environment
  - Limit environmental impacts
- Protect heritage
Fire & Life Safety Objectives

Building Fire Safety Design

- Materials
- Construction
- Systems
- Accessibility
- Aesthetics
- Comfort
- Useability

- Building
- People
- Fire

Human Factors
- Decision-making
- Response to Hazards
- Risk Tolerance

- Fuel
- Ignition sources
- Ventilation
Competing Objectives?

• Recent studies identify potential several concerns
  – NASFM – *Bridging the Gap: Fire Safety and Green Buildings Guide*
  – BRANZ (New Zealand) – *Building Sustainability and Fire-Safety Design Interactions*
  – BRE (England) – *Impact of Fire on the Environment and Building Sustainability*
  – FPRF (USA) – *Fire Safety Challenges of Green Buildings*
Potential Fire Challenges

• 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
    • Sudden glazing failure and modified burning environment
Potential Fire Challenges

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http://koreabridge.net/post/haeundae-highrise-fire-busan-marine-city-burns
• Naturally vented double skin façade, composed of two separate planes of glass separated by a 76 cm (30-inch) air space
• Access and fire environment concerns?

http://gaia.lbl.gov/hpbf/design_g4.htm
Potential Fire Challenges

- 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.noburn.com/intumescent-paints-fire-retardant-coatings

http://www.hoffmaninsulation.com/Products.html
Potential Fire Challenges

• Natural ventilation vs. smoke management
  – Smoke exhaust?
  – Interior environment?

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

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


Courtesy MSU
Potential Fire Challenges

- Green exterior vs. fuel load and FF access

Potential Fire Challenges

- PV panels impact FF access and fire risk
Potential Fire Challenges

- Green roof vs. fire fighter access
Potential Fire Challenges

• High density housing
Fire Safety is Sustainability

• If ignitions and fires are limited, that is good for the environment
  – Materials can be made more ignition and fire resistant
  – Automatic sprinklers can reduce overall size of fire and fire effluents
  – Proper separation / fire resistance of exteriors limits building-to-building fire spread potential
  – Fewer fire means lower impact from building and fire department apparatus (emissions)
Fire Safety is Sustainability

Figure 1: Contribution of risk factors to total lifecycle carbon emissions.

Fire Safety is Sustainability

Figure 31: Total volume of water used as a function of time.

Table 13: Water Usage Results

<table>
<thead>
<tr>
<th></th>
<th>Sprinklered</th>
<th>Non-Sprinklered (a)</th>
<th>Non-Sprinklered (b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sprinkler [L (gal.)]</td>
<td>1393 (368)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hose Stream [L (gal.)]</td>
<td>545 (144)</td>
<td>4221 (1115)</td>
<td>3835 (1013)</td>
</tr>
<tr>
<td>Total [L (gal.)]</td>
<td>1938 (512)</td>
<td>4221 (1115)</td>
<td>3835 (1013)</td>
</tr>
<tr>
<td>Time to Extinguishment [s]</td>
<td>820</td>
<td>1484</td>
<td>1017</td>
</tr>
</tbody>
</table>

Various studies looked at sustainability benefits as well as challenges:

- BRANZ (New Zealand) – *Building Sustainability and Fire-Safety Design Interactions*
- BRE (England) – *Impact of Fire on the Environment and Building Sustainability*
- FMGlobal (USA) – *Environmental Impact of Fire Sprinklers*
Sustainable and Resilient Building Design

- Materials
- Construction
- Systems
- Accessibility
- Aesthetics
- Comfort
- Useability

- Human Factors
- Decision-making
- Response to Hazards
- Risk Tolerance

- Building
- People
- Fire

- Fuel
- Ignition sources
- Ventilation

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Thoughts for Discussion

• Potential topics for discussion
  – Development of comparative performance data between green & ‘conventional’ methods
  – Development of an approach to convert relative performance data into relative risk measures
  – Development of a multi-objective, building risk and performance assessment tool
  – Quantification of sustainable benefits of fire safety measures
Thank You

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