Do we understand the impact of new "sustainable" materials on the fire load of buildings?

Fire Safety Design and Sustainable Buildings:
Challenges and Opportunities
Chicago – 7 November 2012

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Overview

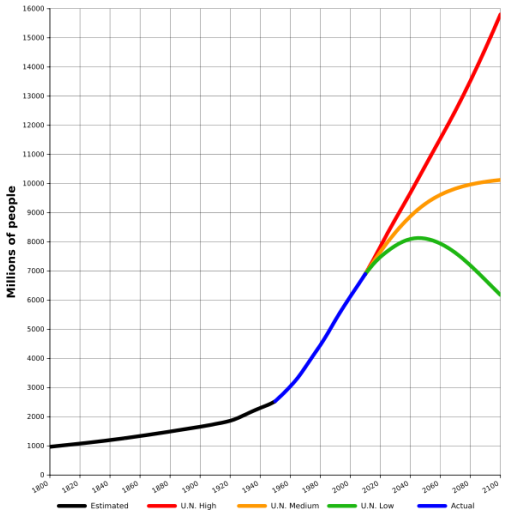
1. Introduction:
   Population Growth: Why is Sustainability an Issue?
2. The Global Perspective on Population Growth
3. The Royal Society Report and Recommendations
4. Sustainability and the Implications of Urban Planning
5. Supply Chain and the Safety Continuum
6. Evolution of Materials and Property Data
7. UL Research Related to the Built Environment
8. Summary and Conclusions

Population Growth - Why Sustainability?

Global Population Growth and Demographic Change:

Historical Global Population estimates and data:

- 1825 – 1B
- 1925 – 2B
- 2011 – 7B
- 2030 – 8B
- 2050 – 8 to 11B with 9.3B median projection
- 2100 - 6.2 to 15.8B
- Global Annual Population Increase: 80M/year

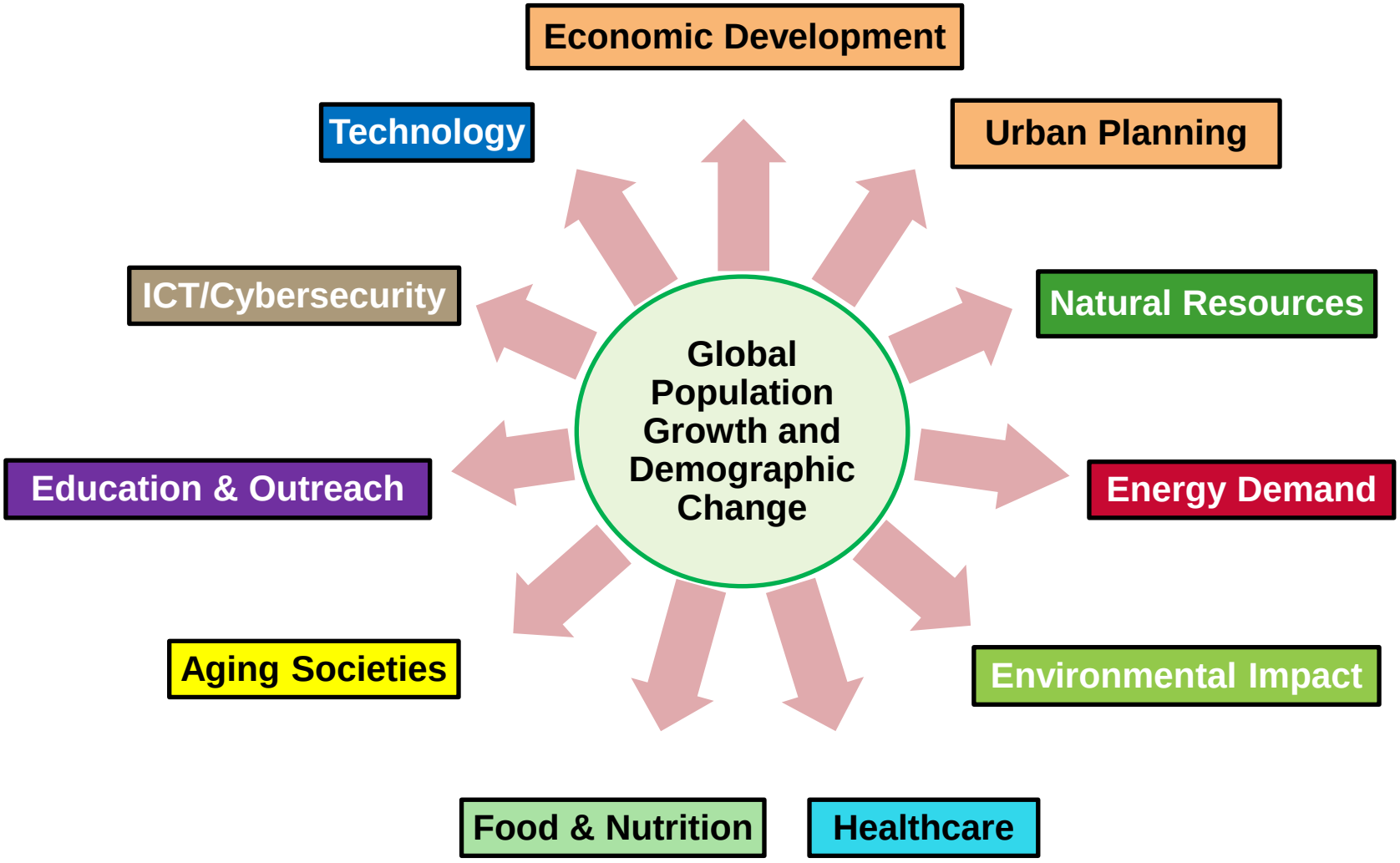


"The Earth's capacity to meet human needs is finite, but how the limits are approached depends upon lifestyle choices and associated consumption; these depend on what is used and how and what is regarded as essential for human wellbeing."[1, 2]

[1]People and the Planet, The Royal Society Science Policy Centre Report, April 2012

[2]*Science & Technology for Society (STS) Forum, Kyoto, Japan October 7-9, 2012*

Global Impact of Population Growth



The Royal Society report:
Recommendations from "People and the Planet"[1]

Economic Development: (4 of 9 recommendations):

- The International community must bring the 1.3 billion people living on less than $1.25/day out of absolute poverty.
- The most developed countries and emerging economies must stabilize then reduce material consumption levels.
- Governments should realize the potential of urbanization to reduce material consumption and environmental impact through efficiency measures.
- Natural and social scientists need to increase their research efforts on the interaction between consumption, demographic change and environmental impact.

[1]People and the Planet, The Royal Society Science Policy Centre Report, April 2012 DES2470

Sustainability and Urban Planning

Urban Planning – major focus areas and trends:

- Megacities - Developing countries will be building the equivalent of a city of 1 million people every 5 days from now until 2050.
- Global Trend - Africa will have 1,000 cities of 500K inhabitants. Asia will have 500 cities of 1M inhabitants each.
- Impact of Urbanization - Governments should realize the potential of urbanization to reduce material consumption and environmental impact through efficiency measures.
- Sustainable Cities – future model for Society?
  - Migration from rural to urban areas
  - Competition for resources
  - Sustainable housing design

Societal Energy Needs and Impact

Energy Generation and Demand

- Existing sources – coal, oil, gas, hydro, nuclear
- Alternatives – shale gas, biofuels
- Renewables – PV, wind, tidal, hydro, fuel cells, fusion
- Transmission and Storage - SmartGrid, Microgrids, battery storage

Environmental Impact

- CO_2 increase (to 500 ppm)
- Global average temperature rise from 2-4^{o}C
- Climate change
- Species extinction
- Sea level rise
- Coral Reef devastation

Supply Chain and the Safety Continuum

Materials	Components	Products	Systems	Structures
Polymers	Conductors	Cable	Telecom	High rise
Compounds	Connectors	Computer	Data	Retail
Liquids, gels	Devices/Chips	Appliances	HVAC	Manufacturing
Films, fibers	PCB/PWB	Electronics	Electrical	Residential
Foams	Switches	Furniture	Security	Warehouses
Minerals		Equipment	Suppression	Municipal

- **Materials analysis**
- **Physical Properties**
- **Chemical Properties**
- **Environmental impact**
- **Human exposure**

- **Product performance**
- **Electrical properties**
- **Fire behavior - ignition smoke/heat release**
- **System aging & reliability**
- **Efficiency**

- **Building Codes**
- **Inspections**
- **Certifications**
- **Fire Services**
- **Sustainability**

Evolution of Advanced Materials

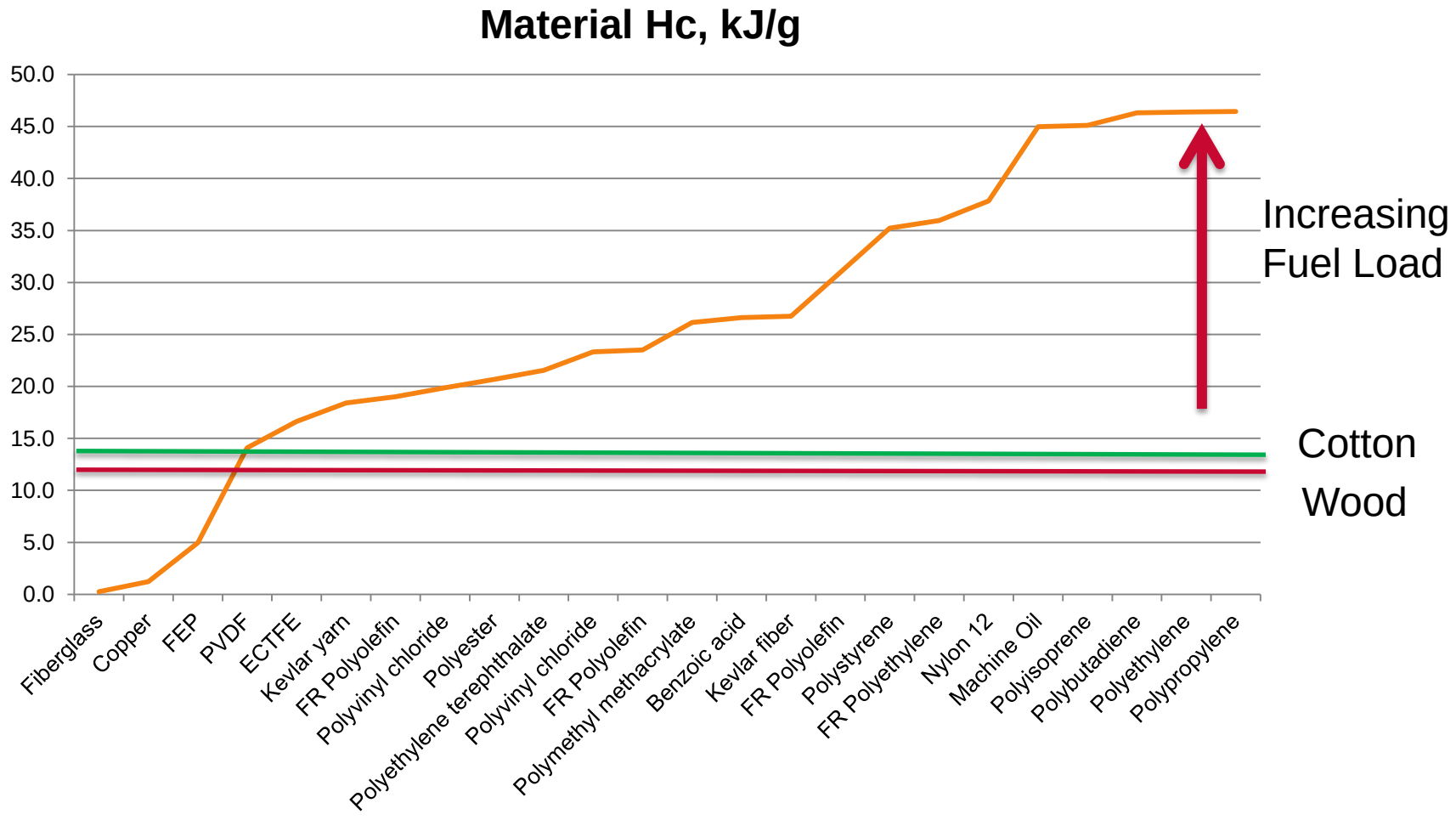
- The advancements in organic, polymer chemistry and materials science over the past century have triggered an explosion of new products and technologies.
- Catalysts for this growth include: WW I, WW II, the aerospace program, as well as increases in ICT (Information Communications Technology) and others.
- The vast majority of advanced materials are based upon crude oil and downstream refining operations. Complexity of materials may lead to unintended consequences.

Polymer Discoveries and Applications

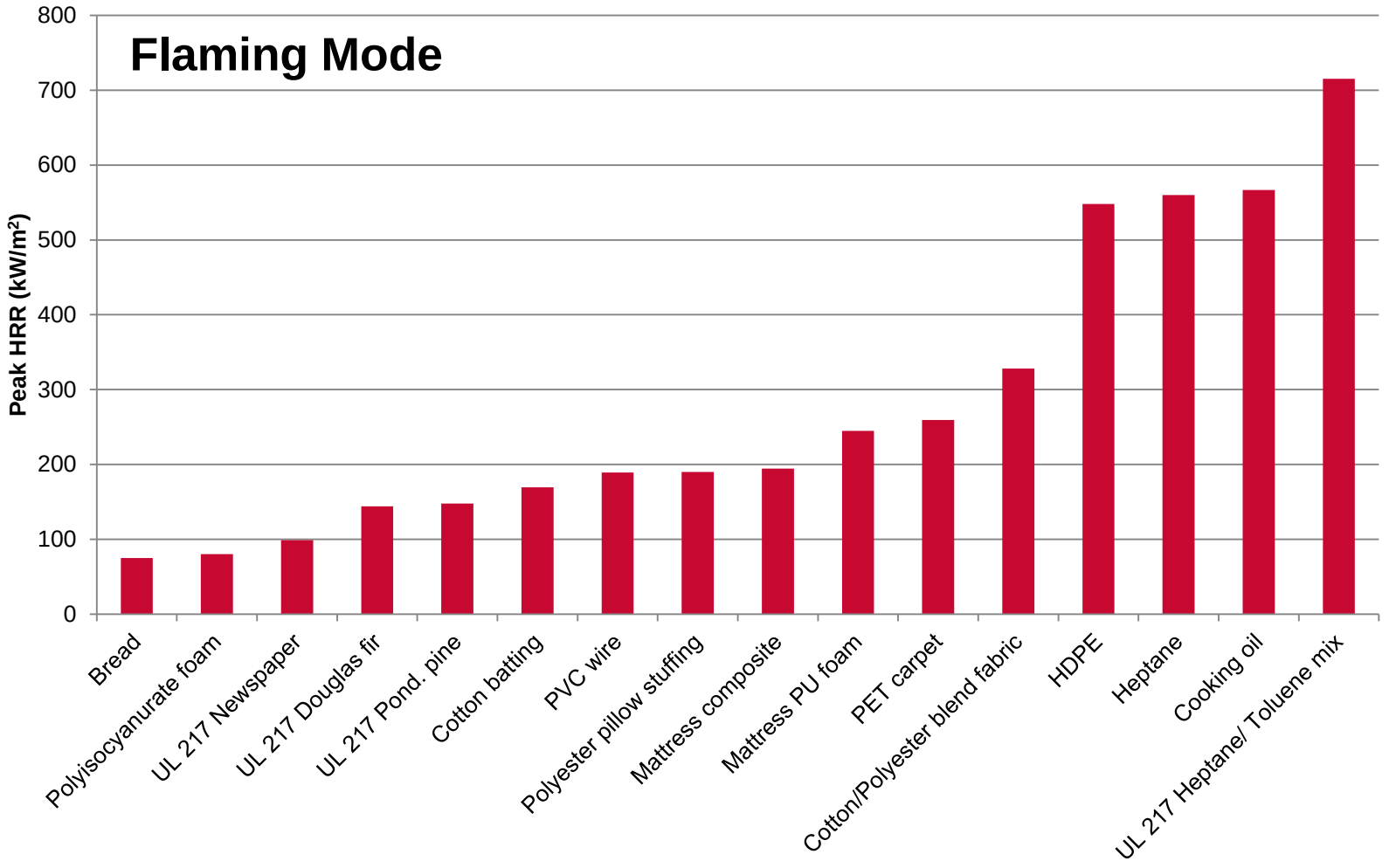
Polymeric Material	Application	Year Discovered-Commercialized	Hc, kJ/g
Copper	Wire & Cable	Traditional	1.2
Cotton	Fabrics, filling materials, apparel, furnishings	Traditional	**14.6**
Fiberglass	Polymer reinforcement	Traditional	0.3
Wood	Furniture, structural, flooring, paneling	Traditional	**12.0**
Polyvinyl chloride rigid (PVC) #3	Pipe, fascia, trim, molded parts	1835 - 1905	16.7
Polystyrene (PS)	Insulation, packaging, containers, profiles	1839 - 1931	43.7
Synthetic rubber, cis-isoprene	Cable materials, gaskets, hoses, seals, tires	1879 - 1909	46.3
Polyethylene (PE) #1	Numerous applications and derivatives	1898 - 1933	46.4
Silicones	Gaskets, coatings, sealants, adhesives	1901 - 1960	17.1
Phenol-formaldehyde resin	Bakelite, electrical housings, outlets, parts	1907 - 1929	29.0
PVC plasticized (PVC)	Cable materials, coatings, films	1926	24.7
Poly(methylmethacralate) (PMMA)	Lenses, lighting, molded articles	1928 - 1933	26.1
Polychloroprene (PCP)	Gaskets, films, fabrics, belts	1930 - 1937	24.0
Polyvinylidine chloride (PVDC)	Saran, barrier wraps	1933 - 1953	11.3
Nylon (6, 6,6, 6,12)	Fibers, housings, ropes, molded parts	1935 - 1938	30.5
Brominated (9-18wt% Br) epoxy polymers	Printed wiring boards	1936	27.8
Polyurethane and foams (PU)	Seals, gaskets, belts, flexible foams	1937 - 1954	24.3
Polytetrafluoroethylene (PTFE)	Cable insulation, coatings, sealants	1938 - 1945	6.7
Styrene butadiene rubber (SBR)	Buna S, gaskets, elastomers, additives	1938	42.0
Polybutylene teraphthalate (PBT)	Electrics and electronics, consumer goods	1941	27.9
Polyetylene terephthalate (PET)	Fibers, containers, packaging, parts	1941	24.1
Polyvinylidine fluoride (PVDF)	Wire & Cable, coatings	1941	13.5
Polyethylene (HDPE)	Cable insulation, piping, sheeting	1950	46.4
Polycarbonate (PC)	lenses, coatings, windows, molded parts	1953 - 1958	31.5
Acrylonitrile Butadiene Styrene (ABS)	Pipes, enclosures, molded articles	1955	39.8
Polyphenylene oxide/Polyphenylene Ether	Electrical switch boxes, connectors, housings	1956 - 1960	32.7
Polypropylene (PP) #2	Fibers, films, packaging, molded articles	1957	45.8
Ethylene chlorotrifluoroethylene (ECTFE)	Halar, cable jacketing, coatings, molded parts	1959	16.6
Polysulfone (PSU)	Housings, membranes, components, films	1960 - 1965	29.2
Polyaramid	Nomex, Kevlar, rope, body armor, reinforcements	1962	26.8
Polyurethane structural (PU)	Polyisocyanurate foams	1967	8.6
Fluorinated Ethylene Propylene (FEP)	Containers, insulation, coatings	1975	5.0
Poly(phenylenesulfide) (PPS)	Ryton, electrical insulation, gasket, packing	1983	29.6
Polyethylene (UHMW)	Machine parts, fibers	2005	46.4

Heat of Combustion Data:

Fuel Load and Chemical Burden

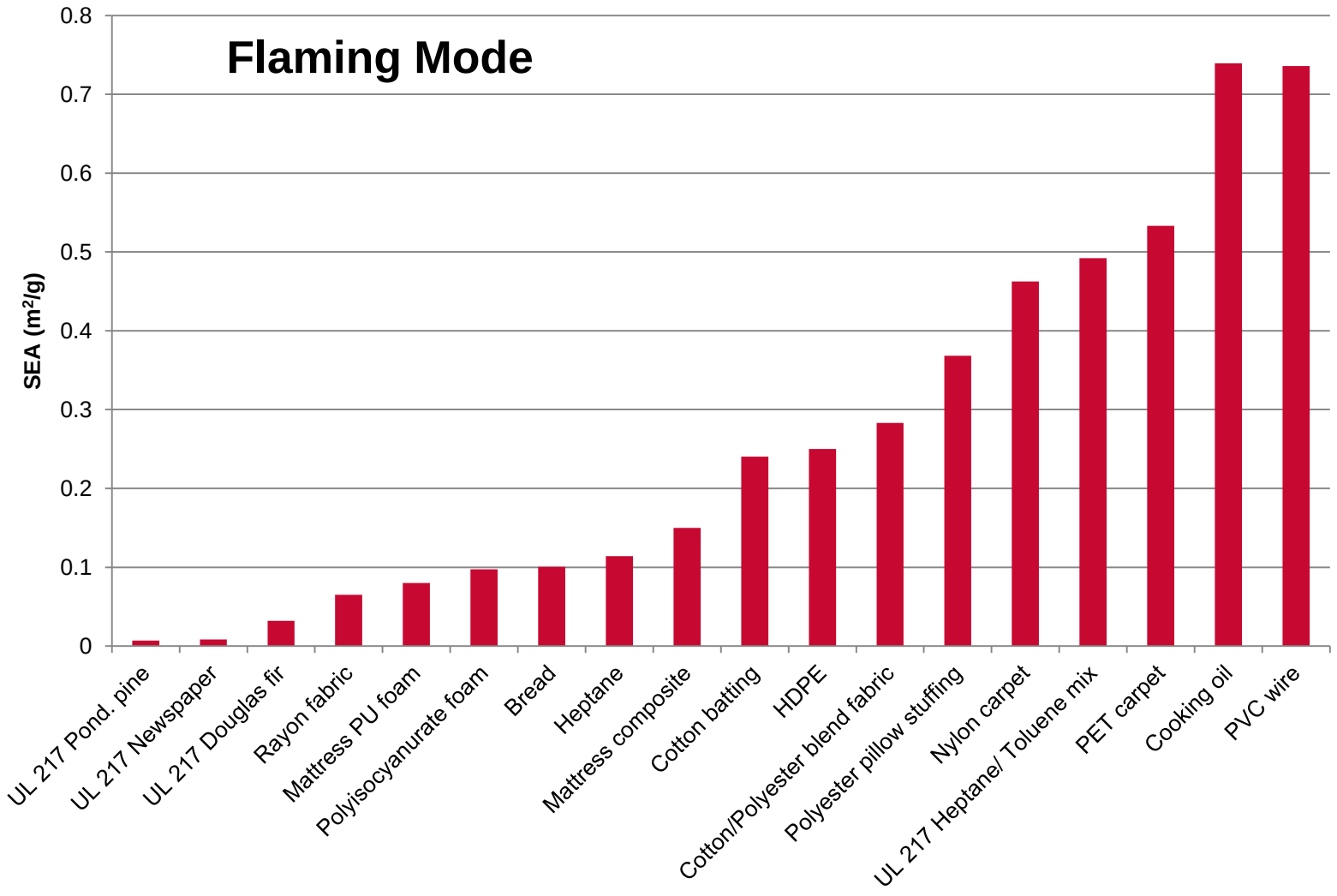


Influence of Material Chemistry – Pk HRR[1]



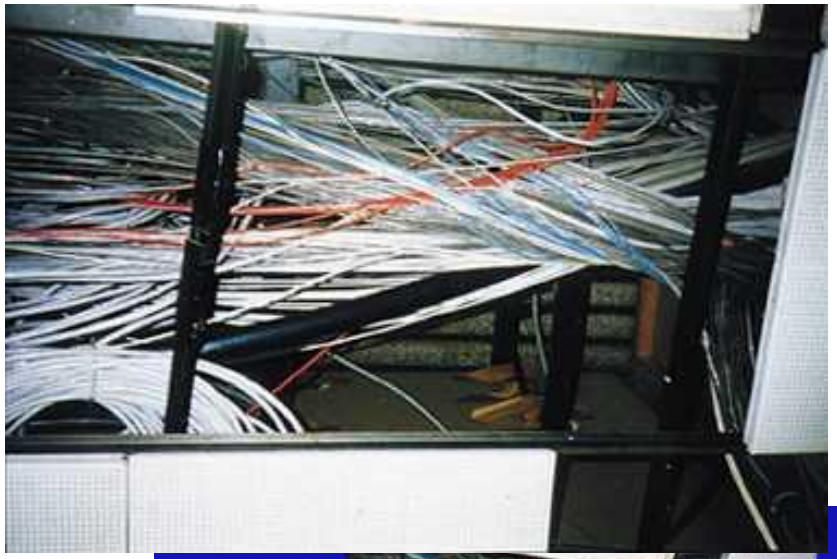
[1]Peak Heat Release Rate, kW/m^2 as measured by Cone Calorimetry at 35 kW/m^2

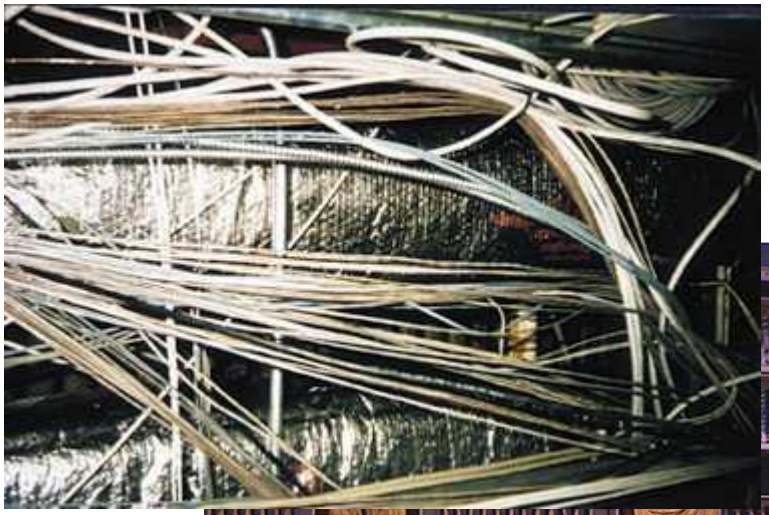
Influence of Material Chemistry – SEA[1]

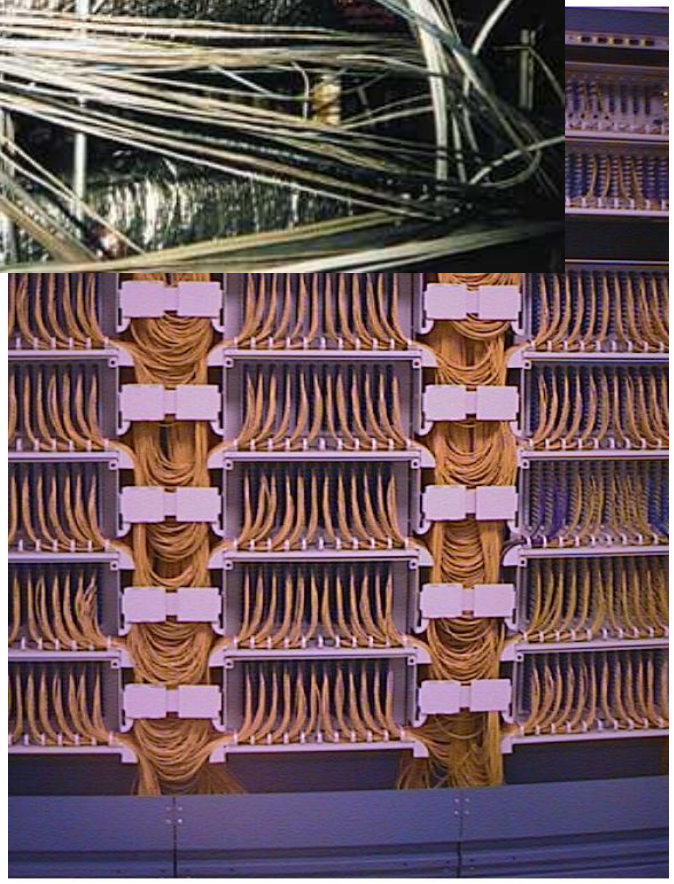


[1]Specific Extinction Area, m2[2]/g as measured by Cone Calorimetry at 35 kW/m[2]

Technology - Cabling Congestion in Buildings





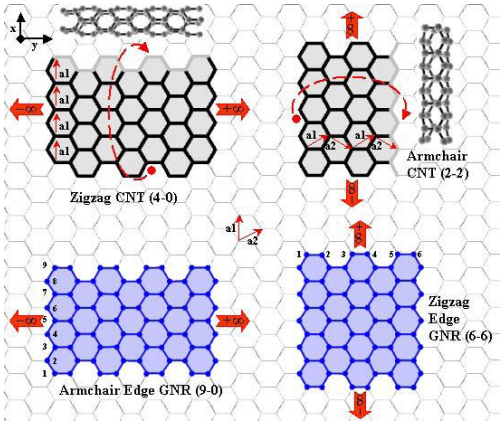


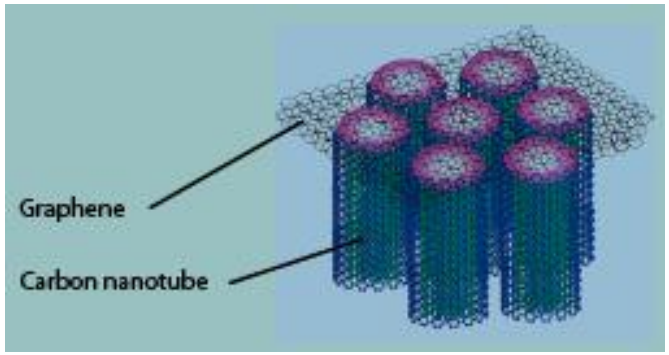
Comparison of Cable Fire Performance

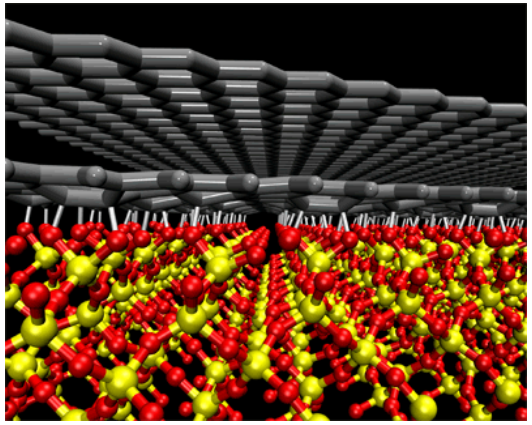
Nanotechnology Leadership

UL international chair of IEC TC113 Nanotechnology Standards Development

- Nanoscale Contacts New Work Item Proposal
- UL/NIST Workshop on Graphene Standardardization
- Liaison to ISO TC229 Nano-labeling standards development
- 25 separate New Work Item Proposals since 2007







Upholstered Furniture Flammability

Phase I | Phase II | Phase III


material-level


mock-up


furniture


living room flashover


tenability and survivability

Improve life safety from the leading cause of home fire-related deaths

- UL Testimony at Senate committee hearing 2012
- Assisting California BHFTI & CPSC, NY with development of regulations

Convergence of fire safety and long-term exposure safety

- Fire retardant usage in upholstered furniture & other products (performance)
- Fire retardants relationship to human exposure (health)

UL Smoke Research Program

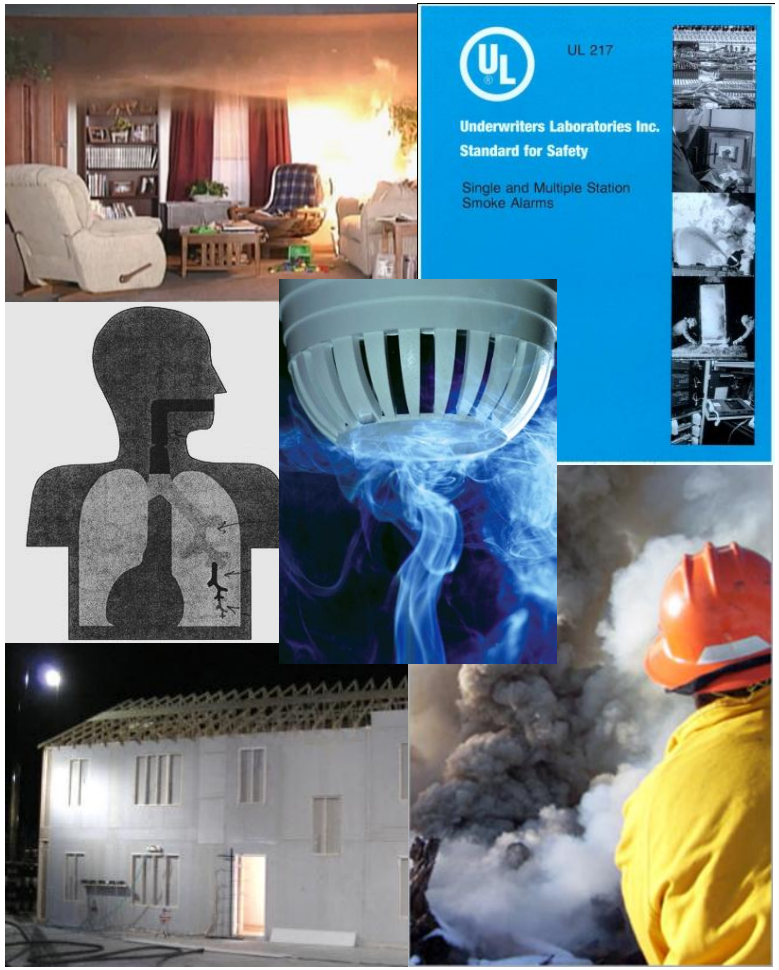
What is “Smoke”?

Smoke Build-Up

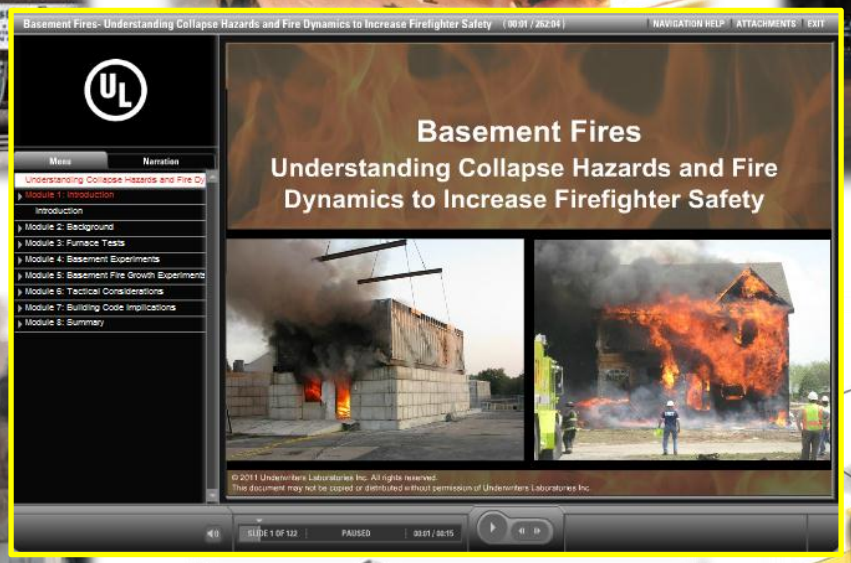
Alarm Response

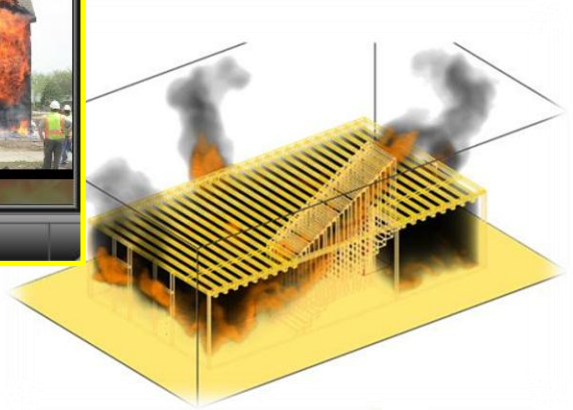
Egress Time & Responder Safety

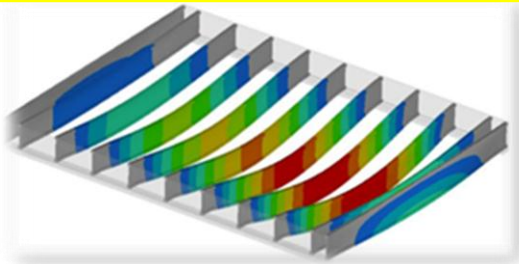
Codes & Standards, Outreach



Lightweight Construction – AFG Grant







Conclusion and Summary

- Macroscopic changes in global population growth are driving new focus on sustainability.
- These changes have significant implications on how cities and infrastructure are designed and built.
- Technology advances over the past century (particularly the last 40 years) have made profound contributions to society, but we need to investigate the impact on safety.
- The issues of acute and chronic safety are converging and require a holistic approach that crosses disciplines of science, engineering, medicine and public policy.
- UL is leveraging the experience gained over the past century to address these emerging issues through research.

Sustainability - Safety Convergence

Acute vs Chronic Perspectives on Safety[1]:

1. Ignition – Flame retardants
2. Flame Spread – Flame retardants
3. Smoke Suppression – Smoke suppressants
4. Advanced Materials – Plasticizers, additives, VOC's
5. High Tech Products – Heavy metals, additives, minerals

[1]UL 94 Plastics iQ Database contains 80,000+ materials, est. late 1960's

Materials Sustainability Challenge

1. Safety Compliance to local codes and standards
2. Environmental and Health Compliance (state, Federal, international norms)
3. Energy Efficiency (product and building level)
4. Recyclability, Reuse (end of life, resource recovery)
5. Enhanced Performance (interoperability)
6. Emissions (VOC's, humidity control, air exchange)

Fire Timeline and Mitigation Tools