# **Resilient Buildings** From Vulnerabilities to Opportunities



The LEED Platinum, LBC-certified, resilient Brock Environmental Center, Virginia Beach - photo: SmithGroupJJR Local Solutions: Eastern Regional Climate Preparedness Conference April 4, 2016

Alex Wilson, President Resilient Design Institute Founder, BuildingGreen, Inc.

# A focus on resilience beginning with Hurricane Katrina in 2005



Flooding in New Orleans from Hurricane Katrina, 2005. Source: FEMA

### The New Orleans Principles



Charrette on Gulf Coast reconstruction in the fall of 2005. Photo: Alex Wilson



U.S. Green Building Council New Orleans Planning Charrette

The New Orleans Principles

#### Why a focus on resilience?



Flood protection at the Brock Environmental Center – photo: Alex Wilson

# We're not making rapid enough progress



Global temperatures 1889 – 2015 NOAA National Climate Data Center

Anomaly (

Keeling Curve of  $CO_2$  levels on Mauna Loa

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#### Resilience can be the motivator for change

*Resilience* is the capacity to adapt to changing conditions and to maintain or regain functionality and vitality in the face of stress or disturbance. It is the capacity to bounce back after a disturbance or interruption. *–Resilient Design Institute* 

#### More intense storms



Hurricane Sandy, Oct. 29, 2012, Photo: NASA GEOS Satellite

#### More intense storms and flooding

- 74% increase in intense storms in the Northeast from 1958 – 2011
- Similar trend in other regions—though not as extreme
- Even in areas where there may be less total rainfall, it is coming in more intense storms
- Causes river valley as well as coastal flooding



Percent increase in very heavy precipitation 1958-2011 (defined as the heaviest 1% of all events). Source: Nat'l Climate Assessment Draft (January 2013)

#### Heat Waves to become more common



#### **Drought & Water Shortages**



Lake Mead at the lowest level on record at 37% of capacity, 2015. Photo: Kirk Siegler, National Public Radio



Lake Lanier near Atlanta, September, 2007 – Photo: Washington Post

# **U.S. Drought Conditions**



Source: National Drought Mitigation Center - University of Nebraska - Lincoln

#### **Drought Puts Power Plants at Risk**

- 89% of U.S. electricity generation from thermalelectric power plants
- 40% of U.S. fresh water extractions in the U.S. used for power plants
- Vast majority of power plants on rivers
- A nuclear plant in CT shut down briefly in 2012 due to temp of cooling water
- In 2003 drought and heat in Europe caused more than a dozen plants to shut down or reduce output



California Dept. of Water Resources - 2014

#### **Power Outages – New York City 2012**

Blackout caused by Hurricane Sandy on October 29, 2012 – photo: Eric Chang

#### **Energy Distribution in the U.S.**



- 160,000 miles of highvoltage power lines
- 3,400 power plants
- 150 refineries, half in the Gulf Coast
- 2.5 million miles of oil and gas pipelines





#### **Cascading impacts can occur**



Gas line in Woodbridge, NJ on November 1, 2012 – photo: AP

# Even those with generators vulnerable



Gas line in Brooklyn, NY, November 7, 2012 – photo: Mario Toma, Getty Images

# **Other vulnerabilities**

- Earthquakes
- Landslides from torrential rain
- Coronal discharges (solar flares) that could cause blackouts
- Wildfire
- Pandemics
- Terrorist actions
- Cyberterrorism



Loma Prieta Earthquake, San Francisoc 1989 – photo: San Francisco Chronicle

### What does resilient design entail?

- Given these concerns, we should be designing buildings and communities
  - That are resistant to damage from storms, earthquakes, and other disasters
  - That will protect occupants from reasonably expected events
  - That a reasonably adapted to a changing climate
  - That will maintain livable conditions in the event of power outages, loss of fuel, or water shortages
- An issue both at the building scale and the community scale

#### **Resilience vs. sustainability**

- Many strategies are the same
  - Improved thermal envelope
  - Water conservation
  - Alternative water sources
  - Durability
  - Communities designed for pedestrian mobility
  - Density

- Some strategies are different
  - Structural features
  - Redundancy
  - Safety
  - Adapting to climate change
  - Functionality during or following disasters
- Some strategies are conflicting
  - Redundancy may increase resource consumption

#### **Retrofitting affordable housing**

© Determine your resilience strategies.	Low to mid- rise walk-ups	Low-rise contemporary	Mid-rise contemporary	High-Rise	Estimated Cost	
Protection					Protection	
Wet Floodproofing	۲	۲	•	•	\$\$-\$\$\$	
2 Dry Floodproofing	۲	۲	۲	۲	\$\$-\$\$\$	
3 Site Perimeter Floodproofing	0	۲	۲	۲	\$\$-\$\$\$	
Resilient Elevators	۲	0	•	•	\$\$-\$\$\$	
5 Backwater Valves	•	•	•	•	\$	
6 Sump Pumps	•	•	•	٠	\$	
Adaptation					Adaptation	
Envelope Efficiency		٠	٠	•	\$\$\$-\$\$\$\$	
8 Elevated Equipment	۲	۲	•	•	\$\$\$-\$\$\$\$	
2 Elevated Living Space	۲	۲	۲	۲	\$\$\$-\$\$\$\$	
Surface Stormwater Management	•	٠	•	•	\$\$-\$\$\$	
U Window Shading	•	•	•	•	\$	
Distributed Heating and Cooling	•	٠	۲	0	\$\$	
Backup					Backup	
Maintaining Backup Power to Critical Systems		•	•	•	\$\$-\$\$\$	
Emergency Lighting	•	٠	•	•	\$	
15 Access to Potable Water	•	٠	•	•	\$	
Community					Community	
16 Building Community Ties	•	•	•	•	\$	17
Creating Community Resilience Spaces	۲	۲	•	•	\$-\$\$	13, 15
18 Developing an Emergency Management Manual	•	•	•	•	\$	16
Organization for Community Resilience		•	•	•	\$	16

#### **READY TO RESPOND**

18, 19

17, 19

17, 18

16, 18, 19

#### Strategies for Multifamily Building Resilience



Enterprise Community Partners – Resilience Manual

#### Dry floodproofing



Enterprise Community Partners – Strategies for Multifamily Building Resilience

# An example of dry floodproofing



Flat Street, Brattleboro, Vermont, Sept, 2011. Photo: Charlie Boswell

#### **Flood barriers**



New England Youth Theater, Brattleboro. Photo: Jerry Stockman



New England Youth Theater, Brattleboro. Photo: Jerry Stockman

#### **Flood barriers**



Flood barrier on a commercial building in Providence. Photo: Alex Wilson

#### **Elevating mechanical equipment**



 Relocate mechanical equipment to upper floors or roof.

- (2) For equipment that cannot be relocated, elevate in place above the Design Flood Elevation
- Strategies not pictured:

Relocate electrical systems above the Design Floor Elevation.

Anchor or elevate fuel storage tanks.

Enterprise Community Partners – Strategies for Multifamily Building Resilience

#### **Elevating mechanical equipment**



Elevating mechanical equipment in Carolina Beach, North Carolina in 1999 - Photo: Dave Saville, FEMA

#### **Protecting mechanical equipment**



3' flood barrier around mechanical equipment Enterprise Community Partners – Colin Hayes



Fuel tank tie-downs anchored to concrete slab – photo: Jon Gravelin

#### **Back-up generator on upper floor**

#### **Spaulding Rehab Hospital**

- Utility service in penthouse floor
- Rooftop CHP system
- Chillers, air handlers, ventilation, boilers in two penthouse floors
- Two back-up generators in penthouse - either could operate hospital
- Most diesel fuel stored in basement - bunkerized



Spaulding Rehab Hospital - Photo: Alex Wilson

#### **Passive survivability**



All-glass condo building in NYC - Photo: Alex Wilson



REPORT TO MAYOR MICHAEL R. BLOOMBERG & SPEAKER CHRISTINE C. QUINN

BUILDING RESILIENCY TASK FORCE

Building Resiliency Task Force in New York City – Final Report, June, 2013

#### **Drift temperatures**

#### **Typical Building**



Temperature modeling by Atelier Ten for the report "Baby It's Cold Inside," Urban Green, NYC

#### **Drift temperatures**

#### **High-Performing Building**



Temperature modeling by Atelier Ten for the report "Baby It's Cold Inside," Urban Green, NYC

#### Achieving passive survivability



Kenogami House in Northern Quebec. Photo: Alain Hamel

- Kenogami House in northern Quebec
- Perhaps the most resilient home in North America
- Extreme climate:
  - 10,450 ° F HDD
  - 130 miles north of Quebec City
- 2,200 sf home built in 2012

#### Alain Hamel lived through two disasters



*Hydro Quebec pylon - Drummondville, Quebec - January, 1998* 

- Saguenay Flood of 1996
  - Canada's first billion-dollar disaster
- Great ice storm of January 1998:
  - Canada's first \$2 billion disaster
  - 3-4 inches of freezing rain January 5-10, 1998
  - 130 power transmission towers and 30,000 utility poles destroyed
  - 4 million homes lost power; 600,000 families forced from their homes

#### Passive survivability - Kenogami House



Kenogami House in Northern Quebec. Photo: Alain Hamel

- Extremely high insulation levels:
  - R-80 walls and foundation walls
  - R-64 floor

- R-150 roof
- Triple-glazed, dual-low-e, high-SHGC windows
  - Tighter than Passive House (0.5 ACH<sub>50</sub>)

#### **Backup power**



Solar array in front of the Kenogami House. Photo: Alain Hamel

- Solar electricity
  - 5.4 kW array (currently)
  - Will expand to 8 kW for net-zero
- Battery back-up
  - 16 deep-cycle batteries store 475 amp-hours
  - Critical-load circuit powers electrical components of propane heating system, water pump, refrigerator, HRV, internet, and one outlet and two USB ports per room

#### Solar inverter and battery system



Inverter, batteries, and controls - Kenogami House. Photo: Alain Hamel

#### Another option for access to solar electricity

- 18 kW "group-netmetered" system
  - We own 12 kW, a neighbor owns 6 kW
- Grid-connected system that we can still draw power from during an outage
- Only daytime power, though



18 kW group-net-metered solar array on our restored 1812 barn in Dummerston - photo: Alex Wilson

#### Access to solar electricity *without* batteries

- New SMA transformerless inverter
- Access to solar electricity when the grid is down and the sun is out
- Outlet can provide up to about 15 amps
- Ideal for charging cell phones, laptop computers, powering cable modem and wireless router
- "Soft-start" refrigerator or freezer using extension cord



Photo: Alex Wilson

#### **Community and social resilience**



Enterprise Community Partners – Strategies for Multifamily Building Resilience

# **Community Gardens**



Community Gardens, Holyoke, MA – Photo: Nuestas Raices

## **3 Credit Suite:** LEED Pilot Credits on Resilient Design



### **Resilient Design Institute** www.ResilientDesign.org



Survivability: A New Design Criterion for Buildings," May, 2006

# Thank you! – Questions?



Leonard Farm, October 18, 2015 – photo: Alex Wilson