RESILIENT DESIGN
INSTITUTE

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Resilient Design: Bouncing Back, Bouncing Forward

A Report from the Benchmarking Resilience Retreat on May 3, 2013

Introduction

On May 3, 2013 at the offices of Terrapin Bright Green and CookFox Architects in New York City, eighteen engineers, architects, and other experts on resilience met for a day-long retreat at the invitation of the Resilient Design Institute (RDI) to address metrics and benchmarks relating to resilience. This group set out to answer the following questions:

- What are acceptable low and high temperatures in buildings that can keep occupants reasonably safe should heating and air conditioning not be available and evacuation not practical? How cold is too cold, and how hot is too hot?
- What other metrics could be identified assess resilience—particularly, keeping people safe during natural disasters and other events that result in lost power, heating fuel, water, and other services?
- With these various metrics, what are the benchmarks needed in buildings and communities to achieve a reasonable level of resilience?
- Is there need for a *resilience rating* or *certification* for buildings that can be demonstrated to maintain livable conditions in the event of extended power outage or interruption in heating fuel?

This document represents a starting point for discussion about these metrics—presenting a "straw dog" that should serve as a catalyst for discussion. RDI is seeking input from the ad hoc Benchmarking Resilience Task Force on the metrics and benchmarks presented in this document.

Participants

Bill Browning, Hon. AIA, Terrapin Bright Green, New York, NY (host)
Alex Wilson, RDI, Brattleboro, VT (organizer and co-facilitator)
Chris Lotspeich, Director of Sustainability Services, Celtic Energy, Glastonbury, CT (co-facilitator)
Meiring Beyers, Ph.D., Klimaat Consulting, Guelph, Ontario
Gina Bocra, AIA, Chief Sustainability Officer, New Your City Department of Buildings, New York, NY
Fiona Cousins, P.E., Principal, Arup, New York, NY
Mark Frankel, New Buildings Institute, Seattle, WA
Emilie Hagen, Atelier Ten, New York, NY
Seth Holmes, R.A., University of Hartford, CT

Laura Jay, Terrapin Bright Green, New York, NY
Nico Kienzl, DDES, LEED Fellow, ASHRAE HBDP, Atelier Ten, New York, NY
Joyce Lee, FAIA, former chief architect, NYC Office of Management & Budget and public health expert, Grand Rapids, MI
Luke Leung, AIA, SOM Architects, Chicago, IL
Dan Nall, FAIA, P.E., Thornton Tomasetti, New York, NY
Jeffrey Raven, AIA, Director, Master of Architecture in Urban and Regional Design, New York Institute of Technology, New York, NY
Paul Torcellini Ph.D., P.E., National Renewable Energy Laboratory, Washington, DC
Adrian Tuluca, R.A., Viridian Energy & Environmental, Norwalk, CT
Jerelyn Wilson, RDI, Brattleboro, VT

Did not participate in 5/3/13 meeting, but involved in discussions:
Robin Guenther, FAIA, Perkins + Will Architects, New York, NY
Mary Ann Lazarus, FAIA, Special consultant to AIA, St. Louis, MO
Vivian Loftness, FAIA, Carnegie Mellon University, Pittsburgh, PA
Ralph Meima, Ph.D., Resilient Design Institute, Brattleboro, VT
Amy Patel, AIA, Sustainable Design Leader and BuildingSMART Specialist, HOK New York
Tom Phillips, Temperature extremes expert, San Francisco, CA
Chris Pyke, Ph.D., Vice President for Research, U.S. Green Building Council, Washington, DC
Sue Roaf, Ph.D., FRSA, Heriot Watt University, Edinburgh, Scotland
Marc Rosenbaum, P.E., Energysmiths, West Tisbury, MA
Steve Selkowitz, Building Program Leader, Lawrence Berkeley National Laboratory, Berkeley, CA

Defining resilience

Resilience is the capacity of a system to retain or rapidly regain functionality and vitality in the face of stress, disturbance, or change.

RDI's *Resilient Design Principles*

1 **Resilience transcends scales.** Strategies to address resilience are relevant at scales of individual buildings, communities, and larger regional and ecosystem scales.

2 **Diverse systems are inherently more resilient.** More diverse communities, ecosystems, economies, and social systems are better able to respond to interruptions or change, making them inherently more resilient.

3 **Redundancy enhances resilience.** While sometimes in conflict with efficiency and green building priorities, redundant systems for such needs as electricity, water, and transportation, improve resilience.

4 **Simple, elegant, passive systems are more resilient.** Features like passive heating and cooling strategies for buildings and natural swales for stormwater management are more resilient than complex systems that can break down and require ongoing maintenance.

5 **Durability strengthens resilience.** Features that increase durability, such as rainscreen details on buildings, windows designed to withstand hurricane winds, biological erosion-control measures that grow stronger over time, and beautiful buildings that will be maintained for generations, enhance resilience.

6 **Locally available, renewable resources are more resilient**. Reliance on abundant local resources, such as solar energy and annually replenished groundwater, provides greater resilience than nonrenewable resources from far away.

7 **Resilience anticipates interruptions and a dynamic future.** Adaptation to a changing climate with higher temperatures, more intense storms, flooding, drought, and wildfire is a growing necessity, while non-climate-related natural disasters, such as earthquakes and solar flares, and anthropogenic actions like terrorism and cyberterrorism, call for resilient design.

8 **Find resilience in nature.** Natural systems have evolved to achieve resilience; we can enhance our resilience by relying on or applying lessons from nature.

Benchmarking Resilience – Straw Dog

Drift temperature requirements for "passive survivability" or livability

Drift temperatures that buildings should be designed to achieve
Chart to separate building type, region, and high/low limits
Drift temperatures determined using accepted energy modeling tools (list tools), assuming [what?] design conditions

"Acceptable" low and high drift temperatures (°F) during emergency conditions

Climate/region	Single-family detached		Low-rise residential		High-rise residential		School or shelter		Office building	
Hot – dry (Southwest)	50	95	50	95	50	95	50	90	45	95
Hot – humid (Southeast)	55	90	55	90	55	90	55	90	50	95
Temperate (Pacific coast, mid-Atlantic)	55	85	55	90	55	90	55	85	45	95
Cold – dry (Mountain)	50	95	50	95	50	95	50	90	45	95
Cold – humid (Northeast)	50	85	50	90	50	90	50	95	45	95

Notes/assumptions:

Regional differences assumed based on general adaptation to climatic conditions—people in warm climates able to accept warmer temperatures and people in cold climates able to accept colder temperatures.

Humidity is factored in at the high-temperature limit (accepting a higher maximum temperature when humidity is likely to be lower).

Lower minimum temperatures are acceptable in commercial buildings as they will likely not need to keep occupants safe at night; higher maximum temperatures are acceptable in the daytime, because they will likely be evacuated during a power outage.

Water and sanitation requirements for resilience

Potable water

- On-site storage of potable water to provide 3 liters per person per day for one week
  - (or)
- Access to well or spring water on the site that can be accessed during power outages
  - Hand pump or gravity-feed spring or electric pump served by islandable PV
  - (or)
- Where municipal water exists for multi-family residential, resident access to a hose bib at a lower floor of the building (at a level municipal water pressure can reach without onsite pumping)
  - (or)
- Community water supply within walking distance, defined as one-half mile
- One gallon standard household bleach (unscented, non-color-fast, no additives for additional cleaning) on hand
  - 16 drops of bleach per gallon of water for emergency water treatment
  - Can dilute 9 parts water to one part bleach for disinfectant

Non-potable water:

- 20 liters per person per day
- 2-3 toilet flushes per person per day (hand-filling of gravity-flush toilets acceptable):
- Wash water for sponge baths, dishwashing, etc.: 8 liters per person per day

Food security requirements for resilience

Food storage in individual residences

- Six months' supply of "durable" foods that do not require refrigeration
  - Dried beans, grains, rice
  - Dehydrated fruits and vegetables
  - Flour, cornmeal
  - Canned goods
- Back-up electricity to charge refrigerator and freezer during daytime hours
  - Suitable to rely on daytime powering of refrigeration

Community and regional food production

- Plan in place to expand capacity for local food production to 50% by 2020
  - "Local" food defined as that grown:
    - Within 10 miles of communities up to 10,000 residents
    - Within 25 miles of communities of 10,000 to 100,000 residents
    - Within 50 miles of cities of 100,000 to 1 million residents
    - With 100 miles of cities of more than 1 million residents
  - Does not necessitate that that agricultural capacity actually *be producing* food crops for those populations, but rather that there would be the capability to convert agricultural and ornamental crop production to food crops serving those populations within a 12-month period

Electricity requirements for resilience

- Minimum needs
  - Capability within every residence to operate emergency flashlights and radio (could be wind-up models)
  - Capability within every neighborhood (one-half-mile walking distance) to recharge cellular phones
- Intermediate targets
  - Onsite fuel-fired generator to serve critical needs with onsite fuel storage for one week of operation

Preferred target:
Islandable solar power system to provide critical loads (necessary lighting; at least daytime power for refrigeration, electrical components of fuel-fired heating and water heating systems)
Ideal to have some limited storage capacity for nighttime critical loads but capability to harvest more of PV array output during daylight hours

Transportation requirements for resilience

Access to critical services (grocery, pharmacy, home supplies, etc.) during potential gasoline shortage
Transportation options to comply with target:
Walking (one-mile range)
Bicycling (two- to ten-mile range, depending on hills and suitability for reasonable bicycling with a bicycle trailer)
Diesel vehicles in areas that rely on heating oil (in an emergency, #2 fuel oil can be used in diesel vehicles)
Plug-in electric or electric-hybrid vehicles with islandable solar-electric or other renewable power source for charging (distance to services defined by battery-only range of vehicle)

Storm resilience

Home or apartment built to withstand worst storm experienced in the area in the past 100 years
In most of eastern U.S. this requires Miami-Dade County Hurricane Code (or comparable) structural features
In any location within 50 miles of a location where an F2 or stronger tornado has touched down in the past 100 years: incorporation of a safe room into house of apartment building
Safe room could be community based (within one-quarter mile) as long as weather-alert radio kept activated during storm conditions
Design of home or apartment to survive flooding without creating health hazards (mold)

Notes:

Daily drinking water requirements (UN):
Drinking water (2-4 liters/day): http://www.unwater.org/statistics_sec.html
Sanitation (20-50 liters/day): http://www.unwater.org/statistics_san.html

Water requirement calculator: http://www.csgnetwork.com/humanh2owater.html

WHO Tech Brief on minimum water requirements (pdf):
www.who.int/**water**_sanitation_health/.../tn9_how_much_**water**_en.pdf

FEMA Ready webpage (download lists, Ready kits):
http://www.ready.gov/basic-disaster-supplies-kit