How HVAC Systems Can Improve Resilience of the Built Environment

Resilience through Efficient, Sustainable and Smart Systems

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Defining Resilience

"Capacity of individuals, communities, institutions, business, and systems within a city to survive, adapt, and grow no matter what kinds of ***chronic stresses*** or ***acute shocks*** they experience"

100 Resilient Cities. *100 Resilient Cities.* http://www.100resilientcities.org/

Distinguishing ‘Chronic’ vs. ‘Acute’

Chronic stress or problems

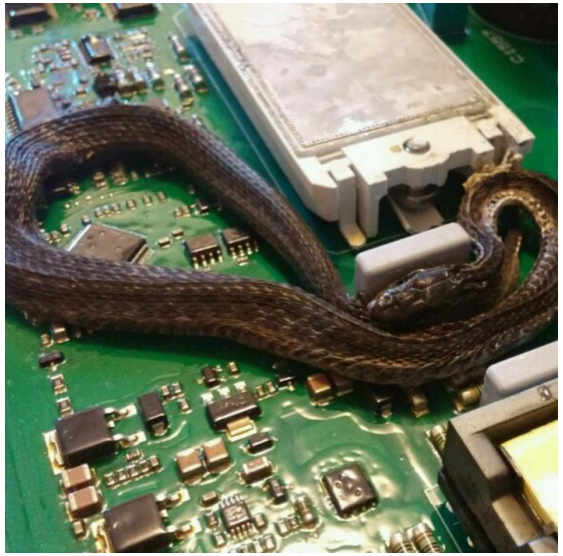
- **In a person**: diabetes; heart disease; etc.
- **In a city**: inefficient public transportation; energy, water or food shortages; air pollution; etc.
- **In a building**: poorly controlled HVAC; air infiltration; bad indoor air quality; etc.

Distinguishing ‘Chronic’ vs. ‘Acute’

Acute shock examples

- **In a person**: heart attack or stroke
- **In a city**: extreme weather events
- **In a building**: grid or HVAC failure

City and their buildings are interrelated!



Chronic:
Can a Major City Run Out of Water?

Cape Town could be the first major city in the world to run out of water

Zaheer Cassim, Special to USA TODAY Published 8:34 a.m. ET Jan. 19, 2018 | **Updated 9:51 p.m. ET Jan. 22, 2018**

Acute: Natural Events, Terrorism

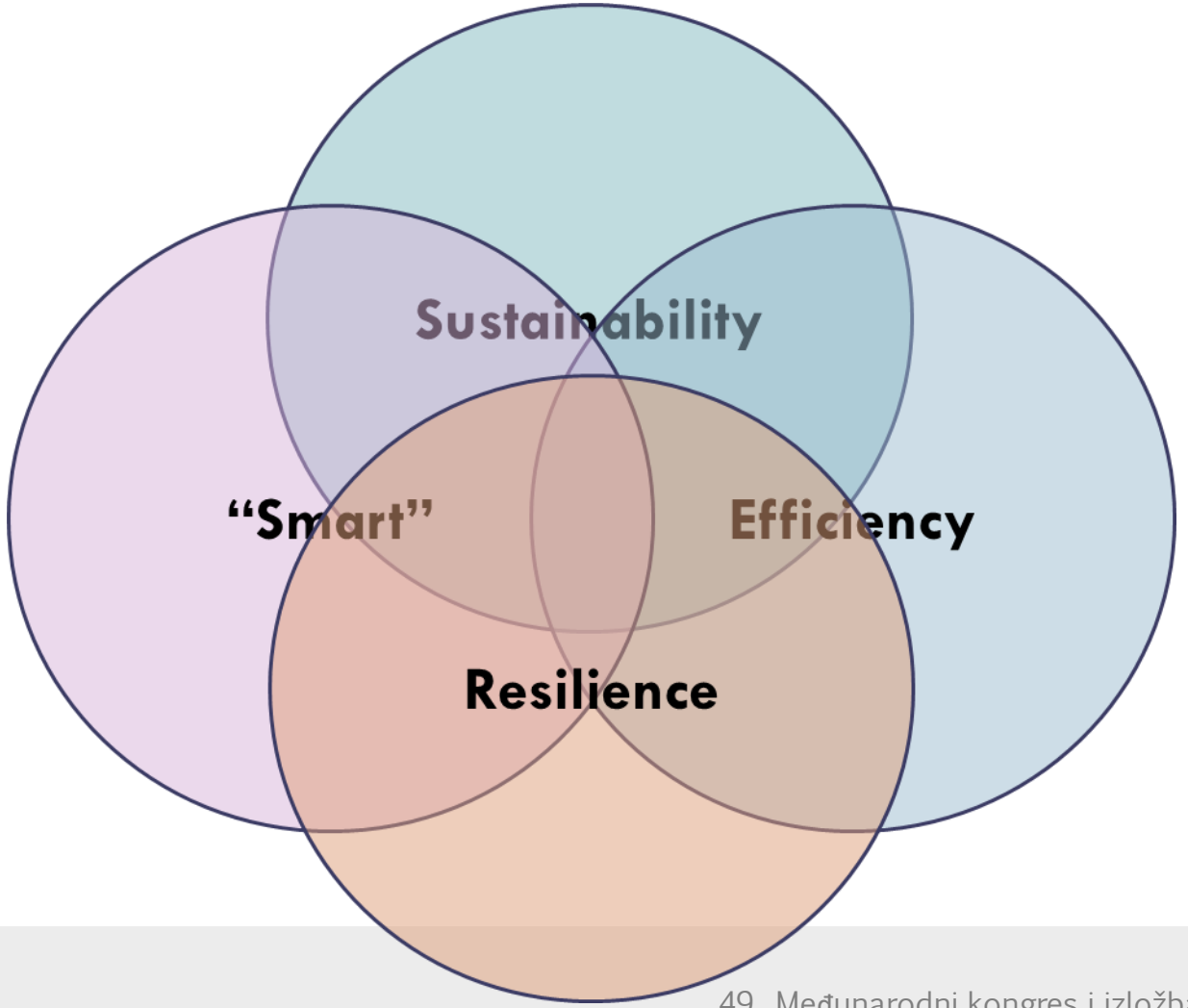
Resilience Concepts Applied to Buildings

- **Reflective**: in the use of past experience to inform future decisions How did this building handle a similar past event (such as power outage)?
- **Resourceful**: employing alternative ways to use resources Perhaps use of alternative water sources?
- **Robust**: with well-conceived, constructed, and managed systems Should be done always!
- **Redundant**: having space capacity purposely created to accommodate disruption Emergency generators or CHP?

Resilience is More than Just Technology

- Resilience of a building, city or country involves more than just the physical nature of built environment
- Vulnerability to disruptive events depends on factors such as climate region or geographic location, structure of the social systems and services.
- For individual buildings, resilience depends on
  - Building function
  - Quality of local services (electricity, water, gas …)
  - Location
  - Occupant demographics, etc.

Sustainability, Resiliency, Efficiency and “Smart” – The Interrelationship



How are These Interrelated? (*A Quick Summary of this Session*)

- Energy and water **efficiency** measures reduce overall level of demand needed to maintain services if connection is curtailed
- Measures designed for long-term **sustainability** also can help with short-term resilience
  - On-site renewable energy can be used to maintain minimum level of services, ***but only if we adapt appropriate interconnection rules with the grid!***
- **Smart** building systems allow for continued operation in short-term emergency situations

How Efficiency Helps Resilience

High-performance buildings should have high-levels of efficiency already built in.

Energy Efficiency

- Reduced demand (through efficiency) means less stress on energy supply networks
  - Electric power
  - Natural gas
- Lower consumption = lower costs +
  - More resources for improved resilience measures
  - Stronger local economy less susceptible to disruptions
  - Less externalities (emissions, etc.)
  - Perhaps easier to survive grid disruptions

Indoor Environment

- HVAC often required in modern buildings to maintain habitability
- Reducing susceptibility to disruptions helps, for example:
  - No chillers in basement level that might flood
  - Demand controlled ventilation for outdoor air
    - Reduces overall energy consumption, AND
    - Reduces amount of outdoor air that may need cleaning or decontamination

How Sustainability Measures Help Resilience

Interrelationship of Sustainability and Resilience

- Sustainability is the process for minimizing a building's overall impact on the environment
- Resilience is more of the reverse: managing how the 'environment' affects the building
- Often sustainability and resilience are aligned, but there are times that it is not (due to special conditions with that space)

Indoor Environment and Systems

- Design for redundancy of power lines, communications, water or fuel supply
- Critical systems (serving command and control infrastructure or critical refrigeration systems) must be treated differently than other systems
- Occupants should be provided measures of safety and locations to survive the event as well
  - ➢ Passive survivability through “shelter in place” rather than evacuation

How a “Smart” Building and Built Environment Helps Build Resilience

- *Smart Buildings and Equipment*
- *Smart Grid*
- *Microgrids*

Individual Buildings and Equipment

- Smart buildings and their equipment can help protect from damage or other harm (such as a cyber attack) by:
  - monitoring operation patterns
  - coordinating via cloud-based or other communications
- Building systems could automatically shift into ‘safe’ or ‘shelter in place’ mode given signals from building operations, monitoring of conditions, fault detection, or external inputs (weather service), etc.

Other Smart Building Features that Aid in Resilience

- Smart buildings should help provide a level of redundancy and be flexible in their operation
  → adds to overall resilience
- Must allow for input from building occupants and for methods of communicating with them in the case of an event

Other Key Areas to Consider

- Passive survivability
- Future proofing buildings and systems

Thank you!

- Comments, questions?