Passive Survivability Lab Insight Brief
Reimagine Buildings Collective–SUMMER 2025

Passive Survivability Lab

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Passive Survivability: No power, no problem?

1. **Resilience means more than efficiency** — Passive survivability is about maintaining habitable, safe indoor conditions during power outages or environmental extremes, not just saving energy.
2. **Heat is the bigger threat** — Over the past 30 years, extreme heat has caused more deaths than any other weather event, making summer overheating and humidity control critical priorities.
3. **Passive only goes so far** — Superior insulation and airtightness help, but without ventilation, dehumidification, or backup power, survivability in heat, smoke, or long outages is limited.
4. **Optimization strengthens resilience** — Smart passive design (shading, form, fire-safe detailing, low embodied carbon) paired with right-sized, all-electric systems and backup energy makes buildings both survivable and part of the climate solution.

1. What do we mean by Passive Survivability?

When considering passive survivability, or building resilience, it is important to define the terms used as well as the specific hazards that a building is resilient to. In general, resilience can be defined as a building's ability to maintain or return to habitable conditions following a loss of power or a change in the environment. Whether this relates to thermal extremes, wildfire, or other natural disasters, passive building practices promote buildings that are able to weather these events and protect the health and safety of the occupants.

For some time now, Passivhaus, Passive House, Passivehouse, or Passive Buildings has been promoted as a "thermal battery," most prominently after the 2014 polar vortex (JLC: Cold Snap Tests High-Performance Homes). However, there are other challenges beyond keeping the cold at bay; we must view survivability within the context of local climate conditions and technical risks.

Threats to occupant health and safety may include:

- Extreme heat or cold
- Fire and particulate matter pollution from smoke
- Flooding
- Electrical grid outages
- Energy shortages

In discussing survivability, the definition of resilience synonymous with security and comfort, anticipation of future escalating events and social impact, potential conflict of urban vs. rural issues, building and zoning codes that can create both barriers and opportunities, the need for redundancy, low tech vs. high tech solutions, the integration of food and energy systems, typical vs. Passive house construction capacity to withstand weather events.
Some questions to consider - Who defines resilience/security? How does it differ among different communities/demographics? How far into the future can we/should we plan for?

For purposes of this paper, passive survivability is defined as the ability of a building to maintain safe thermal conditions in the event of an extended power outage or loss of critical services like heating or cooling.

A reason passive survivability prioritizes summer overheating above winter cold is because heat and heat related deaths kill more people each year, and on average over the past 30 years, than from any other weather-related event. [source: National Weather Service: www.weather.gov/hazstat/] In passive designed buildings, due to its superior insulation and airtightness, once heat from air temperature or sunlight enters it stays inside until it can be flushed out with cooler nighttime air or mechanical cooling.

2. One size does not fit all

Too often we throw the same solutions at vastly different conditions and risks. Dealing with cold is almost easy compared to the problems of dealing with smoke, heat, and in particular, how climate change is driving dangerous "wet-bulb" temperatures.

Research published by Penn State University in the Journal of Applied Physiology in 2022 revealed that young, healthy adult subjects in a warm-humid environment begin to experience heat stress at a 31oC / 87oF wet-bulb temperature, at critical point where the body can no longer effectively regulate its core body temperature. Prolonged exposure at and above this level can potentially lead to heat stroke or death. For older and disadvantaged populations, who are more vulnerable to heat, that heat stress point is likely even lower. This wet-bulb temperature threshold corresponds closely to the NOAA Heat Index danger level which starts at 40°C/104°F.

Passive House can only go so far as a thermal battery for keeping cool if the wet-bulb temperaturesstay high; dehumidification will also be essential.

3. The need for active systems as well as passive

Building to passive building standards alone does not ensure survivability. It is assumed that a passive building can "coast" for a couple of days through a cold or smoke event because of its insulation or airtightness. Eventually, interior air quality begins to deteriorate due to buildup of CO_2 and humidity, and Passive House does not provide ventilation when the power goes out.
Consideration should be given to installing small backup battery systems to keep HRV/ERV fans operating, as well as some emergency lighting. The backup battery system can be small and simple, as the ventilation fan power and lighting provided by high-efficacy lighting is a low power draw. With the increasing commonality of on-site renewable energy generation, the batteries can be recharged during the event without dependence on the broader grid.

In hot and humid climate zones, humidity is the dominant factor in thermal comfort during extreme heat. A 'heat index' is a measure of how hot it feels to the human body when both air temperature and relative humidity are considered together. At higher humidity levels, sweat evaporates less effectively, reducing the body's ability to cool itself, making it feel hotter than the actual temperature.

While passive enclosures can significantly lower indoor air temperatures compared to the outdoor temperature during extreme heat events, they are not able to address humidity control without dehumidification. In hot, humid climates, managing humidity is not only a matter of comfort, but also a fundamental need, making battery backup and other distributed energy resources a critical component to ensuring health, safety, and survivability.

4. Optimization of Passive Design

Andrew Michler writes from experience in Building Forward in the Face of Fires how simple forms eliminate corners and crevices where firebrands can grab hold. Eliminating vents, careful selection of materials, and a continuous wrap of non-combustible insulation can improve fire resilience.

In an increasingly hostile climate, additional forms of building optimization should be considered. Rather than contributing to the problem of climate change, we ought to reduce the use of materials with high embodied carbon. Plans should be optimized to reduce building area and the absolute demand for energy. Sean Armstrong of Redwood Energy has demonstrated that with careful optimization and with smart choices of appliances, an all-electric 2000 square foot home including an EV can be run on a 100 amp panel.

Where passive first design can excel is limiting summer heat gain with an optimized building enclosure and proper shading. Perhaps the most important metric in design is a low BTU-h/sf to minimize peak cooling. That single metric reduces mechanical equipment sizes that are grid friendly and creates the favorable conditions of survivability during periods of power outages and extreme heat events.

Passive buildings should not just be a well-equipped lifeboat riding out the storm; from first principles it should be part of the solution, reducing demand and perhaps even giving back.