Passive Survivability and Building Codes by Alex Wilson

Hurricane Katrina taught us many important lessons. One of those is the vulnerability of our buildings to power outages. Evacuees in New Orleans were directed to the Superdome but the building overheated without electricity for fans and cooling, and recently built homes in areas that lost electricity couldn't be occupied without air conditioning. Meanwhile, older houses built using vernacular design that included low-tech, passive solutions to climate control such as wrap-around porches to shade the windows and layouts that facilitated natural ventilation remained reasonably comfortable.

Sustainability experts who were brought together by the U.S. Green Building Council in the Fall of 2005 to address Gulf Coast reconstruction recognized this problem and incorporated the concept of "passive survivability" into their *New Orleans Principles* (available online at *www.green-reconstruction.buildinggreen.com*), advising that homes and apartment buildings be designed and built to maintain livable conditions in the event of extended loss of power or heating fuel.

Understanding New Threats

Hurricanes Katrina and Rita caused extensive coastal flooding in 2005 but river systems are also overflowing their banks with increasing frequency, with some of the worst such flooding in decades having occurred this Spring in the Upper Midwest.

This "new age" vulnerability is not limited to power outages due to flooding—there are significant other threats as well.

Heat Waves

In 1995, a two-week period of unusually high temperatures resulted in the deaths of more than 700 Chicago, Illinois, residents: mostly of low-income and without access to air conditioning. A more widespread heat wave in Europe in 2003 was implicated in the deaths of more than 35,000 people.

With global climate change will come more frequent episodes of elevated temperatures. Residents in areas that have traditionally not needed air conditioning may be especially vulnerable. Heat waves not only create dangerous conditions for occupants without air conditioning but put load stresses on power grids.

Ice Storms

A January 1998 ice storm in Northern New England and Eastern Canada deposited 3 to 4 inches of ice over several days, knocking down 30,000 utility poles and 130 high-voltage power distribution towers. Four million utility customers experienced blackouts and 700,000 remained without power after three weeks.

Even the vast majority of affected residents who had natural gas or fuel oil for heat could not use it because today's heating systems rely on AC electricity to operate mechanical pumps and fans (whereas the first central heating systems employed steam distribution).

Droughts

In 2000, coal, natural gas and nuclear plant cooling accounted for 48 percent of total surface water use in the U.S. During times of severe drought the inability to cool plants may result in loss of significant power generation capacity—potentially leading to brownouts and blackouts. Droughts can also dramatically reduce hydropower electricity generation.

Terrorism

A number of leading experts, including past Director of the Central Intelligence Agency James Woolsey, believe that our power grids and fuel processing and distribution systems are particularly vulnerable to terrorism. Our energy distribution systems—which include 160,000 miles of high-voltage power lines—are largely unprotected, as are many of our major natural gas pipelines and the Alaska Pipeline. Added to this is emerging concern over potential "cyberterrorism" based on recent studies that have found our power plants to be vulnerable to attacks via the Internet or poorly protected corporate intranets.

Fuel Shortages

Many energy and economics experts contend that most of the dramatic rise in petroleum prices is not due to market manipulation but rather the result of the fundamental law of supply and demand. Simply put: the world demand for petroleum is greater than production capacity. Further, the peak in world oil production is expected within the next decade if it is not here already, as some petroleum geologists believe. In any case, the latest BP "Statistical Review of World Energy" reports that global oil production fell 0.2% in 2007 compared to 2006, and Woolsey is among those warning of the serious threat of a terrorist attack on Saudi Arabia's oil production infrastructure (as was attempted by al-Qaeda in 2006). While natural gas is produced closer to home, it too is limited—and when the yield of a natural gas field begins to drop off, the decline is much more rapid than with a petroleum field.

Both long-term shortages in petroleum and natural gas and shorter-term interruptions in supply can cut off vital fuel supplies to homes. Should petroleum or natural gas shortages or dramatic price increases result in a significant shift to electric heating (as may occur in New England this winter), it could put tremendous capacity stresses on the electric grid, potentially leading to brownouts or rolling blackouts.

Rising Energy Costs

Steeply rising energy costs pose a threat in themselves. Many low-income Americans now spend more than 20 percent of their household income on energy, up from just 4 to 5 percent a decade ago, meaning that many of them are going to have to make hard choices between heat and food this winter.

Incorporating Resilience

Given the vulnerabilities described above, it only makes sense to design and build homes that protect occupants in the event of extended power outages or loss of heating fuel. Incorporating that type of resilience is what passive survivability is all about.

The good news is that we know how to do this. Thirty years of the solar movement, superinsulation

Hurdles to Codifying Passive Survivability

Significant challenges need to be met if we are to incorporate passive survivability into building codes.

We need to begin by defining what is meant by "survivable" conditions. This will likely be a metric of how low the temperature can be allowed to drop in a house to which no heat is supplied or how readily a house can be kept at or below ambient temperature in the summer if there is no air conditioning. Is the "survivable" temperature 55°F in winter—far from comfortable but not so low that occupants would be at serious risk of dying of hypothermia? Is it 50°F? How hot can houses get before heat stroke and hyperthermia threaten lives? Further, how active can occupants be assumed to be in maintaining those conditions?

Once we determine the passive survivability targets, how do we model that aspect of building performance (a quite different measure than the peak heating or cooling loads or annual energy consumption metrics that today's energy modeling programs are generally designed to measure)?

Finally, can passive survivability performance be achieved through prescriptive measures, or would code provisions have to be performance-based (again, as with typical energy modeling programs)? ◆

movement and now the green building movement have demonstrated the feasibility of creating homes that won't get too cold if they aren't heated and won't get hotter than ambient temperatures in the summer if they aren't air conditioned. The components of passively survivable homes include the following.

- **Superinsulated envelope.** In most climates, the number-one priority is to dramatically reduce heating loads with high levels of wall, ceiling and foundation insulation, and high-performance windows (for example, triple-glazed with two low-emissivity coatings and low-conductivity gas fill).
- **Passive solar design.** Sunlight can be relied on to provide base-load heating needs during the winter. Tremendous advances have been made in computer modeling to aid in passive solar design.
- **Cooling load avoidance.** As previously noted, houses built in New Orleans in the 1900s remain reasonably comfortable in the sultry summer months largely because of wrap-around porches and overhangs that shade windows from the sun. With computer design tools, such vernacular designs can be achieved far more precisely today. Carefully situated plantings can also dramatically reduce cooling loads.
- **Natural ventilation.** Along with cooling-load avoidance, operable windows, floor plans that allow cooling breezes to blow through houses, and landscape plantings to channel summer breezes toward houses and produce cooler microclimates can all help to maintain reasonable comfort without air conditioning.

While such measures certainly have first-costs associated with them, some of those costs can be recovered by downsizing heating and cooling systems or even eliminating whole-house distribution systems. Given rising energy costs, the monthly savings from these first-cost investments in energy efficiency and passive design, if amortized into the mortgage, are typically greater than the increase in monthly payments, resulting in a cash-flow benefit.

It is also worth reiterating that unlike the conventional response of relying on gas- or diesel-powered generators during power outages, these survivability features are passive. Within a day or two of the blackouts following Hurricane Katrina, most of the buildings with back-up generators had run out of fuel or their generators had failed. Passive survivability solutions are inherently more robust because they are based on the design of the building itself.

Incorporating Passive Survivability into Building Codes

Based in part on the charrettes conducted in response to Hurricane Katrina, a small but growing number of experts now believe that passive survivability measures should be incorporated into the nation's model building codes, maintaining that passive survivability is just as much a life-safety issue as fire, wind and seismic resistance. Like each of these, passive survivability varies by actual site conditions. In northern climates, measures could include high levels of insulation, high-performance fenestration and passive solar design, while in the south cooling load avoidance and natural ventilation are more important priorities.

Broadening building codes to include passive survivability will not be easy (see sidebar), but the hard lessons taught by Katrina provide a hint of the potential catastrophe if we fail to do so. Consider the following scenario.

In the midst of a prolonged drought in the Western U.S., an extended heat wave occurs. The high temperatures prompt a sharp spike in electrical demand to serve air conditioning units, but low water levels in rivers cause many coal-, natural gas- and nuclear-fired power plants to be shut down due to inadequate cooling capacity. This in turn results in very thin margins of reserve capacity. Then some accident (a falling tree or switch malfunction) triggers a cascading power outage over a large portion of the region. Without air conditioning or other residential cooling options, the 100-plus-degree temperatures could realistically account for tens of thousands of fatalities.

While it unfortunately may take just such a tragedy for citizens and policy-makers to demand that buildings be capable of maintaining livable conditions in the event of an extended loss of power or heating fuel, we should at least begin doing the homework necessary to prepare to implement appropriate provisions when the demand comes. ◆

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Wilson is actively engaged in strategies for incorporating passive survivability into building codes and welcomes feedback to alex@buildinggreen.com.