Timbuktu; Copyright 2010 Google and Aerodata International Surveys

Climate Responsive Urbanism

Historic Precedents and Progressive Practice

by Michael Tavel

Abstract

Climate-responsive, passive design, such as for passive heating and cooling, was always an integral part of urban environments until the era of cheap energy. Patterns of passive design from the past can now be relearned from historic precedents, and applied to the urban environments of today. This paper and session will overview historic precedents for patterns of passive design in urban environments in a variety of climates and on several continents. These patterns involve not only urban morphology, but also cultural patterns of behavior that relate to climate, and to the harnessing of natural resources.

In contemporary progressive practice, urban environments have been designed to conserve resources with an emphasis on energy. This paper presents several case studies. The patterns employed involve both the energy performance of buildings in urban contexts, and the culture of peoples' relationship with resources.

Sustainability Is Not A Technology

There are many metrics that demonstrate how cities can be sustainable. Lower CO2 emissions per capita and so forth. Metrics are valuable tools in building an objective case for changes in land use policies, for example.[1] There has also been much effort on developing green construction technologies that, when applied to our built environment can reduce our resource consumption. But much more fundamental to resource conservation, to associated cultural change, and to the democratic process of that change, is to consider sustainability as a behavior.

Sustainability is not a technology. It is not a public policy. It is not an urban morphology – by itself. And it is not something you buy. Sustainability is a cultural practice of people in their relationship with resources.

The medium of the craft of urban sustainability involves technology, policy, morphology, and consumerism. What I want to consider is how urban morphologies in particular -- development patterns and building types – have been developed to make different climates habitable, reducing resource demands, and dramatically reducing heating and cooling loads. It is in the coupling of passively designed urban morphologies with behavior, with cultural practices, that we can see the role that environmental design can play in supporting an increasingly sustainable relationship that people can have with energy and with resources.

Green technologies can be applied to such passively-designed environments to further reduce resource consumption. Public policies, informed by metrics, can support sustainable urban morphologies and behaviors. But first designers, planners, and our societies need to increase their literacy in how the configuration of urban environments can reduce resource demands. Secondly, we need to understand how those configurations become coupled with cultural practices. If morphology and behavior can reduce resource demands, then technology has a much smaller job to do. If sustainable public policies are to emerge from a democratic process, then citizens need to understand those policies in terms of their personal experience – experience and practices that are related to sustainable urban form.

Old Tricks For A New World

We, and our ancestors, have just lived through a hundred years of increasingly cheap energy. The end result is that we have lost the environmental literacy, and the sustainable behaviors, that our great grandparents took for granted: The habits for keeping cool or warm without cheap fossil fuels; the practice of canning fruits and vegetables for example; and the architecture and urbanism that enables this. Everything that we do - and produce - today presumes the availability of cheap energy because that is what we have experienced.

Add to this the fact that in the United States, even in the nineteenth century, most cities were built very quickly. American traditions of urbanism were mostly exported to their locations, and cities and countryside were quickly platted so that they could be quickly sold. We lack, in North America, long-standing traditions of climate-responsive, passively designed, urban environments, fine-tuned to their circumstances. This problem was magnified during the era of cheap energy, and post WWII suburbanization, with the same building types being replicated in all North American climates. It is because of this history that Americans, in particular, need to use terms like "sustainable" or "green." We need these terms in order to describe practices that do NOT presume that energy and resources are cheap.

Moving forward, we need to relearn the passive design strategies that reduce resource demands through urban morphology and cultural practices. These strategies are best identified through the study of traditional urban environments with long-standing building traditions. For North Americans, we could study traditional urban environments on other continents in locations with similar climates, and identify strategies and behaviors employed that made those environments habitable and reduced resource demands.

The challenge is that we do not live in the preindustrial world any more. There are 7 billion people on the planet -- not the one and a half billion from before the era of cheap energy. We therefore need to take the knowledge of climate-responsive urbanism and translate it to a different context: to the cities of the 21st century, cities that will continually be increasing in density out of environmental necessity.

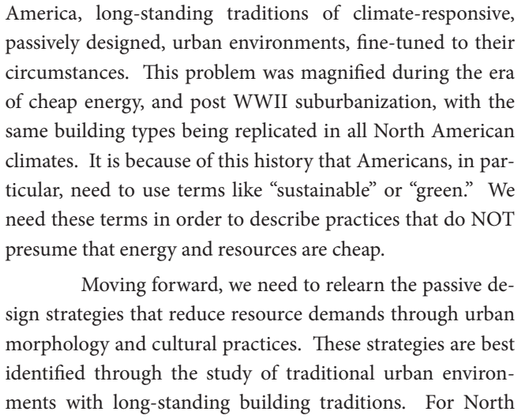

Figure 1: Locenice, Czech Republic; Copyright 2012 Google, GEODIS Brno, and Tele Atlas

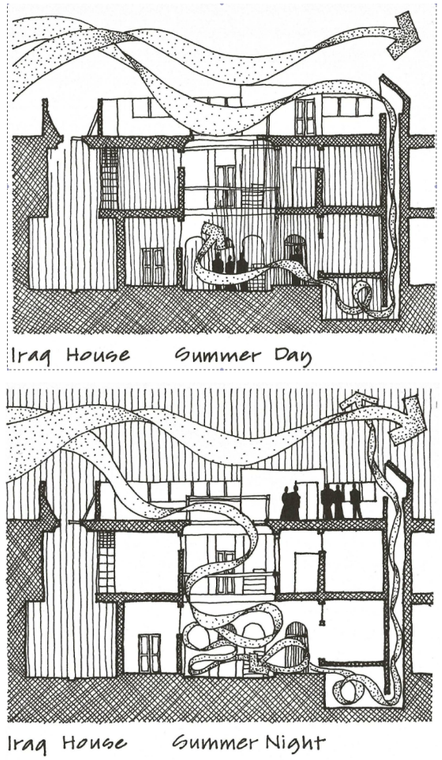

Figure 2: Iraq Courtyard House with Cool Tower; From G.Z. Brown, Sun, Wind, and Light, (John Wiley & Sons, Inc. 1985) Used by permission

Traditional Precedents

Most traditional agrarian villages would provide a picture of climate-responsive urbanism. In a Czech village, courtyard farm compounds might be stretched-out east to west to reduce summer heat gain to buildings and to maximize winter heat gain. Farm animals provide food, winter heat, and produce fertilizer for use in adjacent fields. Crop rotation keeps the soil and crops healthy. The agrarian village, and its traditional agriculture, forms a polyculture in contrast to the food production of Monsanto, with its monoculture.

In hot arid climates, keeping cool is the priority. In the traditional Islamic city, extremely narrow pedestrian streets and narrow central courtyards act to minimize summer solar gain. Evaporation provides cooling, through the use of fountains, evaporative cool towers, or deciduous trees. Breezes might be channeled through cool basements. Residents might sleep on the roof during cooler summer nights, and take shelter indoors during hot summer days.

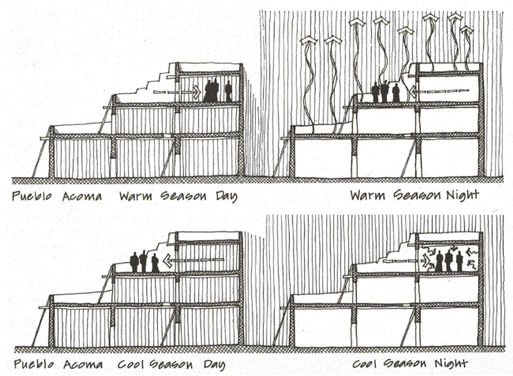

Figure 3: Acoma Pueblo; From G.Z. Brown, Sun, Wind, and Light, (John Wiley & Sons, Inc. 1985) Used by permission

In a dry, diurnal climate, like parts of Afghanistan or New Mexico, people may live and work outdoors in the winter in the sunshine on the south faces of buildings. At night they retreat inside to sleep. In summer the pattern is reversed, with sleeping on the roof in the cooler nights, and working inside during the day to escape the heat. The pueblo illustrates this.[2]

All through history people have been able to tolerate huge ranges of temperature during the day, both outdoors and in our buildings. This may have been as much as 30 or 40 degrees Fahrenheit. This ability is born of necessity, and is fine tuned with clothing, urbanism, architecture and cultural practices that are tied to a climate. With cheap energy; by contrast, American's tolerance of temperature swings is but a few degrees per day. Architecture and urbanism, where it helps people inhabit the outdoors year round, could possibly help to acclimate people to the temperatures of the seasons, reducing their demands on the indoor thermostat.

In northern European cities, like Cesky Krumlov in the Czech Republic, compact, attached building forms reduced exterior surface area, thus reducing winter heat loss. Winter sun, however, penetrated into market squares and market streets.

Victor Olgyay, in his 1963 book Design with Climate, identified passive design strategies for buildings for different climate types.[3] A summary might go something like this:

COLD CLIMATE

- Compact buildings
- Attached structures
- Slightly elongate buildings east to west, in order to capture winter sun and to reduce summer heat gain on east and west facing surfaces
- Space buildings to capture winter sun on south facades and in outdoor spaces.
- Shelter against winter winds
- Small windows except on the south
- Deciduous trees for summer shade

TEMPERATE CLIMATE

- Stretch buildings out east to west in order to reduce surface area facing east and west, and to capture winter sun
- Buildings should open to the south and southeast and be closed to the west
- Breezes cool you, so cross ventilate in summer
- North-south wings are acceptable for capturing summer breezes
- Deciduous shade trees on east and west sides of buildings, and over outdoor spaces
- Encourage outdoor living

HOT ARID CLIMATE

- Breezes do not cool you
- Evaporation and shade cools you
- Block out the sun
- Courtyards and skinny shaded streets
- Slightly stretch buildings and courtyards out east to west in order to reduce surface area facing east and west
- Minimize east and west exposure

Figure 4: Compact attached buildings in northern Europe: Czesky Krumlov, Czech Republic; Copyright 2012 Google, GEODIS Brno, and Tele Atlas

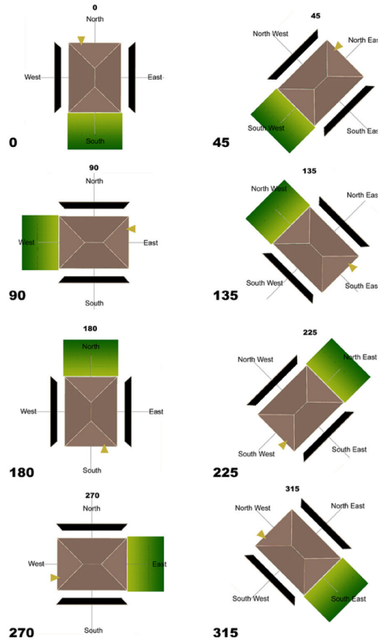

Figure 5: Different orientations of the same production home led to as much as a 70% difference in heating and cooling bills. Consol and BIRA, 2004, used by permission

- Windows small and shaded
- Deciduous trees for shade and evaporative cooling

HOT HUMID CLIMATE

- Breezes cool you, so maximize cross ventilation
- Separate and staggering buildings to capture breezes
- Minimizes walls and maximize overhead shade
- Stretch buildings out east to west in order to minimize surface area facing east and west
- Block out summer solar gain, particularly the east and west sun

One of the common and simplest rules of thumb, that run through these strategies in all four climate types, is to stretch buildings, and groups of attached buildings, out east to west in order to reduce heating and cooling loads. Simple building orientation can reduce heating and cooling loads from 20 to 70 percent. The cost of orienting buildings to reduce energy demands can be free, if considered from the outset and optimized against other interests.

In a 2004 study by ConSol and the Building Industry Research Alliance (BIRA), heating and cooling bills were compared between the same suburban house oriented north-south versus east west. A house type in San Diego, California saw a 70% lower annual heating and cooling bill when oriented east-west as opposed to north-south. A similar house type in Sacramento, California saw its heating and cooling bill reduced 30%.[4] Passive strategies to reduce heating and cooling loads are more complex than simple building orientation. But it is astounding how simple differences in orientation and configuration can have such significant impacts on energy demand.

Olgyay's 1963 book provided prototypical examples of passively-designed suburban development patterns for his four climate types. Suburban development was the imagined future in 1960. Today, dense urbanism is the imagined future. Environmental impacts per capita is greatly reduced with urban density,[5] and the continuing increase in world population is leading to cities of increasing density. The strategies for passive design therefore need to be understood within the context of dense urban development patterns. These bodies of knowledge exist in everyday culture and everyday urbanism around the world, particularly in the third world. What is needed is to bring these bodies of knowledge back into the literacy of design and planning professionals, and into the public discourse of urban policymaking.

Das Sonnenschiff

Contemporary practice in sustainable urbanism and green building emphasizes smart growth and green technology. Some developers and architects; however, are building examples of sustainable urbanism that emphasize climate responsive, passive design. One is Das Sonnenschiff in Freiburg, Germany, designed by architect Rolf Disch. The 53 dwelling unit mixed-use development incorporates passive solar design and convenient access to south-facing outdoor spaces. Rows of townhouses are stretched out east to west. South-facing overhangs block the summer sun but let in the winter sun. Homes open to the south to outdoor living spaces that are heavily planted in the summer as vegetable gardens. By emphasizing outdoor living, it is presumed that residents acclimate to the seasons, reducing their demands on the indoor thermostat. The layout also blocks winter winds, rainwater is used for irrigation, and the roofs are covered by solar panels.

Figure 6: Das Sonnenschiff, Freiburg, Germany, Rolf Disch Architect; Copyright Rolf Disch

Greensburg Green Neighborhoods

Greensburg, Kansas, destroyed by a 2007 tornado, is being rebuilt as a demonstration green municipality. Michael Tavel was asked by the non-profit Greensburg GreenTown to design prototypes of sustainable neighborhood development for Greensburg. His collaborative teamed developed proposals that emphasize design for children, seniors, and a variety of family types. Climate responsive strategies emphasized passive solar homes, outdoor living, and local food production.

In one of the proposals, a city of block is ringed by a diversity of sizes of passive solar homes. The heart of the block contains a common area with a large vegetable garden, children's play equipment, and a common green ringed by fruit trees. Building placement and hedgerows block winter winds. The intent is to make outdoor living easy, connect different generations of people together, and connect child's play with healthy food production at the heart of a community.

Figure 7: Common Green at Greensburg Green Neighborhoods, by a collaborative team led by Michael Tavel

Figure 8: Yards treated as outdoor rooms at Greensburg Green Neighborhoods

Private yards are treated like courtyards or outdoor rooms, easily accessible from building interiors. Winter winds are blocked while winter sun is captured. In summer, deep porches and deciduous trees support outdoor dining. Clotheslines are placed outdoors yet close to the laundry room. Yards are planned to accommodate large vegetable gardens and fruit trees, while also having small lawns. The morphology of the development pattern reduces heating and cooling loads by itself. But the morphology is also designed to make sustainable practices easy. Designing for outdoor living supports acclimation to seasonal temperatures. Designing for vegetable gardens or clothes drying gives dignity and convenience to those activities.

Historically, society changes its relationship with resources out of hardship, and people engage in sustainable practices out of necessity. We also change our relationship with resources out of convenience. When energy is cheap and abundant, we become dependent on that abundance. Designers can also provide convenience. We can identify sustainable practices and design places that make those practices convenient and easy.

Solar Village

Solar Village, designed by Michael Tavel, is a 27,000 sf mixed-use building at the entrance to Prospect New Town in

Figure 9: South-Facing Terraces at Solar Village, Longmont, CO, by Michael Tavel Architects in collaboration with David Kahn Studio and Solar Village LLC

Longmont, Colorado. The building optimizes passive solar orientation within a three-story urban building type. As in a pueblo, dwellings open to south-facing private and public terraces, thereby supporting outdoor living while embracing winter passive solar gain. Deciduous trees were planted on second story common terraces, to provide shade and evaporative cooling in the hot dry summers. While the building incorporates photovoltaic and solar thermal panels, it is the passive design strategies, and outdoor living that reduce energy demands.

Geos Net-Zero Energy Mixed-Use Neighborhood

The Geos Net-Zero Energy Neighborhood, designed for Arvada, Colorado, by Michael Tavel Architects and David Kahn Studio and developed by Norbert Klebl, emphasizes the reduction of resource demands through passive design strategies and by supporting sustainable practices. The 280 dwelling-unit, mixed-use neighborhood was designed from 2005-2008 and has been entitled to break ground since 2009. Energy consumption of the buildings is expected to be reduced by one third due to passive solar design. High performance building envelopes are projected to reduce energy consumption by another third. Smaller than average homes reduce energy demands even further, permitting a building design with no furnace. Yards are treated like courtyards, encouraging habitation of the outdoors. Stormwater is directed through a network of tight urban public landscapes, passively irrigating street trees. Food production, in the form of private and community gardens and greens lined by fruit trees, is laced throughout the neighborhood as its own system. The common greens, called percolation parks, form the social heart of the neighborhood and its sub-neighborhoods. They receive winter sun while supporting community gardens, fruit tree orchards, and child's play.

Figure 10: Geos Net-Zero Energy Neighborhood by Michael Tavel Architects and David Kahn Studio

The morphology of this neighborhood optimizes urban density with climate-specific passive heating and cooling strategies. This morphology; however, is also designed to make it easy for residents to be stewards. Outdoor spaces are designed to make it easy to inhabit the outdoors, to personalize private and semi private outdoor spaces. Private yards and common greens are designed to make fruit and vegetable gardening convenient, easy, and social.

Climate-Responsive Urbanism

Smart growth, green building, and green infrastructure are central parts of making sustainable urban environments. But we also need to relearn a lost vocabulary of passive design, and climate-responsive behaviors, in cities. Traditional environments around the globe provide precedents for both climate-responsive urban morphologies, and climate responsive practices. Metrics could be used to evaluate the performance of different morphologies in different climates and cultures.

Figure 11: The Geos Percolation Parks are designed to support community gardens, fruit tree coops, child's play, and community stewardship

Climate-responsive urbanism is not a paradigm in and of itself. It is a huge body of knowledge that has existed for thousands of years, but is mostly lost from the people who currently produce and consume our built environment. We need to relearn this body of knowledge, and translate it into the urban conditions that we face in the 21st century. This is relevant both to the design and policy of urban environments, and to practice of living in them.

Passive design can greatly reduce resource demands. Passive design is also, by necessity, coupled with and supportive of sustainable practices. Employing passive design strategies in urban environments has the benefits of reducing resource consumption, making urban living more affordable, and connecting human experience more deeply into a direct relationship with resources.

People's attitudes are to a great extent a reflection of their experience. When people can experience their relationship with resources, and experience the convenience of sustainable practices, it makes it easier for them to make sustainable choices as consumers, as voters, and as stewards. The process of bringing passive design into the public consciousness may be a slow one. Designers and planners; however, can support this cultural change by bringing it into their professional vocabulary, and by providing the built environments that make climate-responsive living all the easier.

Endnotes

[1] See Peter Calthorpe, Urbanism in the Age of Climate Change (Island Press, 2011)

[2] G.Z. Brown, Sun, Wind and Light: Architectural Design Strategies (John Wiley & Sons, Inc., 1985)

[3] Victor Olgyay, Design with Climate: Bioclimatic Approach to Architectural Regionalism (Princeton University Press, 1963)

[4] Abhay Bhargava, Bruce Baccei, Rob Hammon, and Mark Mrohs, "Solar Orientation Impacts on Production Home Communities," Proceedings of the 2004 International Solar ISES/ASES Conference.

[5] See David Owen, Green Metropolis (Riverhead Books, 2009)