Alternatives to Active HVAC Systems

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Alternatives to Active HVAC Systems

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Space conditioning may be provided by active cooling systems or passive systems. Active cooling systems generally consist of electricity powered vapor compression refrigeration equipment which consumes significant energy. It is not always necessary to install a complex active system to realize an acceptable thermal condition indoors. Good thermal insulation, low proportion of glazing, outdoor solar shading, the use of thermal mass, night ventilation, and alternate cooling technologies can sometimes jointly make an active cooling system redundant. These forms of passive climate controls need less energy, for cooling as well as heating, and make the indoor environment more stable. Even in combination with an active climate control system, good passive design can make the environmental conditions more comfortable.

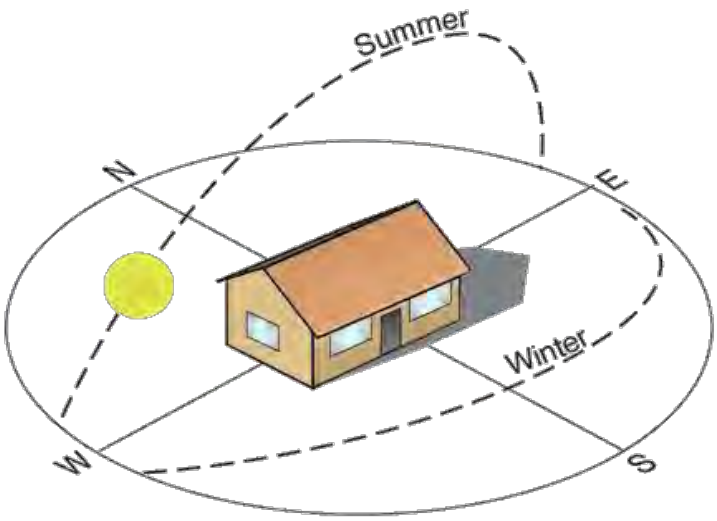
Passive cooling works on two basic concepts:

1. Minimizing or preventing heat gain

2. Rejecting unwanted heat

Heat-gain control is a simple and effective strategy. It involves an intervention in the external setting by reducing the impact of solar radiation and internal heat gains. The simplest and most effective passive cooling techniques include:

- **Building Orientation:** Keep out the sun's heat from entering the building. The fact that the sun is lower in the sky in winter than in summer allows us to plan and construct buildings that capture that free heat in winter and reject it in summer. The orientation of the whole building plays an important part; the ideal orientation for hot and dry climates should be to keep the long axis of the building east/west. This will reduce the heat gain. Conversely, buildings with their long axis running north/south will have higher peak cooling loads and will require larger cooling equipment and obviously high energy costs.



- **Vegetation:** When deciding the orientation, take into account the location of landscape. Mitigation of undesirable summer direct sun is achieved through use of vegetation; for example, planting deciduous trees interrupts the summer sun's direct path, and ground covers of grass prevent ground reflection as well as keep the earth's surface cooler.
- **Shading:** If vegetation is impractical, combinations of overhangs, awnings, exterior shades, venetian blinds, curtains, and drapers are effective strategies. The effectiveness of sun shades is not equal for all orientations of walls and therefore glazed areas should be provided only in those positions where effective protection against the sun can be ensured. Protection against diffused and reflected radiation cannot be provided by any simple method. To reduce heat gain through glazed areas they should be kept to the minimum for good day light.
    - Shading against direct radiation is easiest to provide on the south wall. A horizontal projection of at least half the window height will exclude the summer sun while still permitting sun light in the building in winter.
    - Mitigation of heat through roof and the east/west walls requires a different approach. Since the sun is low in the horizon during sunrise and sunset, overhangs are not effective and vertical louvers, or a movable screen is a better option. Vegetation is perhaps the most effective way of keeping the intense morning and afternoon sun off the east and west walls and windows, but care must be taken to avoid blockage of nighttime summer breezes that can be part of the diurnal cooling strategy.
    - The north wall can be protected by vertical louvers.
    - The roof can be shaded only by a horizontal cover extending over the whole roof and projecting beyond it on the east, west, and south sides.

- **Building finishes:** Light-colored paints and materials on the roof and the walls have low absorption coefficient that has an important advantage of reflecting much more heat than darker materials do. A white roof may absorb only 25 percent of solar heat, far less than the 90 percent absorbed by a black one. This greatly reduces the amount of heat getting into the building and simplifies the task of comfort cooling. Whitewash with lower reflectivity than aluminum will stay cooler when exposed to solar radiation because of its very high emissivity. Roof surfaces, which are exposed to solar radiation for long hours in summer, should be painted white.
- **Building construction:** Buildings characterized by high thermal mass act as "heat sponges," absorbing heat and slowing internal temperature rise on hot days. The effect of massive construction is to lower the maximum daytime temperature and to raise the minimum nighttime temperature. In warm climates it is advantageous to use massive building construction. The uncomfortable nighttime conditions in such structures can be modified by introducing additional ventilation into the building at night. High thermal mass construction is particularly desirable in regions with large diurnal ranges. They serve no useful purpose in climates with small diurnal temperature changes. For composite climates a combination of light weight and heavy construction is desirable. Historically, building materials in temperate regions adopt the low mass approach, using walls and floors of wood, which doesn't store much heat. Others, needing insulation against winter cold, have learned to use dense adobe or masonry walls.
- **Glazing:** Appropriate windows and glazing with low thermal conductivity (double glazing with inert gas) and coated with reflective film keep out more heat while remaining transparent. Wooden or PVC frames are a better option for glazing, and aluminum, if used, should be fabricated with thermal break.
- **Insulation:** The demand for heating or cooling can be significantly reduced by designing a building envelope with effective and efficient insulation. Basic steps to achieve maximum effectiveness in insulation include the following:
    - Insulate attic, outside walls, floors over crawl space, etc.
    - Add insulation to attic access panels or pull down stairs.
    - Install insulation in gaps around pipes, ducts, fans, or other items which enter the attic or exit the house from a conditioned space.

  Air cavities can be used in place of resistance insulation. By ventilating these cavities to the outside at certain times of the day or during a particular season, their resistance value can be decreased. In other words, air cavities can be employed to create wall or roof element with flexible conductivity (u-value). A similar effect is achieved by applying movable insulation to a fixed building element, although at much greater cost.

- **Radiant barriers:** Radiant barriers are materials that are installed in buildings to reduce summer heat gain and winter heat loss, and hence to reduce building heating and cooling energy usage. Radiant barriers usually consist of a thin sheet or coating of a highly reflective material, usually aluminum, applied to one or both sides of a number of substrate materials. These substrates include kraft paper, plastic films, cardboard, plywood sheathing, and air infiltration barrier material. Some products are fiber reinforced to increase the durability and ease of handling. Radiant barrier materials must have high reflectivity (usually 0.9, or 90%, or more) and low emissivity (usually 0.1 or less), and must face an open air space to perform properly. For a material that is opaque (that is, it does not allow radiation to pass directly through it), when the emissivity and reflectivity are added together, the sum is one (1). Hence, a material with a high reflectivity has a low emissivity, and vice versa.

  Radiant barriers perform a function that is similar to that of conventional insulation, in that they reduce the amount of heat that is transferred into the building. They differ in the way they reduce the heat flow. When a radiant barrier is placed on the attic floor, much of the heat radiated from the hot roof is reflected back toward the roof. This makes the top surface of the insulation cooler than it would have been without a radiant barrier and thus reduces the amount of heat that moves through the insulation into the rooms below the ceiling.

- **Control of Internal Heat Gain of the Building:** If a building is fully insulated from the outdoor thermal environment, with normal use its internal temperature will rise because of the accumulation of heat from within the building. People, lights, machines, kitchen stoves, and many such devices used in buildings produce heat. To prevent the accumulation of heat from individual sources like machines and kitchens, they should be thermally isolated from living areas and if possible they should be ventilated to the outside.

  Within the living and working areas, the heat produced from lights can be reduced by using more efficient luminaries and by proper day lighting of the building, as daylight (not direct sun light) has higher light to heat ratio than most artificial light sources. Use of premium efficiency motors and energy star rating appliances are not only low on energy consumption but also low on cooling load.

- **Natural Airing:** Design for natural ventilation especially for night cooling. A constant supply of fresh outdoor air can provide a greater assurance of good indoor air quality and improved comfort. Too much fresh air may cause uncomfortable drafts and high energy bills. Not enough fresh air can lead to poor indoor air quality.

- **Reduce Infiltration:** Air leakage through the building envelope accounts for between 25 percent and 40 percent of the energy used for heating and cooling. Tighter building

construction can improve the energy efficiency, air quality, and comfort by eliminating unwanted drafts. There are hundreds of penetrations through a typical building's exterior. These gaps and holes are often incurred during framing, and from penetrations for wiring, plumbing, and ducts. Today, off-the-shelf technologies such as house wraps, sealants, foams, and tapes reduce air infiltration. Use outlet and switch plate gaskets to reduce air infiltration. Caulk, seal, and weather strip around windows/doors.

The heat control methods mentioned above should suffice to keep buildings comfortable during mild summer temperatures but there are many harsh hot and ...ns of the Southwest, where additional cooling sources may be necessa... ...ay be used:

1. Ventilation / nigh...
2. Evaporative coolin...
3. Absorption chillers...
4. Desiccant cooling
5. Radiative cooling
6. Ground coupling and...

We will discuss the key n... ...ving sections.