# Living Buildings – The Human Analogy

**By Michael Haughey**
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Introduction: This article is an excerpt from presentations by Michael D. Haughey, P.E., to the Colorado Chapter of the US Green Building Council at the "Fall Greening Conference", on September 23, 2003; and the keynote address to the Rocky Mountain Chapter of ASHRAE (the American Society of Heating, Refrigerating, and Air Conditioning Engineers) at their annual Technical Conference on September 25, 2004, and to other groups. It is a subset of the concept of Integrated Design. Those presentations began with background material about the need for extreme energy use efficiency and sustainability in the design, construction, and operation of buildings. Those concepts will be discussed in other articles. This article begins at the question: "What does the future hold for building energy efficiency and sustainability". Some explanatory material has been added to broaden the article to be suitable for a general audience.

Many excellent and noble concepts have been developed over time to address the question of how to make buildings more energy efficient. A concept that gained momentum during the introduction of direct digital control systems (modern computer controls) in the 1970's and 1980's was that of Intelligent Buildings. It was thought that by now buildings would be learning from how occupants used their building and anticipating and adjusting to their needs. Prototypes were installed and there seemed to be momentum building. However, good old fashioned economics would not be overcome. While some controls are sold as "intelligent building controls', in reality they are not. The market place continued to demand lower and lower costs. Meanwhile the coming energy crises looms and global warming and climate change are already happening.

An Intelligent Building, as originally conceived, would need a number of components. It would need sensors to tell it what is happening throughout the building as well as in the exterior environment. These would include temperature, dew point (or humidity), concentrations of various gasses such as oxygen and carbon dioxide, concentrations of various pollutants such as nitrous oxides and ozone and excessive levels of carbon dioxide and carbon monoxide, and sensors to know how many occupants were in the building and where and their level of activity. There would be mini-computer programs, or algorithms, to compare what the sensors were reading to the levels that the occupants desire. Other computer programs would learn from how the building reacts to changes in building use as well as external weather changes. A historical database would contain information about weather and the information gained from the learning program. Predictive logic would take all of this information and use it to predict how the building will respond to changes in both use and weather, and that would feed into programs to adjust the building systems to accommodate those changes.  All of this would result in an automatic response to the occupants needs.

The concept of “Integrated Design” has also been gaining momentum. Traditionally, an architect would develop concept designs in response to the owners requirements for a building.  Once developed, those design would be given to the engineers to add their systems to the design.  While the architect does have a good idea of what typical systems, such as heating, cooling, and lighting systems, will need in terms of space and other accommodations, it remained common for there to be surprises that led to less than optimal results. The concept of Integrated Design brings all stakeholders together from the beginning.  Not only are the engineers involved in the concept design phases, but the future building occupants as well as the nearby community are often involved as well.  In this way the systems can be integrated into the building design from the start and have the benefit of the perspective of a wider variety of eyes.  While economics still preclude this from truly occurring in many if not most designs, it is becoming more widely accepted.  Combining Intelligent Building concepts with Integrated Design concepts paves the way for Living Buildings.

I believe that Living Buildings are now the ultimate goal, depending, of course, on how “Living Buildings” are defined and implemented.  In many cases, they will be able to take advantage of and optimize the earlier concepts of Intelligent Building Design.  The Living Building concept is simply that the building itself becomes essentially a living entity responding to the environment and the needs of the occupants in an energy-efficient and sustainable manner.  The components of the building begin to take on multiple roles.  Where heating an cooling systems were once completely separate systems attached to and hidden within the building structure, now we would be designing building components, such as walls and windows, to BE the heating and cooling system.

To see how this might work, I like to use the “Human Analogy”.  The building acts like the biological systems of the human body – one derivation of the term “Living Buildings”.  A number of examples can be envisioned:

> The human body sweats to remove heat – a building can use evaporative cooling systems and roof sprays
> The human body constricts exterior blood vessels to increase insulation – a building needs a variable insulation system
> The human body dilates blood vessels to pump heat to the exterior for efficient heat removal – buildings can do the same
> The human lungs clean and filter the air we breath – the building mechanical systems filter and clean the air, and can do a better job with available technology

 

Windows and other openings provide light and self-adjust as needed

> Window glass changes shading characteristics as heat or light needs change, or as the brightness of daylight (sunlight, direct or indirect) changes
> Physical shading devices adjust themselves automatically to provide cooling (or really, avoidance of heating)

The building becomes the mechanical system:

> The building mass stores heat or cool from night to day and vice versa
> Natural ventilation – stack effect – provides ventilation:  cross ventilation and wind towers are some of the concepts already in use
> Fresh air is tempered through ground heat exchangers as well as by being passed through rows of plants
> The building "sweats" to help remove heat (roof sprays and vegetated walls)

The building becomes the electrical system:

> PV (photovoltaic) circuitry built into the building exterior provides electricity from the sun
> Natural ventilation and wind towers coupled with wind turbines also generate electricity

If you think of buildings acting like the human body, and then expand the thoughts to other living systems, there opens up a vast array of ideas and possibilities.  We will then also be using "biomimickry" to design buildings.  What ideas can you think of?

The Challenge is partially to develop new technologies, however many of these technologies already exist.  The larger challenge is to apply the technologies and concepts economically and to integrate capital, utility cost (operations), and productivity budgets.  Many government entities, such as school systems, are plagued by the requirement to keep capital and operating budgets completely separate.  Thus capital can't be spent to reduce operating costs through energy savings.

A significant advantage to a well-designed Living Building, also true of a well-designed sustainable building, is that it can be inherently more comfortable and a healthier place for humans.  Comfort and health in turn can lead to increases in productivity.  Think for a moment how fast you work when you are hot and uncomfortable and your lings hurt from breathing fumes vs. being cool and breathing fresh air while being bathed in a light breeze.  Try to put a percentage to how much slower you move when you are trying to keep cool in a hot environment.  Now we can take a peak at the numbers.  A 1% productivity improvement when converted to salaries and overhead costs is about equal to the annual energy budget for a typical building. How does that compare to your estimate?

A word of caution is in order. In the interest of saving energy, some building designs count too much on the occupants accepting a lesser level of thermal comfort, yet the sales pitch for the building includes the anticipated productivity improvements. However, if the building is less comfortable, it is likely that the anticipated productivity improvements will not occur. We must be realistic in assessing what is comfortable and recognize that each individual person is different. Therefore one of the most important features of an Intelligent Living Building is the ability to adapt to the requirements of each occupant without excessively increasing energy consumption. Clearly there is much work to be done in this area.

There remains much to be done in developing the overall concepts as well. New technologies need to be developed and implemented. Technologies need to become smarter yet simpler to use. And unfortunately we are running out of time. There is an urgent need to achieve Intelligent, Living Buildings. If you doubt that we still have a long way to go, ask your local or favorite architect or engineer to describe the latest “Intelligent Living Building” project they have worked on. If you get more than a blank stare, or a denial of the concept, then look at the building yourself and see if you agree that it is truly an effective Intelligent Living Building (built in an environment that really requires a building to protect occupants from the environment, that is to say not in Hawaii).

Finally, to put some perspective into where we are now in terms of efficient building systems, here are a few examples.

Lights can now be controlled to change their output in response to daylight using photocells. Lights can also be turned on and off depending on whether people are in the room using motion detectors of infrared technology. Heating, cooling, and ventilation systems can be controlled in coordination with the lighting systems to use les or no energy when occupants are not present. Task lighting (lights on individual desks for example) can be used to dramatically reduce the overall light energy used in a space, keeping the general light levels much lower.

A number of efficient technologies are also available. Direct and indirect evaporative cooling systems can be effective in some climates and combined with mechanical technologies in intermediate climates. Ground Source heat Pumps can use the earth to store heating and cooling energy and thereby dramatically improve the system energy use efficiency. Variable speed motors are used for pumps and fans to save energy at conditions that are less than full load. High efficiency motors, as well as high efficiency boilers and chillers are also in use now.

 

Heat recovery systems are in use in a wide variety of applications to take waste heat or “cool” and recycle it back into the system to save energy. Natural ventilation can be integrated using controls to provide cooling when available and automatically (or manually) turn itself off when mechanical cooling is needed (or the converse – turn of the mechanical cooling when natural ventilation is in use).

Do you recognize any of these technologies from the building where you work?

The list of current technologies goes on, and the future list of Living Building Technologies will hopefully be a long one as well.

I expect that in the future architects, owners, engineers, and occupants will work together to “engineer” buildings as active, “living” systems that put more energy back into the grid than they use and also help to clean the air and water in the nearby communities. Countering the effects of climate change and peak oil demands no less.



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**Reference material and links:**

**Tags:**

Living Building, Intelligent Building, Integrated Design,

 

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