Over the last 20 years, there has been a lot of discussion and debate about the concept of an “intelligent building.”  Work has gone on in many forums to define and quantify what the term really means. The end result of all of these efforts is that an intelligent building is not just one thing. My definition of intelligent buildings is as follows:

**“Use of technology and process to create a building that is safer and more productive for its occupants and more operationally efficient for its owners.”**

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The results from implementing these technologies and processes are buildings that cost less to operate and are worth more to their occupants. For projects that are owner occupied, such as corporate, government, and institutions, the benefits of an intelligent building provide an immediate ROI in terms of higher employee productivity and reduced operating expenses. For commercial developments, these projects are expected to result in above market rents, improved retention, higher occupancy rates, and lower operating expenses. All around, this is a win-win situation!

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| Intelligent buildings mean many things depending on your perspective and role.  The following list is one summary of these attributes.**Process**Design:• Flexibility – designed to change;• Energy efficient design (LEED®);• Complete building modeling;• Focus on building circulation and Feng Shui and common spaces for networking; • Integration with transportation and surrounding community.Construction:• Sustainable construction practices;• Electronic project documentation;• Modeling extended into construction.Operations:• Integration of all systems;• Remote operations and optimization;• Tenant portals;• After-hours operation;• Maintenance management and dispatch;• Energy information and management systems;• Real-time energy response;• Continuous comfort monitoring and feedback.**Technology**General:• Tenant amenities:  • Concierge;  • Shopping;  • Restaurants;  • Lodging;  • Parking;   • Restrooms.• Optimized vertical transport.• Personal comfort control:  • Temperature;  • Humidity;  • IAQ;  • Lighting;   • Acoustic.Networking/Telecom:• Common network infrastructure;• Structured – maintainable cabling;• WiFi;• VOIP; and• Digital signage.Security/Life Safety:• Digital video monitoring;• Access control and monitoring;• Automatic fire suppression;• Fire detection and alarm;• Egress support (lighting, signage, smoke control, etc.);• Contaminant monitoring and containment; • Proximate security/guard services.Mechanical:• Energy efficient equipment;• Thermal storage;• Combined heat and power;• Controls optimization;• Extensive sensing;• Energy efficiency;• IAQ;• Comfort monitoring;• Internet enabled controls;• Enterprise integration;• Water and gas metering, sub-metering.Electrical:• Energy efficient lighting;• Lighting control;• Distributed generation;• Dual power feeds/emergency power;• Power quality monitoring;• Sub-metering/billing. |

So what are the technologies and processes that are required to create such a project? The list is long, starting with design and going through long-term operations, retrofit, and eventual decommissioning. See the sidebar article for a brief summary of the attributes.

Let’s start by looking at the design process for intelligent buildings. The decision to make a project “intelligent” needs to come early in the design process. Making the decision to create a new project or retrofit an existing one to make it intelligent is similar to what goes into creating a LEED®-certified project. There needs to be a commitment from the owner and their design team to invest in a project with superior performance and value. Once this occurs, the design process can continue as usual. But it is important to keep the focus on creating a superior project and avoid the temptation to “value engineer” out the intelligent components.

**PROJECT SCOPE AND PURPOSE**

One of the first attributes in an intelligent design is to carefully evaluate the current and future use of the project. This starts by clearly identifying the purpose and needs of the targeted building occupants. This process will vary depending on whether it will be an owner occupied or a commercial development. For an owner-occupied building, surveys and focus groups can be held with the building occupants, analyzing and prioritizing their needs to select proper project features. For a commercial development, the project target market needs to be identified and attributes designed to suit. For example, an office building might target technology companies that would benefit from an urban environment, high-speed network access, and 24/7 availability.

It is important to realize, however, that few projects are used as originally envisioned. A good intelligent design should incorporate flexibility to allow for easy change. Examples of this type of design characteristic include CLA (communications, life safety, automation), structured cabling design, and open space with movable or demountable partitions. An intelligent building needs to be designed to meet the needs of initial occupants and be flexible to meet the needs of future occupants.

**CONCEPT AND BUDGET**

When setting initial project budgets, intelligent attributes must be included. Creating an intelligent building does require an investment in advanced technology, processes, and solutions. An upfront investment is required to realize a significant return later on. It is unrealistic to expect to make a project intelligent unless there is early buy in on investment. Again, these decisions need to happen prior to the start of design work. One of the challenges is to educate owners on the benefits of an intelligent building design. Waiting until the MEP is brought on to the design team may be too late. This makes the education of both owners and architects about the benefits of intelligent solutions critical for success.

**SITE SELECTION AND INTEGRATION**

An intelligent design begins by looking at the site as it integrates with the community. Is this a location that is a new “green field” location, or a reuse of an existing “brown-field” site? Can the project be sited for maximum solar efficiency? How will it fit in with community land and space planning? Does it integrate with existing (or planned) public transportation?

Site integration and impact are critical for environmental impact, and strongly affects how the building occupants interact with the building. At a macro scale, community integration is determined by community space planning and zoning regulations. An intelligent building should go beyond that with consideration as to how this fits in with the community’s needs, transportation, and amenities. The combination of the two makes the building more marketable with a lower impact on the environment.

**ENVIRONMENTAL DESIGN**

An intelligent building starts with an environmentally friendly design. Creating a project that is environmentally friendly and energy efficient ties in closely with many of the intelligent attributes. Intelligent buildings are designed for long-term sustainability and minimal environmental impact through the selection of recycled and recyclable materials, construction, maintenance and operations procedures. Providing the ability to integrate building controls, optimize operations, and enterprise level management results in a significant enhancement in energy efficiency, lowering both cost and energy usage compared to non-intelligent projects.

Intelligent buildings are intended to be the preferred environment for occupants. This requires focused attention to environmental factors that affect occupants’ perception, comfort, and productivity. An intelligent design finds the balance, providing a superior indoor environment and minimizing energy usage and operating labor. This is where the technology becomes valuable. Using integration and automation we are able to implement solutions that both provide a superior environment and minimize energy (Table 1).

**USGBC LEED®**

The USGBC LEED program provides an excellent mechanism to promote, measure, and quantify environmental and energy efficiency in both new and existing projects. There is a very strong synergy between an intelligent building design and a LEED-certified design. Intelligent buildings demand reduced energy usage through optimization, system integration, and enterprise applications. LEED certification requires energy efficiency, monitoring, validation, and control of all building systems. The goals and benefits of LEED and intelligent building design go together arm and arm. An intelligent building program should start with LEED certification and work to improve the building beyond that.

**BUILDING MODELING**

An intelligent design needs to start with a complete model. This modeling begins early on with CAD designs that evolve into project renderings. Using new standards such as AEC-XML and GB-XML, this information can readily be shared with HVAC and other system models. Modeling of an intelligent building will be used not just in design, but will continue into construction and operation.

In the past, building modeling has been widely used as a design tool and often for construction as well. In an intelligent building we would expect that this model will be used by new sophisticated tools that will actually be able to use the original modeling information to make decisions about optimization and continuous recommissioning of critical building systems. Ideally, the model will follow through the lifespan of the building, be updated as necessary and serve as a digital document of the building.

[****](http://www.automatedbuildings.com/cgi-bin/redirect/sinclair/hotspotclicks.log?http://www.spartan-pd.com)**BUILDING CIRCULATION AND NETWORKING**

Buildings exist to enable collaboration, allowing occupants to be productive, efficient, and creative. Intelligent buildings provide for improved occupant circulation, interaction, and collaboration. From a design perspective this means attention to how the occupants will circulate through the building. How will they enter the space? How will they move efficiently vertically and horizontally through the space? Can we incorporate digital signage to improve navigation and circulation?

Collaboration can also be improved through the use of design elements to encourage networking in both formal and informal spaces. Formal collaboration
spaces are conference rooms, break rooms, classrooms, and seminar rooms. Informal collaboration spaces include niches and seating spaces in corridors, coffee shops, outdoor seating areas, and other places where building occupants can get together for brief planned or unplanned interactions.

**CONCLUSION**

The goal of having an intelligent building only starts with early planning in the design stage. In many ways, this mirrors the design and fulfillment of many green or LEED projects today, but it uses technology to provide for a superior space. There are enormous benefits to be gained by creating intelligent buildings. We need to continue to work as an industry to quantify these benefits, educate owners and consultants, and to deliver a superior product to the market.

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| **FEATURE** | **BENEFIT** |
| Dimmable fluorescent lighting integrated with sun blind control | Optimal lighting level and quality can be determined by the occupants. |
| Lighting control with motion sensors integrated with security | Only provide lighting as needed. Reduces energy use and increases security. |
| Natural and displacement ventilation. | More efficient and effective distribution of ventilation. |
| Use of economizers for free cooling. | Energy efficiency. |
| Individual temperature and lighting control. | Improved comfort is shown to improve productivity. Addresses the number one concern of tenants as found in BOMA surveys. |
| Radiant heating and cooling. | Improved comfort, reduced energy use. |
| Optimized control algorithms. | Reduce energy use with little or no impact on comfort. |
| Combined heat and power plants. | Improved energy efficiency and sustainability. |
| After hours control of lights and HVAC integrated with security. | Improved security while reducing energy use. |
| Monitoring of IAQ and contaminants. | Improved comfort, safety, and productivity. |

TABLE 1. Examples of how technology helped provide energy efficiency and a superior environment.

Growing greener buildings is not a new concept.  In September 2003, I presented a paper at the Worldwide CIBSE/ASHRAE gathering of the building services industry in Edinburgh, Scotland. The conference addressed the issue of delivering sustainable buildings while remaining profitable and delivering value to clients. My paper was titled “The Greening of Buildings with Computerized Web Enabled Automation,” and an excerpt follows:

*“Opportunities arrive daily to intelligently use building automation as more than just a connector of ‘brute force’ comfort generation systems. To realize this renaissance, the building automation industry must become part of the globally expanding green building movement and show how improved occupant/architectural interaction can enhance environment-friendly buildings. Using evolving automation, we can bring passive designs alive with the necessary missing ingredient ‘intelligent interaction.’*

*“The low energy impact of the original raw materials required to create the building automation systems, coupled with their potential power creates the greenest of all building materials. Automation’s capability to provide significant change with only grams of substance, and the inherent ability to be easily reconfigured to grow and adapt with the building makes it the essential backbone of leading green building design. Web-enabled building automation takes us to a higher level of interactive communication with the architectural fabric.”*

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**THE HEAVY HITTERS**

So, what are the new opportunities that are arriving to allow us to intelligently use building automation. I predict that GridWise™ (<http://www.gridwise.org>  will become the killer application for building automation, making all large buildings part of the electrical grid.

The GridWise Alliance is a consortium of public and private stakeholders who have joined together in a collaborative effort to provide realworld technology solutions to support the DOE’s vision of a transformed national electric system. It is an electric system that will employ new distributed “plug and play” technologies using advanced telecommunications, information, and control approaches to create a society of devices that functions as an integrated transactive system. GridWise refers to the national electricity system, information technology, networking, and the Internet. GridWise is an initiative to stimulate development and adoption of an intelligent energy system that enables more effective use of the U.S. electric system. This will result in significant opportunities for energy efficiency, but of equal importance it can result in a more reliable electric grid.

GridWise is the first of many automation strategies that will extend building automation beyond the building envelope to the community, and even to the nation and beyond.

What else?

The LEED® green building rating system, ( [http://www.usgbc.org/DisplayPage.aspx?CMSPageID=221&](http://www.usgbc.org/DisplayPage.aspx?CMSPageID=221&" \o "http://www.usgbc.org/DisplayPage.aspx?CMSPageID=221&) ), version 2.1, was promulgated to improve the environmental and economic performance of new and existing commercial, institutional, and high-rise residential buildings.

The acceptance of many new communication and computerized concepts has radically changed the function of our large buildings. Office hotelling has allowed the sharing of expensive office buildings with an increased number of telecommunicating occupants. To manage this phenomenon effectively, coordination of everything is required, such as personal environment, phones, workstations, data links, security access, etc. Occupants also must have the ability to interact with their environment virtually. The greenest of buildings extends beyond shared office space; it includes sharing the total transportation and support infrastructures while making our residential interface more efficient.

**WHAT ARE SOME OTHER RESOURCES?**

[****](http://www.automatedbuildings.com/cgi-bin/redirect/sinclair/hotspotclicks.log?http://www.automatedlogic.com)The CABA IIBC.The Continental Automated Buildings Association (CABA) Intelligent & Integrated Buildings Council provides a significant resource and works to strengthen the large building automation industry through innovative technology-driven research projects.

“The IIBC is extremely pleased that both private and public sectors are actively supporting the completion of the integrated automation life cycle cost tool,” said Tom Lohner, vice president of TENG Solutions and IIBC chairman. “The task force has put significant effort in the development of the life cycle cost model. These contributions will go a long way to funding the completion of an interactive, Web-based life cycle costing tool. The industry intuitively believes that integrated and intelligent buildings have significant return on investment. Now we can prove it.”

The Intelligent Building Ranking System Task Force is developing an online tool intended to assist building owners/managers, the commercial real estate industry, and other industry stakeholders to assess the level of integrated systems within a building (a Building Intelligence Quotient [BIQ]). A comprehensive list of intelligent building criteria has been developed as well as a “ranking matrix.” The next phase of this project is to develop content detail on each line item in the matrix to be available as part of the online tool – for ease of use by all industry stakeholders.

The following and other resources can be found at <http://www.caba.org/councils/council-pubs.html>.

**Middleware White Paper.** This paper defines middleware and describes a number of case studies where middleware has provided a solution to integrate new intelligent building technology implementations with legacy systems.

**Building Control Network Protocols White Paper.** Communications protocols are simply a means by which different systems may communicate. They are the message formats and procedures used to transfer information, in an understandable form, from one device, or array of devices, to another. They permit products from different vendors to communicate with each other and interact to produce intelligent integrated building systems and manage and interface with these products as if the same vendor supplied them all. This paper, prepared by CABA’s IIBC Building Protocol Task Group explores four of the most common protocols used today and compares a number of the parameters that “Assist the large building industry to understand the strengths and overall features of the building control communication protocols that are available for use in designing and implementing an “intelligent building.”

**Best Practices Guide for Evaluating IBT.** This guide, authored by Kenneth P. Wacks, Ph.D., builds upon the Technology Roadmap for Intelligent Building Technology. This paper consists of criteria by which intelligent building technologies can be evaluated. The topics in this guide are important for various audiences, such as building owners and managers, intelligent building designers, and installers.

Building intelligence can close blinds, lower awnings, turn solar panel arrays, increase ventilation air, predict outdoor air temperature, flush urinals, lock doors, recognize identities, and turn on and off the lights. These are conventional concepts but with a little imagination we can help the green team achieve what has never been done before.

We need to reset the hinges of our conventional thoughts and think in freer terms. Much of our wisdom is based on many years of applying hardware limitations to our complex occupant interface applications. Our prior interfaces are a collection of compromises to achieve an acceptable occupant, environment, and system interface. We now have new tools and can do a better job. We need to revisit our reasons for reason and work as a new team of occupant, owner, and vendor. The industry is now freer in structure, with tools that are softer and more pliable. Together we can do a better job of occupancy integration while reducing the environmental footprint.

[****](http://www.automatedbuildings.com/cgi-bin/redirect/sinclair/hotspotclicks.log?http://www.fieldserver.com)As new relationships with building owners evolve, our ability to provide cost effective optimization and support services online will win us market share. Access to our assembly of online individuals will be our added value. Our collection of expertise that we are able to reach out and utilize will become a tangible asset. Our strengths will evolve into managing the complex building services requirements for the owners’ enterprises.

**CONCLUSION**

Growing greener buildings with Web-enabled automation will not only change our industry, it will have significant impact on how building owners approach management and optimization. The guidance of successful convergence will become a valuable art. The practitioners that can work with this new fabric and create the dynamic interface while making the myriad of complex technologies used to create this reality all but invisible will be the winners. To the companies and their artisans who move us ahead with successful demonstrations will go increased market share.

New relationships and partnering will abound. Smaller and smaller companies will provide greater impact on the industry through online interactions that become available with Web-based presentation. The concept of partnering to provide our clients’ complex requested software functionality will become common. These partnerships will lead to significant cross-pollination with complete new technologies and concepts, all of which will feed the convergence fire. New mediums for our industry such as cell phone, PDA, video, digital signage systems, etc., will be seamlessly integrated.

The reality is the convergence of facilities management and IT is well underway. It is a convergence that heralds the inevitable move of environmental monitoring and control onto the building information infrastructure. Though it is often the technological issues that are stressed, it is a convergence of both technology and the working community relationships.

The understanding of the above concepts will allow the green building practitioners to discover the true power of “growing greener application for building automation, making all large buildings part of the electrical grid.

The history of the green building movement to date shows a subtle but persistent bias by architects away from the application of more advanced technologies in the comfort systems that serve these buildings. There are rational and valid historical reasons behind such a bias. At times, more advanced comfort system designs have tended to preclude the use of simple “green” elements. For example, a perceived incompatibility between the use of operable windows and more advanced climate control systems has led architects to seek lower technology comfort systems in order to keep operable windows.

However, the design community as a whole appears to be awakening to the reality that simple, occupant- and resource-friendly building elements can be entirely compatible and even synergistic with the application of more advanced technologies in the comfort system elements. It is also becoming apparent that the application of advanced technologies has the capacity to significantly improve the sustainability of building projects. As a result of this progress, it is now becoming essential that designers consider advanced technologies in their green building comfort system designs.

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**EVALUATING THE POTENTIAL BENEFITS OF ADVANCED TECHNOLOGIES**

The first step in considering advanced technologies for a green building project is to determine what benefits these technologies can bring to a design. The answer for many projects is that advanced technologies offer large potential reductions in comfort system energy use. New network enabled system configuration and control technologies that are made possible with the Equal Marginal Performance Principle1 have the capacity to achieve significant reductions in electric energy for the fans, pumps and compressors that are fundamental components of many building comfort systems. Use of these technologies makes it possible to configure integrated building comfort systems that can generate and deliver comfort with considerable reductions in electric energy use.


Figure 1

Figure 1 shows a comparison between cooling system electric energy usage for an office building in the south western US when an optimized conventional system (green bars) is reconfigured to a network based system of the same first cost (blue bars). It is important to note that the comparative (percent) reductions shown in Figure 1 remain essentially the same as the building envelope and other aspects of the building are designed for improved efficiency. This means that the electric energy budget for cooling in many buildings can be expected to be cut about in half when the conventionally optimized cooling system is reconfigured for network controls. And these savings can be achieved without increasing the cost of the system.

**MAKING ADVANCED TECHNOLOGY SYSTEMS WORK**

[****](http://www.automatedbuildings.com/cgi-bin/redirect/sinclair/hotspotclicks.log?http://www.csimn.com)Reducing building comfort system electrical energy use by half without adding to the construction budget is certainly an attractive design option, especially for green buildings, but achieving this level of reduction is not as simple as merely adjusting the project drawings and specifications to incorporate newer network based technologies and control concepts. Designers must also recognize that the current processes by which building systems are designed, constructed, and turned over for operation are not usually effective in supporting the application of newer technologies. So, to achieve success with advanced technologies, the design team must be ready to change the project ***process*** as well as the technologies that will be applied.

The root of the “process” problem in applying more advanced technologies to building comfort systems is the disconnect, or lack of effective communication, between the various entities in a building construction project. The designer, individual contractors, equipment suppliers, commissioning agent, and system operators are the key players in achieving a successfully operating building comfort system. But in many projects, there is little or no opportunity for all to sit together and discuss freely how the basic elements of the design intent will be provided in the equipment, installed, verified, and supported in operation. As a result, building systems that employ even small variance from conventional comfort system technologies run a high risk of underachieving their performance goals. There are then two elements upon which designers must focus to apply advanced technologies effectively in their green building projects if they wish to maximize the performance of these projects. First, designers need to assemble a team that truly understands and is ready to support all the technologies that are desired for the project. Second, designers need to work with the architect and owner to ensure the process empowers the design team with the ability to ensure the technologies are properly applied in order that the performance expectations of the design are achieved.

**VERIFICATION OF SYSTEM PERFORMANCE**

One of the most important aspects of adjusting the conventional building design and construction process to support the application of more advanced technologies is to incorporate a simple and effective ongoing system performance verification process within the system design. Such a performance verification process need not be expensive nor cumbersome when it is applied into the same intelligent Web-based network system that is incorporated as the platform for the advanced controls employed to achieve the higher level of building energy performance. Such Web-based systems permit contractors, the commissioning agent, and later the operations and maintenance staff or contractors, to collect real-time information on operational anomalies that can be quickly diagnosed and remedied with oversight from the designers — simply and inexpensively.

To be successful, such a performance verification process must be a central element of the project design. It must be simple to use, and it must provide useful performance information and make available more detailed information, both real-time and historical. With this information, any operational anomaly or performance shortcoming can be quickly and easily diagnosed remotely and corrective actions coordinated for effective and prompt resolution.

[****](http://www.automatedbuildings.com/cgi-bin/redirect/sinclair/hotspotclicks.log?http://www.catnetsystems.com?src=9)**SUMMARY AND CONCLUSION**

The application of advanced network based technologies in cooling system designs offers a reduction in energy use of about one half of the electrical use of more conventional optimized system designs. But to ensure the success of these advanced technologies in green buildings, design engineers need to focus on a role of making the system work. Certainly this includes establishing a realistic system design intent, developing drawings and specifying equipment and processes. But these traditional engineering functions are not sufficient to ensure success when more advanced technologies are being applied. For these, the designer must also work closely with the equipment suppliers, contractors, commissioning agent and system operators to ensure the design intent is adequately supported throughout the implementation and startup and initial building operation. This increased role is absolutely essential in realizing the full potential of advanced technologies in green building projects.

**REFERENCE**1Hartman, T. 2005, “Designing and Operating More Efficient HVAC Systems with the Equal Marginal Performance Principle,” ASHRAE Journal, July.