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Blackout Puts Buildings Under the Microscope

Gill

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Shifting Analysis from Supply Side Deficiencies of August 14th Blackout to Demand Side Aspects Suggests Logic of "Smarter" Buildings

by Tony Gill

Highlights:

- Power outage suggested changing usage patterns will ultimately impact operations of organizations forcing them to incorporate this uncertainty into business continuity plans
- Many regions prepared for rolling blackouts as operators tried to stabilize situation; had immediate impact on businesses having to establish reduced work schedules and operational downtime
- office buildings consume 27%-36% of the US's electrical supply; their energy bills are highest of any commercial building type; configuration and economics makes them energy hogs
- Tenants who lease office space employ approximately 25% of U.S. work force
- Buildings are often wasteful because they are built according to a linear model generating waste; runs contrary to building operating within context of a closed-loop natural systems model
- 50% of energy used to operate HVAC and lighting; "smarter" facilities can reduce this; requires coordinated movements from public/private entities, changing attitudes i.e. increasing importance of organizational responsibility (studies show corporate ecological sustainability is being embraced)
- capital expenditures associated with building new or upgrading existing with smart features can often be recaptured within compressed payback period
- energy smart buildings enhance worker productivity by improving comfort and performance
- although there might be an incentive for a user to take a more environmentally-friendly approach to a customized design-build, the economics of multi-tenant office use traditionally have not supported smart buildings; rethinking building economics can constructively address problem
- increasing standards of organizational responsibility, prospect of enhanced financial performance, and energy-efficient building features actually help building owners attract and retain tenants
- Smart Building definition 1: one that is healthy and efficient in its use of resources, with little or no toxicity, and places emphasis on less wasteful work practices, and energy efficiency; definition focuses on integrating nature's renewable systems, including daylighting, solar power, on-site water treatment, deep water cooling
- Smart Building definition 2: one that integrates new technologies from computer automation, space age materials, and energy management; synthesis of these inputs resulted in a structure that was much less like a building than an entity; this is made possible through new intelligent building systems including smart sensors
- Building energy efficiency programs that dovetail with business continuity can occur on wide range of projects including design builds, retrofits, and building systems upgrades

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Introduction

The power outage that affected over 50 million people in the North America's northeast corridor on August 14th demonstrated North America's insatiable appetite for energy. This demand has resulted in tenuous supply conditions. Although authorities haven't pinpointed the exact cause of the blackout, one fact has become crystal clear: North America is in a critical balancing act between supply (generation capacity) and demand for power. It's ironic that the interstate electric power grid that failed was initially designed to make blackouts a thing of the past. The thought was that by linking local power systems, a failure in one could be made up by the rest, ensuring that no one would be without electricity the power. August 14th suggests that at the current rate of increasing consumption we will not be able to satisfy our demand for power. Should this occur, it will affect operations of organizations across the continent, and force them to incorporate this possibility into their business continuity plans.

Sound farfetched? Let's compare Canada, a country of 30 million people to India which has over 1 billion. Despite the gap, Canada actually consumes more total – not per capita – *total* energy than India. For example, according to a Canadian officials per capita electricity use is 347 kwh in India, while Canada's per capita power usage is 43 times higher. Quite remarkably, however, it is *India* that has had to adjust to rolling blackouts and become accustomed to 10% power downtime. Downtime of even a fraction of that figure could be disastrous to some organizations in North America, who need to be fully operational at all times. Thus, business continuity planning under the specter of rolling blackouts plays a critically important role.

A glimpse into the possible future was provided in the Province of Ontario in the week following the blackout. Throughout the week Ontarians prepared themselves for rolling blackouts as government officials and utility operators tried to stabilize the region's power grid. This had an immediate impact on businesses that had to establish reduced work schedules and cutbacks to accommodate. Although the figures have not been tabulated, the cumulative cost of these restrictions could be anywhere between $500 M and $1B. These figures don't even begin calculating losses incurred in the US (The New York Times reported that losses in personal income among 8 million city residents could run as high as $750 million). These cutbacks are unsustainable; therefore, it's not only vital to make changes to the infrastructure that *supplies* the power, but to change the infrastructure that *consumes* it as well.

Real estate facilities are big consumers. In fact, office buildings are among the biggest energy hogs in North America. A 1997 article by Daniel Kaplan in the Clean Air Counts website claimed office buildings consumed 27% of the US's electrical supply (1) (Scientific American claims buildings drain 36% of the nation's total energy(2)), and according to the U.S. Department of Energy, office buildings "consume operating budgets as voraciously as they consume energy; in fact, office building energy bills are highest of any commercial building type"(3). The US Energy Department notes that while HVAC/lighting are still the big power consumers, office equipment now accounts for almost 16% of an office building's energy use(4). The problem with buildings simply can't be ignored any longer, especially since tenants who lease space in office buildings represent approximately 25% of the work force (Statistical Abstract of U.S.)(5).

A snapshot analysis of a typical office building shows why they are so energy inefficient. For starters, consider typical floor plates have large core-to-wall depths, as well as a correspondingly low ratio of perimeter envelope to interior space. This combination of factors requires additional lighting and ventilation requirements. The fact that most buildings lack a significant amount of roof space limits their owners' abilities to tap into natural systems such as solar power. The prospect of incorporating interior lighting systems and better insulation is limited by a natural economic penalty for creating multi-story spaces, thick exterior walls and additional height. In short, the natural configuration of office buildings makes them energy hogs. If we want to address our excessive reliance on power and avoid entering a period marked by rolling blackouts, it would be logical to begin by examining the places where we work, and make them more energy efficient.

This paper provides building owners, users, business continuity planners and the institutional investment community with an overview of the current landscape of smart building technologies that can significantly reduce energy use in office buildings. It will show that on an aggregated

The Northeast Power Outage left buildings in Manhattan in the dark
(McGraw Hill *Construction*)

Quick Stats:

- Office buildings consume 27-36% of the total energy consumed in the United States
- Office equipment now accounts for 16% of office building's energy use
- Tenants who lease space in office buildings employ approximately 25% of U.S. workforce

Smart Buildings: Not a New Concept

basis, a concerted effort by the real estate industry to create smarter, more energy-efficient facilities will contribute to stabilizing energy-related problems that somehow don't seem as far-fetched as they did before the blackout. By addressing these issues, the real estate industry will positively contribute to strengthening the ability to maintain business continuity.

We organize the discussion as follows:

- provide evidence office building over-consumption of energy
- highlight new standards of corporate governance that mandate environmentally friendly policies
- demonstrate ways in which smarter buildings can more effectively tap into natural elements to reduce their dependence on non-renewable resources
- provide an overview of new building-centric technologies that will contribute to lowering energy usage
- and finally, provide examples of particularly smart buildings that offer a glimpse of what a new energy-efficient building landscape might look like in the not to distant future

Ultimately, this paper provides a useful framework for organizations to begin the task of assessing how the facilities they occupy or build use energy, and how to incorporate these findings into the realm of business continuity planning.

Linear vs. Closed Loop Systems

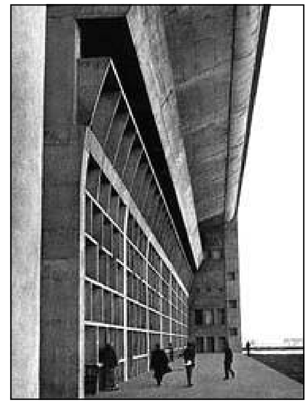
One of the traditional contributors to building wastefulness has been their being built according to a linear model that generates waste (e.g. they leak water and heat, and generally use non-renewable resources for heating and cooling). Such facilities often pay little or no attention to regenerating the resources they use – clearly, an energy-intensive and environmentally non-sustainable model (it should be pointed out that we shouldn't be so rash in making sweeping assumptions about all buildings; for instance, most municipalities have made it illegal to put water from building systems into sewers). Linear systems run contrary to the idea of a building operating within the context of a closed-loop natural systems model – an ideal primarily modeled upon the sustainable closed loop systems that exist within nature.

The blackout demonstrated just how heavily dependent we have become on a continuous flow of electricity to the point that when a blackout occurs, it can have a pronounced effect on business continuity and have made us especially vulnerable to breakdown. The impacts of these outages can be minimized or eliminated altogether if a participatory design approach is implemented. Indeed, public and private organizations, developers, architects, urban planners and all levels of government can collaborate to replace linear systems with natural systems that work around buildings to create a higher degree of sustainability. Such natural systems would include readily renewable resources such as sun, trees, water and wind.

Early Smart Buildings

The challenge to construct buildings that minimize their reliance on non-renewable power sources and are designed in accordance to closed-loop systems is hardly a new phenomenon. For example, after India's independence in 1947, one of the great projects it embarked on was to build a new capital city for its northern Punjab state (the former capital, Lahore was absorbed by the new country of Pakistan). The city was named Chandigarh and the fledgling government was committed to create a unique living environment that reflected the new spirit of post-colonial India. A worldwide design competition was launched, and was won by the noted French architect Le Corbusier. The central challenge faced by his team was not only to lay out the blueprint for a new city, but to design buildings that would logically address limitations including a dry arid climate, oppressively hot summer temperatures, and most notably, the scarcity of electric power.

One of the Executive Engineers of Construction on Le Corbusier's team was Ajit Gill, a civil engineer and Professor Emeritus of Florida Agricultural and Mechanical University in Tallahassee. Dr. Gill noted that in a place where temperatures from April to June often reached the mid 40's (centigrade), and air conditioning systems were virtually non-existent, the challenge was to create a comfortable working environment within office buildings. The buildings were thus designed to avoid direct sunlight, and provide building-wide cross ventilation -- this was accomplished by positioning buildings parallel to prevail-



The Palace of Justice (Chandigarh) is a large umbrella structure that covers the entire site and is raised high above the main part of the building to permit the circulation of air to keep the lower part of the building cool (serialdesign.com)

"The impacts of outages can be minimized or eliminated altogether if a participatory design approach is implemented"

Quick Fact: "50% of the energy used to operate buildings HVAC and lighting"

Economic Reward for Implementing Change…

ing wind patterns. "Sun Breakers" (or "light shelves") (discussed later) were put in place to not only shade offices from direct light, but used to create valuable sources of dispersed internal light. Finally, in some instances "hollow walls", where air was entrapped between walls would be used for insulation, not allowing heat to flow (hollow wall techniques would be the pre-cursor to contemporary construction techniques such as double-skin cladding).

These systems lessen the demands of heating ventilation and air conditioning (HVAC) systems. In fact, statistics suggest 50% of the energy used to operate buildings HVAC and lighting(6), therefore the greatest way to counteract this requirement, reduce the environmental impact, and save money is to tap into natural systems such as sun, water and wind for HVAC needs (according to Worldwatch, positioning windows to capture sun in winter, along with insulation and airtight construction, can cut heating needs more than 97%(7)). Because of the substantial capital expenditures involved in making these changes (not to mention the long-term nature of real estate commitments) they cannot occur overnight, as they are thus long term in scope. However, savings can be generated in the short-term by selecting efficient appliances and climate-control systems, and using better construction materials.

Implementing Smart Change at the Institutional Level

The feasibility of change on such a wide scale might initially seem impossible; however, we believe it is attainable given the rising importance of corporate governance and responsibility. For instance, over the past decade corporate ecological sustainability (i.e. "going green") has been embraced on a steadily increasing level and incorporated into the organizational culture. One study, conducted by Arthur D. Little in 1995, indicated that just 4% of 187 companies that responded took environmental issues seriously in their business decisions. By 1998, that number had grown to 90% of 287 businesses polled by Industry Week magazine. In fact by 1997, Over 80% of Fortune 500 companies had created environmental charters(8). The incentive isn't all about image either; it is also about enhancing an organization's bottom line. According to Sustainable Development International Corp (SDI), a study by Joseph Romm of 84 companies compared those that had been proactive in dealing with pollution through recycling, energy efficiency, and waste minimization with those that hadn't. The companies that had been environmentally proactive had a 4% higher rate of return on investment, a 9% higher sales growth, and a nearly 17% higher operating-income growth(9).

What makes the reduction of energy usage and costs in the workplace particularly challenging is the fact that workers and tenants are often unaware of facility expenses. Therefore, change actually begins with office building designers, owners, and operators who can incorporate energy-efficient building design with existing natural systems and new technologies, and create a more sustainable workplace, also known as the "smart building". To provide the incentive for changing design standards to take root, many countries are now establishing industry or government groups that are implementing rating systems that rank buildings for energy efficiency. For example SDI states that nearly one-quarter of Great Britain's commercial properties are now rated, and a particular building's high smart-building score becomes a key feature promoted by commercial real estate brokers(10).

Economic Payback of Smart Buildings

The movement toward smarter buildings seems logical from both an environmental and financial standpoint. In fact, the US Department of Energy state that using energy-efficient design and technologies in constructing new office buildings can reduce energy costs by up to 50%. The capital expenditures associated with building a new facility or upgrading an existing one in accordance to heightened environmental standards can often be recaptured within a compressed payback period, through the savings realized through higher degrees of energy efficiency.

A notable area contributing to quicker economic payback is gains associated with heightened worker productivity. Simply stated, a more energy-smart facility can boost productivity by enhancing the comfort and performance of workers, thereby providing a more comfortable work environment. This can be achieved through daylighting, smart temperature control systems, and better ventilation and indoor air quality. Given the high cost of labor, payback on capital expenditures is further compressed through reduced employee absenteeism.

Quick Fact:
"Positioning windows to capture sun in winter along with insulation and airtight construction, can cut heating needs more than 97%"

"...by '97, Over 80% of Fortune 500 companies had created environmental charters. The incentive...is also about enhancing an organization's bottom line"

The Economics of Multi-Tenant Facilities…

Writing in The New York Times Real Estate section, John Holusha cited an example of how Boeing achieved a quick payback on its investment. Working with the Environmental Protection Agency, Boeing reduced its lighting energy use by up to 90%. This translated into a two-year payback, a 53% return on investment, as well as qualitative benefits including reduced interior glare, which in turn contributed to employees working more productively.

Economies and Diseconomies of a Multi-Tenant Movement to Smarter Buildings

Some argue that although there might be an incentive for a user to take a more environmentally-friendly approach to a customized design-build, the economics of multi-tenant office use (where the owner, not knowing specific requirements for a tenant's use, unless pre-lease agreements has been signed prior to construction will minimize its expenditures) do not support smart buildings.

Andrew Thomson, President of Toronto-based Thomson Real Estate Advisors points out that a very small proportion of what an end-user would pay in rent goes toward utilities (for example, if the tenant is paying a total of $60-$65 per square foot, perhaps $2 of that goes to utilities), thus the marginal cost of utilities often doesn't register as a major cause for concern. Thomson further states that one of the main problems associated with launching a concerted effort to make buildings smarter is dealing with the competing objectives of energy and space efficiency of planners who are focused on increasing efficiency with architectural and public demands for emphasis on the built form.

Another factor associated with multi-tenanted facilities that might limit the incentive to adopt more environmentally-sensitive systems, according to Thomson, is the way leases are structured. For instance, if a tenant has a net lease, any reductions in operating expenses an owner achieves through greater efficiency is reaped by the tenant; i.e. in a net lease, the landlord doesn't capture the benefits of lowered costs – the revenue benefit on utility saved goes directly to the tenant. The opposite is true in the case of a gross lease, where all economic benefits associated utility reduction are captured by the landlord. (this examples shows whey large companies choose to sometimes build their own facilities, as they reap benefits associated with lowered utility costs).

The disconnect between these two sides, combined with the dynamics of the free market has created an opportunity for third party providers to structure a model that satisfies all parties. For example, the outside party will approach a building owner with the offer to audit the building's systems (e.g. HVAC) and create an energy profile (often this is simply a case of determining if a wholesale utility upgrade is required for the building). If both the building owner and the third party agree, the latter will outsource new systems to the building owner.

By doing this, the third party will lower utility costs of the building, and enter into a fixed contract with the building owner assuring a stable utility price (usually lower than the price the building owner was paying prior to entering into the contract). This is advantageous to the owner as it eliminates the risk of uncertain fluctuations in utility prices, and providing a more stable measure to be incorporated into pro-forma calculations. The incentive to the third

Economics of 3rd Party Outsourcing:
A Hypothetical Example

A building owner pays $8.00 per square foot in energy costs. After auditing, they guarantee the owner a fixed price of $7.50 for a set time period. The third party implements capital expenditures for the upgrade totaling $10.00 on state of the art upgrades
As a result energy costs drop from $8.00 to $6.00. In this situation, all parties win:

- Third party provider is getting a return on its invested capital
- Building owner lowers its energy costs, and receives the benefit of paying a fixed price over an extended time period
- Tenants are assured a fixed price as well (providing small guarantees like this to tenants are especially valuable, as they simply like to know what they're paying)

Here, the free market gives the ultimate user the opportunity to get the benefit, and imbedded within all of this is the societal upside of achieving greater energy efficiency

Source: Thomson Real Estate Advisors

"a small proportion of what an end-user would pay in rent goes toward utilities, thus the marginal cost of utilities often doesn't register as a major cause for concern"

"one of the main problems...is dealing with the competing objectives of...space planners who are focused on increasing efficiency and architectural interests who place emphasis on the built form"

"if a tenant has a net lease, any reductions in expenses an owner achieves through greater efficiency is reaped by the tenant; i.e. in a net lease, the landlord doesn't capture the benefits of lowered costs"

Carving a Path to Sustainability…

party provider is keeping any spread between the fixed price the owner pays over the contract term and the cost of that utility provision.

These examples show the free market at work, by increasing the incentive for multi-tenant facilities to adopt smarter, more efficient technologies. This increased incentive, combined with 1) increasing standards of *organizational responsibility* (which drive the movement to smarter facilities), 2) the prospect of enhanced *financial performance*, and (perhaps most importantly) 3) the fact energy-efficient building features *help attract and retain tenants* (thereby reducing vacancy risk), make the prospect of more energy efficient multi-tenant facilities entirely feasible

The U.S. Department of Energy states that the overall payback of incremental costs associated with making a skyscraper energy efficient is expected to be between 6-10 years. This is good news not only for the end-users of energy efficient facilities, but for building developers and owners, as environmentally-friendly modifications to facilities can play a large role in attracting and retaining tenants, whose standards of corporate responsibility are increasingly putting such facilities at the tops of their facility wish lists.

Making a Building Truly "Smart"

The term "smart building" was originally used near the end of the dot com era as industry professionals often denoted buildings that provided high-speed access to the Internet as smart. However, this is no longer the case. In an era where concern has shifted toward replacing current non-renewable resources with sustainable ones, the definition of smart has accordingly changed. Today, a smart office could be defined in a number of ways. For instance, one that is healthy and efficient in its use of resources, with little or no toxicity, and places emphasis on less wasteful work practices, and energy efficiency. This definition focuses on integrating nature's renewable systems and reconfiguring existing infrastructure to create greater efficiencies. A sample of such systems would include:

Reconfiguration of Existing Building Infrastructure:

In many buildings, air intake systems designed to pull fresh outdoor air inside are often placed by loading docks. Not surprisingly vehicular fumes remain and are left to circulate within the buildings. This needlessly increases the demand for other air sources. Keeping this in mind, newer buildings are increasingly placing their air intake systems on the roof.

Raised floor, air plenum systems offer instant flexibility in configuring a work environment to its most efficient use. Plenums offer space for cabling, power distribution and air conditioning. Having all amenities in a central location saves building owners costs that are typically associated with moving (churn costs). Substantial energy savings are achieved through a plenum's flexibility and locational portability, as it can easily adjust to increases or decreases in the number of workers per square foot. This eliminates of pricey, labor-intensive remodeling projects and maximizes tenant comfort at all times.

Daylighting:

Full spectrum sunlight can be harnessed to create interior daylighting systems that improve energy efficiency and occupant comfort while reducing operational costs. Numerous studies confirm daylighting contributes to substantial energy savings and statistically significant improvements in productivity and health. For the most part, effective daylighting strategies can be achieved using all the benefits of the sun without the downsides associated with heat gain and glare – and it can all be accomplished without sacrificing any natural light.

Some of the more contemporary daylighting technologies include light shelves (exterior shading devices that bounce sunlight off the top of the light shelf onto the ceilings of the floor above, while shading the window below it); high performance skylights that incorporate reflectors or prismatic lenses; clerestory windows (vertical glazing located high on an interior wall); and sawtooth roofs(11).

Solar Power:

This technology relies on the careful placement of thin film solar modules on building surfaces that receive large amounts of sunlight. An example of a building that uses this technology is the headquarters of BP's solar division (bpsolar). This 18,000 square foot facility located just outside of Baltimore uses the electricity derived

Example of Clerestory Window system
(EERE)

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"The overall payback of incremental costs associated with making a skyscraper energy efficient is expected to be between 6-10 years"

"...environmentally friendly modifications to facilities can play a large role in attracting and retaining tenants"

Wireless Technology Smart Sensors…

from these modules and powers everything but HVAC and lighting systems. In the event of a power outage, all other machines (computers, security systems, copiers, etc.) would immediately switch to an uninterrupted power source (UPS) that is powered by batteries that are charged by the solar modules. The UPS can provide up to six hours of power. During power downtimes (i.e. weekends or days of low power demand) the modules can generate additional power that can be stored and eventually used to replace power from external sources. At the end of each month, the company would receive a power bill that reflects the difference between electricity consumed and electricity generated. The long term goal for Bpsolar as well as others using the technology is to become a net-energy exporter(12).

On-Site Water Treatment:

Many analysts are predicting that as fresh water becomes commoditized over the coming years, the providers of this resource will increasingly become privatized. In anticipation of this, new building techniques are gradually emerging that use renewable energy systems, water conservation features, recycling and waste management systems, and environmentally-sensitive building products and systems. One of the more interesting emerging areas is on-site waste treatment facilities where waste is processed on site through technology or naturally occurring ecosystems that treat wastewater, thereby conserving freshwater by recycling "graywater" through toilets. This is intended to save the energy and expenses associated with off-site treatment plants.

Late Night Cooling:

Andrew Thomson relays an anecdote concerning efficient cooling systems that were installed in an office tower construction project he worked on in the early 90's. To meet the cooling demands in the summer, large tubs were placed in the penthouse of the tower complex, where ice was made at night (using glycol - the same material used to de-ice aircraft wings) and melted during the day to provide all the building's cooling requirements. What was significant in this instance, was that because the ice was being made during the night, the energy costs required to produce it were significantly lower than the rates they would pay during peak daytime hours.

Thomson noted, however, that installing these systems are generally economically unfeasible and require government grants to make them cost-effective for the developer. This example points out the importance of grants until the cost of producing lower-cost alternatives to these systems are devised.

Deep Water Cooling:

The amount of heat generated within an area is directly proportional to the number of people congregating within that space, therefore the number of people per square foot affects the amount of cooling (or heating) required. It is no surprise then that air conditioning is one of the most important critical office systems. Office cooling is typically carried out by large electrical chillers. However, these machines consume an exorbitant amount of energy and cause damage to the environment through the release of ozone depleting chlorofluorocarbons (CFS's). Driving factors including the 1987 Montreal Accord (signed by 43 countries and intended to eliminate the production of ozone depleting substances), and now the need to reduce energy consumption have been powerful catalysts in creating alternate methods of cooling(13).

A new method that has emerged to replace wasteful chilling technology is deep water cooling. This innovative procedure involves drawing cold water from the depths of a nearby body of water where the temperatures hover just above freezing, to a heat transfer station where it cools the water flowing within a buildings air conditioning system while keeping the liquids completely separate. The chilled water is then used to air condition a facility or a network of facilities attached to a single loop. The water originally drawn from the source is pumped back anywhere from 5-10 degrees centigrade warmer. To avoid the potential disruption of key ecosystems within the targeted body of water, the warmer water is pumped back to the source at a level closer to the water's surface.

The first institution in the world to install a deep

"During power downtimes (solar) modules can generate additional power that can be stored and eventually used to replace power from external sources"

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water cooling system was Cornell University's $60 million project that drew cold water from nearby Cayuga Lake, a 250 foot deep part of the Finger Lakes chain. Other places such as Stockholm, Rochester, Hawaii and Toronto have followed suit with their own deep water cooling projects. Vancouver is currently undertaking a similar system that will draw cold water from nearby Burrard Inlet, and will be looped around a major portion of the downtown area.

Of course these deep water cooling projects have not gone without encountering their share of initial growing pains (i.e. drawing marine life from oceans, trying to keep troublesome species such as zebra mussels out of the system, as well as potential environmental concerns), but problems are being addressed and the impact of these projects are being closely monitored(14).

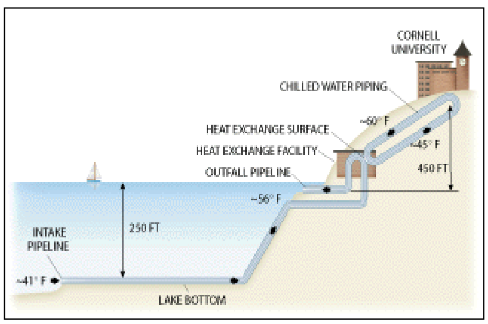


Illustration depicts basic dynamics of deep water cooling at Cornell University
(Laurie Grace, from Scientific American)

Intelligent Systems: Smart Sensors

Beyond naturally occurring systems such as those cited above, scientists are now using technology to further enhance a building's ability to reduce energy consumption. In the April 2001 edition of Business Facilities Magazine, Deb Lehman-Stein noted that students at the University of Kansas defined a smart building as one that integrates new technologies from computer automation, space age materials, and energy management. The synthesis of these inputs resulted in a structure that was much less like a building than an entity, since it has the ability to adjust and adapt to its occupants.

Smart buildings automate many aspects of a building's systems, including lighting, heating, cooling, and communications and can control these areas using a single computer. Thus, a building can monitor its own integrity and automate many of the mundane maintenance tasks performed on traditional buildings. The result? The building is more functional, and energy efficient. Proponents of smart building technologies believe that by integrating these systems into buildings, the building power consumption statistic cited by Scientific American (i.e. 36% of US total power consumption) could be reduced in half by 2010.

In addition to these savings, organizations can better streamline operations simply by being able to centrally manage functions from a single computer. For instance, if a target organization owns multiple facilities spread across a wide geographic area, operations of all facilities can be centrally managed and performance tested from a remote location. The head of operations in this case could compare all company buildings, thereby establishing baseline performance standards. Such an exercise in streamlining could directly contribute to that organization's profit margin and success.

The range of technological options ranges from simple to extremely complex. A simple way to reduce power consumption is by using sensor technology. These devices play an important role in building operations by monitoring and maintaining comfort levels. For instance, occupancy sensors can switch lights on and off, modulate air flow, or even monitor internal temperature control simply by detecting motion within a given space and relaying data that tells a specific system how to act. They can be programmed to create a productive work environment specifically tailored to individual requirements. The three basic types of occupancy sensors are: passive infrared (detects body heat within a given space); ultrasonic (emits sound waves that hit a source and bounce back, and initiates systems based on deviations in normal sound patterns); dual-technology (hybrid between passive infrared and ultrasonic).

More complex technologies are on the horizon as well. A policy paper co-authored by Aaron Crow and Justin Seem from the University of Washington states that more smart buildings have an ever-increasing number of MEMS (Micro-Electro-Mechanical System), systems that are becoming heart and brains of smart building technology. In their paper, the authors assert

"smart building (defined) as one that integrates new technologies from computer automation, space age materials, and energy management -- The synthesis of these inputs resulted in a structure that was much less like a building than an entity"

"(Sensors) play an increasingly important role in building operations by monitoring and maintaining comfort levels. For instance, occupancy sensors can switch lights on and off, modulate air flow, or even monitor internal temperature control simply by detecting motion within a given space and relaying data which tells a specific system how to act"

this decade will be marked by a revolution in sensor technology that will impact business and society. At the heart of this revolution will be the proliferation of wireless technology, due to the mobility of wireless devices (in comparison to their wired counterparts) and the fact that no connection cabling is required. The elimination of wiring instantly brings cost savings in short term. As of this writing, devices are now being developed that are capable of organizing themselves into networks that can repair themselves and manage their own power consumption(15).

Some of the most innovative smart building technology is currently coming out of Center for Information Technology Research in the Interest of Society (CITRIS) at the University of California, Berkeley. This organization's goal is to create power-aware buildings that could eventually save the state of California between $5B-$7B per year and the nation $35B in energy costs per year, a figure that equates to 30,000 tons of carbon emission per year. This will be accomplished by developing a network of tiny and inexpensive electronic sensors.

How tiny? Kris Pister, a professor of electrical engineering at Berkeley ironically coined the phrase "smart dust" referring to low-power, matchbox-sized wireless devices called "smart-dust motes", which are equipped with wireless radio transceivers as well as "TinyOS" operating systems. These relatively inexpensive devices (about $100 now, but could conceivably be produced for $1 in the near future) continually monitor light and temperature conditions, and replace the bulky energy monitors that can cost $1000 each to deploy, and require walls to be ripped out to install sensors and run conduits. Smartdust Motes, when properly coupled to electrical circuits in breaker boxes jump from one mote to another, eventually landing at a central website (called a SensorWeb) for storage and data mining. Therefore, by enabling these small sensors to turn off lights, or reduce the use of HVAC controls, savings can be attained immediately. "The SensorWeb will provide huge reams of data about what's actually happening at any moment," explains Pister "this is important information because people have no idea where electric power is actually being burned in their homes or offices."

The benefits of such technologies are virtually limitless, considering the range of tasks that can be performed. Consider instance that most existing power meters average low-cost, late night electricity with the highest-cost afternoon electricity, producing a single-cost reading that gives no useful information about the specifics of consumption. If consumers had a better idea of the true cost of power, and when spikes in pricing occur (currently, industrial and commercial consumers pay higher costs in the afternoon when prices typically skyrocket), there would likely be sharp reductions in peak usage patterns. Giving the end-user the ability to go to the web to monitor the costs of running lamps and appliances makes energy conservation much easier. Technological advances like these could significantly impact usage patterns simply by making people more aware of what they're doing.

Smart-dust motes represent a system that can provide users with a rapidly deployed network of real time meters that can specifically monitor usage. According to CITRIS research, such real-time pricing of electricity capability, when combined with power-aware buildings represents a key component in limiting peak demand. Such systems don't even necessarily require human monitoring, as they can be programmed to respond to various circumstances. For instance, by receiving real-time pricing information, a smart refrigerator would know to initiate its compressor only during off-peak periods when power prices are low. According to Pister, "It's just a matter of closing the feedback loop". In California, state funds have already been set aside to outfit office towers with smart sensors imbedded within air conditioning systems that know when the state is running low on electricity, so those systems can cycle on and off.

In addition to the benefits associated with monitoring consumption, wireless sensors are steadily increasing their role in monitoring seismic occurrences, thereby creating safer work environments, especially in areas with increased incidence of seismic activity. Smart buildings imbedded with these wireless monitoring devices will be able to sense and adjust their bearings to survive earthquakes. The portability of smart sensors are demonstrated by their ability to be poured directly into concrete, thereby enabling the building to monitor its own health. In addition, larger sensors can be attached to beams to further enhance its monitoring ability(16).

Quick Fact: CITRIS at UC Berkeley leading the way in developing smart building technology; their goal is to create technologies that will save the State of California between $5B and $7B per year and $35B nationwide

Case Analyses of 6 Buildings that Provide a Glimpse of the Future:

There are numerous buildings and even more in the conceptual phase that are integrating smarter technologies and ideas into their systems. The following is a list of six that provide a good cross-section of smart elements that make buildings more efficient:

1. Internationale Nederlanden (ING) Bank Headquarters

Category: Single User, Design Build
Location: Amsterdam
Opened: 1987
Square Feet: 540,000
Notable Systems:

- Building's primary reliance on conventional air conditioning was replaced by passive cooling with back-up absorption chillers;
- other HVAC needs were met by using passive solar heating and ventilation;
- daylighting provides illumination to offices and interior cores;
- water-efficient landscaping used on grounds

Energy Efficiency:

- ING's headquarters used less than 10% of the energy of its predecessor and a fifth that of a conventional new office building in Amsterdam.
- The annual energy savings were approximately $3.28 million (2003 U.S. dollars) from features that added roughly $800,000 to the construction cost of the building—and were paid back in three months;
- 92% reduction in primary energy compared to conventional building of similar size.
- Productivity gains, absenteeism lowered by 15%. Estimated energy savings of $3.28 million;

Building Economics:

- Site Acquisition Costs: $5.55 million (2003);
- Site & Building Construction Costs: $55.46 million (2003);
- Average Development Cost/SF: $113 (2003) ($226 SF with furniture, fixtures, and equipment 2003);
- Total Costs for Green Technologies: $979,232 (2003);
- Total Costs: $60.89 million (2003);
- Total Return on Investment: Three-month payback on investment in energy efficiency

Notable: This project was instrumental in raising the profile of ING to from a relatively anonymous bank (# 4 in the Netherlands) to # 2. This demonstrates how corporate responsibility can positively impact the building of brand. As of 2003, ING has in fact outgrown these headquarters and have opened up a new facility that has been planned to have the same impact as the original.
Snapshot Analysis: What makes this project significant is the way in which ING used facilities as the primary means to gain market share. This building demonstrates the power of well thought out corporate responsibility initiatives, as well as how far ahead on the curve ING was.
Sources: Rocky Mountain Institute

ING Headquarters interior shows vertical slice in Atrium to provide internal daylighting
(Rocky Mountain Institute)

2. PNC Firstside Center

Category: Brownfield Site, Single Use, Design Build
Location: Pittsburgh
Opened: 2001
Square Feet: 647,000
Notable Systems:

- Building's major green features are location, daylight, hybrid HVAC system and materials;
- innovative hybrid system of air distribution improves energy efficiency, comfort and maintenance
- system includes a raised floor 'plenums', enhancing workspace flexibility
- Daylitghting provides 90% of the occupants with outdoor view; skylight slice runs perpendicular to atrium; skylight runs along entire roof to bring light in
- Energy efficiency enhanced through twin fuel options for chillers; gas absorption and electric chillers are installed, each can be run with alternative fuel, depending on the price and availability of the primary fuel

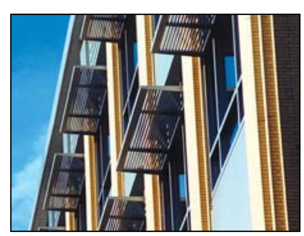
Energy Efficiency:

- estimated to be 33% more energy efficient than the biggest building the operations were relocated from
- Water Efficiency; Sub-surface irrigation system reduces water use for irrigation by more than 50%

Building Economics:

- Firstside Center Costs $167 psf
- Completed 3 months ahead of schedule

Twilight view of PNC Firstside Center in Pittsburgh
(PNC)



Lighting shelves provide shading and dispersed lighting at PNC Firstside Center
(PNC)

within budget of $155/square foot, including systems furniture and redundant systems
- Return on investment analysis used to compare various alternatives, using a two-year payback requirement

Notable: The decision to build on a brownfield site was a key component of the environmentally-focused nature of the project. By opting for an urban brownfield as opposed to a suburban Greenfield, PNC was able to convince local transit authorities to build a rapid transit stop at that location, thereby reducing the number of employees whose primary source of transportation was car. This set the tone for the entire project.
Snapshot Analysis: PNC Firstside center provides an example of a where a large company chooses to build its own facility and reap benefits associated with lowered utility costs
Sources: Environmental Design + Construction (Megan Moser), Green Building Alliance

3. Audubon House

Category: Retrofit
Location: New York
Opened: 1891; retrofitted 1992
Square Feet: 98,000
Notable Systems:
- Enhanced Natural Lighting Systems (i.e. large windows on Southern/Western exposures, central reception area skylight) permit large quantities of natural light to illuminate workspaces
- Exterior thermal shell
- Pale furnishings, interior surfaces contribute to "reflectance" of natural light
- building's air intake is on roof, where air is cleaner, rather than over loading dock

Energy Efficiency:
- In existing buildings, renovations replacing older systems with more efficient technology can yield savings of up to 30%
- retrofit made building 60% more energy-efficient than conventional office building
- designed to use 62% less energy than a "conventional" New York City code-compliant office building.
- energy-efficient features designed to save estimated $100,00/yr., thus reducing Audubon's energy costs by 64%;
- Pendant ceiling fixtures give light near 360-degree dispersion and reflect 88% light;
- Conventional office buildings use 2.4 watts of electricity psf of lighting, Audubon House designed to reduce that figure to 0.6-0.7
- uses no CFC's, chlorofluorocarbons in its cooling or insulation

Building Economics:
- The Schermerhorn Building purchased in 1989 for $10 million (price mostly reflected land value cost)
- Restoration began 1990, completed in 1992 at a cost of $14 million
- The basic renovation and design costs were $122 per square foot (a figure falling within market rate for projects of comparable location, size, and time - which average $120-128 per square foot)

Notable: Project demonstrated that "smart building systems" can easily be applied to retrofit projects. In this case, The Audubon society restored an extremely architecturally significant building (an example of Romanesque Revival architecture) that was an important piece of the New York City landscape
Snapshot Analysis: Smart buildings can come in many shapes and sizes. Audubon House is an example of how great architecture can be maintained while making it much more energy efficient. Depending on profile of organization, the selection of a historic building can also be used to reinforce brand.
Sources: National Audubon Society, Business Magazine (A.K. Townsend), Office of Energy Efficiency and Renewable Energy (US Department of Energy)

4. Four Times Square

Category: Multi-tenant Office
Location: New York
Opened: 1998
Square Feet: 1.6 Million Square Feet

Notable Systems:
- all building systems/construction technology evaluated for impact on occupant health, environmental sensitivity, energy reduction, making it first project of its size to adopt state-of-the-art standards for energy conservation, indoor air quality, recycling, and use of sustainable manufacturing processes;
- high visible light transmittance glass,
- natural gas-fired CFC-free absorption chillers/heaters,

Audubon House, located at 700 Broadway in New York; a very smart retrofit
(National Audubon Society)

Four Times Square from 42nd Street (Midtown view)
(Wired New York)

Four Times Square from Broadway
(Wired New York)

- on-site fuel cells
- high efficiency lighting

Energy Efficiency:

- building's energy costs 25-30% lower than those for buildings built in 80s
- 15-20% better than current government standards
- building's lower operating costs passed to tenants

Building Economics:

- Payback for the very high transmittance glass is about 14 months.
- Payback for the natural gas-fired CFC-free absorption chiller/heaters is approximately three years.
- Payback for 2 on-site fuel cells could be less than ten years, depending upon the price of natural gas;
- The Durst Organization has leased almost 100% of the building's floor space, including 82% to the Condé Nast publishing company and to the Skadden Arps law firm,
- proving that large, energy efficient structures can attract leasors and be profitable

Notable: has been called the first "green" skyscraper in New York City; has 2 orientations; on side facing Broadway, takes on character of Times Square; on side facing 42nd street, takes on subtler building featur
es that allows it to nicely blend with midtown business community

Snapshot Analysis: The economics are in place so smart, energy-efficient systems can be implemented in multi-tenant facilities. The tenants who have committed to the building are probably happy about perhaps paying less energy costs, but more importantly, the choice to locate in this building might enhance the way those organization's are perceived, i.e. it's a great way to enhance the brand

Sources: Business Magazine (A.K. Townsend), Office of Energy Efficiency and Renewable Energy (US Department of Energy), Wired New York, Daniel Kaplan (Clean Air Counts)

5. 1 University Avenue

Category: Multi-Tenant Office, Internal System Upgrade
Location: Toronto
Opened: 1984, Systems upgrade in 2003
Square Feet: 259,000 Square Feet
Energy Efficiency:

- Early North American example of large office building that has implemented deep water cooling to provide primary source of building air conditioning
- Air conditioning consumes high quantity of power, office building particularly notable given the density of computers and people
- According to seawatercooling, such systems are 80% more energy efficient than current air conditioning systems
- Provider of system believes this system will reduce electricity consumption in commercial buildings by 75 per cent

Project Economics:

- Savings will be realized by reducing the overall amount of energy consumed
- Payback period likely to be higher than other examples given the infrastructure costs of system
- Greater economic gains to be realized as more buildings are added onto deep water cooling loop; this provides the basis of the partnership between building owner and system provider (i.e. building owner owns substantial portfolio of properties that are concentrated and can thus be included into this loop)
- Complete economic analysis cannot be priced until further implementation

Snapshot Analysis: Beyond the innovative systems that have been put in place, this building provides a glimpse of the power of joint ventures. The system provider (Enwave) has teamed up with an owner with a large portfolio of buildings in the downtown core (Oxford); as more buildings come on line, better economies of scale might be realized. (both of these organizations have common elements of ownership)

Sources: Enwave, Oxford Properties, Cornell University, Sea Water Cooling

One University Avenue, Toronto
(Oxford Properties)

6. The Lewis Center for Environmental Studies, Oberlin College

Category: Single Use, Net Energy Exporter (solar power)
Location: Oberlin, Ohio
Opened: 2000
Square Feet: 14,000
Notable Systems:

- 3,700 square foot of photovoltaic (PV) panels on the main south-facing curved roof provide electrical energy for the building;

The Lewis Center for Environmental Studies, Oberlin College
(EcoCity Cleveland)

And the Crystal Ball Says…

- PV system will feed fuel cells to provide storage for the collected solar energy;
- Environmental Studies Center is intended to export energy--on the order of 40,000 to 60,000 kWh per year

Energy Efficiency:

- energy budget for the facility is estimated at 10,000-15,000 Btu/sq ft/year. This compares to budgets of 30,000- 50,000 Btu/sq ft/year for "green" buildings; and around 70,000 Btu/sq ft/year for typical good designs
- *Active heating and cooling* is provided by a closed loop groundwater circulation system that brings water at ground temperature into the building

Notable: Oberlin College's new Environmental Studies Center is being designed as a "net energy exporter," to create more energy than it needs by using both active and passive solar methods
Snapshot Analysis: The ultimate goal with this facility is to become a fully self-sufficient net energy exporter. The success or failure of this project will dictate whether implementation of larger scale versions of this will take place in institutional-grade facilities.
Sources: gbt Forum, Oberlin College

Conclusion

The perceptual linkage between the energy efficiency standards of office buildings and business continuity planning might seem tenuous at first glance, however, the facts speak for themselves. The amount of energy office buildings use, squarely places them in the highest echelons of consumption. Consumption on this magnitude is made all the more alarming by the fact that this demand can be significantly reduced, simply by making facilities smarter.

By lessening the demand for power, especially during periods of high consumption, the risk of downtime (imposed by situations such as rolling blackouts) is reduced. The net result is simple: business continuity becomes an imbedded component of more efficient energy usage.

Although it sounds all very simple, the economics of office buildings, coupled with the dynamics of design and construction do not lend themselves to standards of efficiency. Reams of statistical evidence that support this still have been unable to provide the impetus required for a concerted movement by public and private officials to initiate chance.

Another key contributor to inaction is the relatively small proportion of expenditure utilities contribute to overall rent for tenants. In fact, the utility component of rent is so small, the need for conservation fails to even register for many large organizations. Events such as the August 14 power outage often can act as the catalysts required for change. The possibility for change is further enhanced by increasing standards of corporate responsibility that result in large institutions being more sensitive and reactive to areas such as energy conservation and efficiency. Such polices are not adopted merely for the purpose of being good citizens, but also for enhancing bottom line operating results.

The future still remains somewhat unpredictable. Andrew Thomson reminds us that a key factor contributing to future uncertainty is the uncertainty of projecting future heat load requirements of computing technology. He points out that over the past ten years, the requirements of telco buildings has increased dramatically. For example, buildings that were originally designed to handle 3 watts per square foot (wpf), proved themselves to be inadequate over a relatively short time period. Not knowing what the future demands of power would be, some facilities actually increased their provision to more than 250 wpf. The actual requirement over this period has been somewhere in the order of 35 wpf.

Given this uncertainty, what is the projected evolution of computer technology? What direction is this moving in? If history is any indicator, systems of the future might be able to produce more power with less heat, but until we know for sure, there is no way to plan for it. This is specifically the unknown factor that will not help things, at least in the short term.

In the interim, there are examples of movements to make buildings more efficient across all categories of office buildings. Whether these involve a systems upgrade, or an entirely new buildings constructed from the ground up, there is reason to believe that a concerted effort to launch initiatives on the real estate front to minimize the changes of a reoccurrence of August 14.

References

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