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Clicks & Mortar:
The costs and benefits of intelligent buildings

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While the real estate sector has traditionally been slow to adapt to new technologies, green and intelligent features can increase energy-efficiency and overall financial performance in both new and existing buildings.

Green and intelligent features are complementary approaches to a set of common goals: increasing energy efficiency and reducing operating costs in order to increase net operating income and asset value.

Intelligent features enhance the performance of green buildings by enabling systems to interact with each other, to respond to changes in the environment, and to track performance in real time.

"In a recessionary economic environment, revenue growth is largely driven by reducing operating expenses," said Greg Kats, Director of Climate Change Policy for Good Energies, a venture fund based in Washington, DC. "Innovations in green and smart buildings reduce operating expenses by increasing the efficient use of electricity, heating, and water."

Energy costs represent roughly 30% of a building's annual operating costs. However, much of these costs result from inefficient equipment, stand-alone systems, out-of-date commissioning, or wasteful practices. The U.S. Green Building Council estimates that green buildings use 25-30% less energy than conventional buildings. According to the USGBC and Energy Star, the most efficient buildings can perform 50-70% above the baseline for conventional buildings. According to Energy Systems Laboratory, improving operational strategies could reduce energy use in buildings by 10-40%.

However, fewer than 1% of the buildings in the United States are classified as high-performance, according to Kats.

"Real estate is not a technology-intensive sector, and construction is even less so," said Jamie van Klemperer, FAIA, principal of Kohn Pederson Fox. "In the last fifty years, contrast the leaps forward in information, manufacturing, medicine, and transportation with the lack of innovation in real estate."

"The current global financial crisis may be one of the best things for innovation in the real estate sector," said Kats. He believes that the downturn will drive adoption of technologies that reduce operating expenses. "As these technologies demonstrate their value to the early adopters, these features will likely become industry standard as the markets return to a boom cycle."

A number of projects worldwide — including Ave Maria University's campus in Florida, the B2 complex in Belgrade, Serbia; Seattle's Hotel 1000; and the planned cities of Masdar and New Songdo — are making a compelling business case for the adoption of these features.

Of all these, Kohn Pederson Fox's master plan for New Songdo City presents one of the most ambitious visions. The US$35B project near Seoul, Korea, is the largest private development project in the world. When completed, it will contain 100M square feet of buildings on 1,500 acres of reclaimed land. Songdo is intended to be a showcase for ubiquitous computing, converged networks, smart devices, and a number of innovations. It is also one of the largest LEED certified projects in the world — not just the buildings themselves, but the city's green and intelligent infrastructure, and sustainable principles underlying the entire project. Songdo received the first annual Sustainable Cities Award in 2008.

"New Songdo City will be a testing ground for new ideas," said von Klemperer. The developers Gale Intl. and POSCO have established partnerships with technology and consumer electronics companies such as 3M, LG, and Microsoft.

Songdo will showcase some of the most sophisticated technologies from building materials such as ICrete (a fly ash based concrete that reduces greenhouse gas emissions by 40%) to a comprehensive Urban Management Center than controls and manages the various connected systems of the city itself.

Converged systems are the foundation for smart buildings

Just as green buildings exist along a spectrum, there is no single definition for what constitutes an 'intelligent' building.

Adding sensors to individual components allows them to react to changes in their environment. The next step is to enable devices to communicate with users, or to allow users to remotely control them. However, intelligent buildings are more then just collections of unconnected smart devices.

Converged systems are the foundation for intelligent buildings. Integrating building systems on an IP network enables the individual components and systems to work collectively to optimize performance and efficiency. A building's 'intelligence' also increases as more sensors are added, enabling components and systems to become increasingly context-aware. Beyond the lot line, intelligent buildings can also communicate with each other and with the power grid.

In contrast, conventional multifamily and commercial buildings have inherent inefficiencies. These buildings have 20-30 discrete systems (HVAC, lighting, water, etc.), each with proprietary networks and wiring. Without sensors, they cannot respond to changes in the environment. These systems cannot interact with each other. In addition to being more expensive to install and maintain, they also inefficiently use resources such electricity, heat, lighting, and water.

For example, in conventional buildings, most lights are on throughout the day, even in spaces that are rarely used, or in workspaces that are flooded with sunlight. Excessive air conditioning means that occupants must wear a sweater at work all summer. Leaking faucets or running toilets may waste hundreds of gallons of water before they are discovered. Not only are these spaces less comfortable to occupy, but they are more expensive to maintain.

Systems can be connected on both a physical and a logical level. New Songdo City has a smart grid that enables sophisticated power sharing among buildings. Connecting buildings that have complementary energy needs (e.g. office buildings need more power during the day, while hotels need more power at night) eliminates the need for additional power plants. Offsite electrical generation loses roughly 30% of energy to transmission loss. Onsite cogeneration reduces this loss.

"Cogeneration enables us to reduce construction costs without reducing the level of services," said Charles Reid, EVP of Development and Design for Gale International.

Connecting systems can create synergies by converting byproducts of one process into inputs for another process.

For example, steam and hot water are byproducts of cogeneration. At their Seaport redevelopment in Boston, Gale Intl. inked deals with third parties to purchase and resell the steam and hot water which are byproducts of cogeneration. "Steam and hot water went from byproduct to product," said Reid. "It's a situation where everyone benefits. It's cheaper for the building, cheaper for the developer, and turns a waste product into a source of revenue for a third party."

Intelligent features can make green buildings greener

Sustainable development initially emphasized green materials and energy-efficient appliances, then focused on systems. However, merely installing green features is not enough for optimal efficiency.

Buildings cannot be efficiently managed until their performance can be monitored and measured.

For example, switching buildings from fossil fuel to renewable resources such as geoexchange reduces exposure to volatile energy prices. However, even the most efficient and ecofriendly systems tend to degrade over the normal course of operations. It is not uncommon for systems which were properly commissioned at installation to have Energy Use Indexes significantly above the industry standard within a few years.

Adding sensors to individual components and systems allows buildings to generate a significant amount of actionable data, at a granular level of detail that was not previously possible. Connecting those components to a BAS (Building Automation Systems) or FMS (Facility Management System) enables real-time performance reporting.

This real-time data generates a baseline for the building's performance, enhances compliance with LEED, and can function as continuous commissioning to ensure that the building's systems are functioning optimally. Continuous commissioning goes beyond monitoring to adjust system controls based on the monitoring results, reducing energy consumption by 10-30% or more.

"Continuous commissioning is one example of how smart features can enhance the performance of green features," said Barry Katz, president of Katz Home Builders in Westport, CT, and author of *Practical Green Remodeling: Down-to-earth Solutions for Everyday Homes* (Taunton Press, 2010).

HVAC

According to the U.S. Department of Energy, HVAC systems represent roughly 40% of the total energy used in buildings. The Rocky Mountain Institute estimates that 40-50% of this energy is wasted. In conventional buildings, the heating, ventilation, and air conditioning systems operate independently of each other, creating inefficiencies which can be remedied by converging these systems and making them responsive to each other and to changes in the environment.

It is also critical to remember that large, commercial buildings use HVAC differently than single family and small multifamily buildings. In larger commercial building, the density of occupancy, lighting, and equipment uses more energy and generates more heat — requiring more air conditioning, even in winter or in cooler climates. As a result, there are considerable savings to be generated by more efficient heating and cooling equipment. In addition, better building envelopes and thermal insulation reduce losses of conditioned air to unconditioned spaces.

Sensors enable intelligent buildings to react to weather changes by, for example, raising exterior shutters to reflect or retain heat. In other buildings, air quality, humidity, and temperature are controlled by setting proper intake and exhaust rates for fresh air that must constantly adjust to fluctuating factors outside (e.g. weather, time of day) and inside (occupancy, time of day, different temperatures for different zones) a building.

The B2 building monitors outside temperatures in order to reduce the expenses associated with inefficient behaviors. "Given a large temperature drop overnight, the system will gradually heat up the office buildings in the early morning, so it doesn't require a big, expensive boost when the first people arrive to a cold office," said Cisco's Can Habib. Cisco's Connected Real Estate Advisory Group consulted on some of the leading connected real estate projects, including the B2 complex and the Ave Maria University campus.

Another demand response strategy is to shift energy utilization to less expensive time periods.

For example, air conditioning works more efficiently when it is cooler outside. Ice Energy is a Good Energies portfolio company which takes advantage of that fact. "Ice Energy efficiently pre-cools water at night, displacing electricity usage that would otherwise cost more during the day," said Kats.

Similarly, the next generation of home appliances can communicate with the power grid in order to respond to fluctuating energy prices. For example, dishwashers and washers/dryers can be set to begin immediately, or to wait until off-peak pricing. These appliances allow users to make more informed energy choices.

"There's high-tech technology and there's low-tech technology," said Rypkema. "Much of this technology is reviving or updating traditional design features that have been addressing these issues for thousands of years, but we've ignored it in the past sixty years."

"Vernacular design features work well for smaller projects where certain smart systems would not be cost-effective," said Amy Weisz, a principal of WXY Studio in New York City. Before the advent of air conditioning and central heating, buildings needed to accommodate weather fluctuations. Low ceilings conserved heat in early colonial homes. In southern climates, higher ceilings help dissipate heat. Roof overhangs shade windows and interiors. Operable shutters provide cross-ventilation. Even something as low-tech as painting flat rooftops to increase their reflectivity can substantially reduce cooling loads.

Energy and lighting

According to the U.S. Energy Information Administration, lighting accounts for 30-40% of the energy consumed in buildings. Roughly 30-50% of this energy is wasted as a result of excessive lighting, inefficient equipment, and careless usage habits. Burning hours for lighting often significantly exceed the occupancy hours for buildings. Excessive lighting also generates waste heat. According to the Rocky Mountain Institute, 20-40% of air conditioning costs can be attributed to excess lighting. Given that the average building has energy costs of $2.00/sf, effective management of the energy load represents potential savings of $0.60-$1.00/sf.

Integrating lighting controls with building management systems can optimize the use of daylight and artificial light, increasing efficiency and reducing operating costs. Light management systems generate energy savings in a number of ways. Daylight harvesting and light level tuning (adjusting the lighting levels for each space) reduce the artificial lighting load. Occupancy sensors, dimming, and scheduling further increase energy efficiency. Lastly, demand response systems recognize that energy prices fluctuate throughout the day, and reduce usage in response to energy price spikes, shift loads to less expensive times, or shift to a less-expensive energy source.

Light management systems can be used in conjunction with other context-responsive systems in order to harvest daylight, reduce glare, and reduce energy costs. There are two approaches in the markets. Solar-adaptive shading (such as Lutron's Hyperion system) automatically adjusts window shades based on exterior light. Another approach is a dynamic glass such as that manufactured by Sage Electrochromics which adjusts its degree of tint based on the sun's position.

Renzo Piano's 52-story New York Times headquarters used Lutron's Quantum light management system, achieving 70% savings in lighting electricity use as compared to the benchmarks the building was designed to meet. The building was designed to use 1.28 watts/s.f., and is using 0.38 watts/s.f. For the 600,000 s.f. building, this represents annual energy savings of approximately $315,000. According to Lutron, the savings were driven 58% by light level tuning, 30% by daylight harvesting, and 10% by occupancy sensing.

Smart buildings may also have the ability to communicate with each other and with the grid, in order to generate savings.

Electricity prices fluctuate throughout the day, even though utility bills imply flat, averaged electricity rates. Semi-automated or automated demand response systems enable buildings to make context-aware 'decisions' (in essence, programming parameters) that reduce electricity demand in response to shifts in market prices. Options for energy savings include cogeneration, power sharing, and demand response strategies such as slight reductions in air conditioning or lighting levels.

Until recently, demand response has been largely manual. Building managers not become aware of a problem until after it has become acute, and would then manually turn off switches. Intelligent buildings automate this process, and direct digital controls are gradually replacing pneumatic controls, reducing the need for building management to visit the site to monitor or inspect.

Intelligent building features conserve water

Water efficiency is often overlooked in green buildings because water currently comprises such a small percentage of overall operating expenses. This is in part because extensive subsidies currently keep water prices below their natural level. Water prices are expected to rise, and per-capita and per-building consumption are also expected to increase. As a result, water usage will become a larger driver of operating costs unless it is managed more effectively.

Water efficiency begins with resource-conserving fixtures such as waterless urinals, low-flow or dual flush toilets, and faucet aerators. This approach can reduce usage by 40% as compared to conventional buildings, according to the U.S. Green Building Council. The next step is to integrate these fixtures into the BAS or FMS by equipping them with wireless sensors. This enables owners to increase efficiency by monitoring and managing water usage.

Technologies such as Sloan Monitored Systems enable property managers to monitor the real-time water usage of buildings. Water management systems can also proactively manage wasted water and potential liabilities related to flooding, leakage and other plumbing problems. For example, if the amount of water use differs from the established baseline, the system automatically sends an electronic alert to designated recipients. These savings can be significant — according to the Environmental Protection Agency, a single faucet leak can waste over 3,000 gallons of water annually, and a leaky toilet can waste 200 gallons daily. Reducing water usage also reduces energy costs slightly, as less water needs to be pumped to restrooms. Such systems have the potential to reduce maintenance and utility costs, and effectively function as continuous commissioning in order to ensure that the system functions optimally.

Even traditional water-intensive cost centers such as a property's landscaping or green spaces are being rethought.

"Sustainable approaches to landscaping — such as xericulture and zero-maintenance gardening — can reduce direct costs for water and labor, reducing operating costs for a building without compromising the quality of life," said Christine Lichatz, founder of Gardenworks, a sustainable landscape design firm based in Mystic, CT. Lichatz devised her proprietary metrics for quantifying landscaping savings after working with the U.S. Naval Base in Groton, CT.

"One of the design mandates for Songdo was to optimize water efficiency throughout the city and to minimize the city's demands on this resource," said van Klemperer. Kohn Pederson Fox designed an extensive graywater system for New Songdo. Rainwater will be directed to support specific city landscape features and then collected for large-scale nonpotable uses such as irrigation and cooling tower operations. From the outset, the canals and central lake in Songdo were designed to use seawater rather than freshwater. This prevents freezing during winter, and also enables the canals to be used for transportation.

Converged networks can reduce construction costs for buildings

Converged networks and integrated cabling design can be less expensive to install than conventional infrastructure when individual systems are installed separately. As a result, they reduce first costs for materials and labor, and can shorten overall project timelines.

For example, Ave Maria University in Florida constructed their campus using integrated systems on an IP platform. Eliminating the redundant wiring and cabling reduced their construction costs by over a million dollars.

Similarly, the 57-story Torre Espacia building in Madrid used 4,200 wireless EnOcean switches in lieu of conventional devices. EnOcean devices do not require batteries; they generate mechanical energy from slight changes in light, pressure, temperature, vibration, or even the motion of a switch being flipped. This single decision in the planning phase eliminated the need for 20 miles of cable, the equivalent of 1.2 tons of copper.

In conventional buildings, each system has its own wiring. Eliminating this redundant wiring reduces construction and demolition waste (contributing to LEED points), reduces direct labor costs and project administration costs. Labor represents roughly 50% of cabling costs; consolidating cabling and removing redundant wiring can reduce this figure by 20-40%. According to Cisco's Connected Real Estate Group, having a single provider for all technology systems can reduce associated project management costs by roughly 30%.

Converged networks can eliminate entire systems whose functions can be created separately out of other systems.

For example, the B2 building eliminated the need for — and both the capital and operating expenses associated with — a dedicated intercom system. "The intercom functionality could be provided through the combination of the IP phone and security camera. Residents can see visitors and buzz them in," said Cisco's Can Habib.

"Conservation is about doing more with less, not doing less with less," said Greg Kats.

However, other technologies and equipment require additional initial investment. "Integrating the access controls system with lighting and HVAC systems will cost more up-front than installing disparate systems. But this initial investment generally has a relatively short payback period," said Charles Reid.

Converged networks reduce labor costs by 40-60% over the building's life

Converged networks require less labor during the initial installation, and also require less labor to maintain.

Integrated systems reduce staffing costs by enabling a small staff to operate more efficiently. "B2 is managed by a staff roughly 30-

50% smaller than that needed for comparable conventional building, and it provides a higher level of services," said Can Habib.

Wireless sensors in the commercial bathrooms at B2 send alerts to the FMS or maintenance staff when paper towels, soap, and toilet paper are running low. "In a conventional building, maintenance has to spend considerable time doing routine checks throughout the day. That is time-intensive. This way, they automatically know which rooms need attention," said Habib.

Matt Hagerman, general manager of Seattle's Hotel 1000 (H1K) regards integrated systems as critical 'back-of-house' technology. "In a conventional hotel, if the boiler fails overnight, the manager finds about it when guests start calling in the morning," said Hagerman. "However, at a connected building like the H1K, electronic alerts escalate up a long chain of command which gives us time to respond to the issue before it affects the guest experience." Integrating the staff schedules with the BAS allows alerts to be routed to the appropriate staff members who are on duty.

As building automation systems (BAS) more sophisticated, they are converging with traditional IT infrastructures. "This raises an interesting question," said Cisco's Habib. "Who will administer these building networks, IT or facilities managers?"

"This changes hiring, training, promotion and retention," said Hagerman. "Now, employees in facilities and operations have to be able to troubleshoot the Internet. We are all IT people now."

Intelligent buildings are safer than conventional buildings

Insurance companies will recognize that certain intelligent building features reduce operational risks related to water leakage, flooding, and fire. In addition, early detection and automated responses can minimize secondary impact of water and fire damage. This should be reflected in lower property and casualty insurance premiums than for comparable, conventional buildings.

The combination of wireless sensors and real-time monitoring permits managers to detect and respond to problems as they occur.

In conventional buildings, problems such as leaking toilets may go unreported for extended periods, and damage compounds. This can cause secondary damage if a problem occurs when the facilities staff is unavailable, such as during evenings, weekends, or holidays. In a connected building, if the system detects a leak, direct digital controls such as an automated ball valve upstream of the problem could shut off water to that zone.

Wireless environmental monitoring systems could also track dampness and temperature in parts of buildings where conditions could lead to mold growth. RFIDs can be equipped with sensors to detect the volatile organic compounds that are produced as mold forms. The combination of wireless sensors and a BAS allows managers to promptly act on the information, reducing risk and associated remediation expenses.

Similarly, integrated BAS systems improve security and life safety functions. In event of a fire, the BAS can initiate a sequence of operations to facilitate evacuation. The BAS can signal the HVAC to stop delivering fresh air to the area and pressurize the path of egress to clear it of smoke. The BAS signals the access control system to unlock doors, and surveillance cameras give responders a live feed. A building's digital signage can display real-time evacuation instructions in case that a disaster or emergency affects exit routes. Motion sensors and lighting control systems can also provide indirect information about occupancy status in a connected building. Lastly, when systems are converged on an IP network, it is possible for a security system to easily transmit digital images or a live video feed to police or emergency response personnel.

High-performance buildings are more valuable than conventional buildings

Appraisers, insurers and lenders are beginning to recognize that efficient buildings — whether those efficiencies are driven by green or intelligent features — are more valuable than 'comparable' buildings that are conventionally built. A life cycle cost analysis demonstrates that a slight initial premium in first costs results in lower operating costs, higher net operating income, and higher asset value. The central questions are: how much more does a green and intelligent building cost than a conventional version of the same building? What is the payback period for this premium? And to whom do the operational savings accrue?

Reducing operating costs improves a building's net operating income, thus enhancing the building's asset value. According to the international consulting firm Frost & Sullivan, the total annual savings divided by the capitalization rate equals the augmented asset value.

According to Rypkema, the standard methods of valuing buildings must take into account the different characteristics of high-performance buildings. For example, the Cost Approach does not address how slightly higher first costs may increase the building's market value by reducing operating costs, and how the depreciation schedules may not reflect the building's longer life cycle.

A comprehensive valuation model needs to quantify all costs and externalities, including those beyond that lot line.

"Conventional approaches don't reflect the value that green or intelligent buildings provide in reducing negative externalities such as carbon footprint or greenhouse gases. These environmental costs are typically borne by municipalities and taxpayers," said Anca Novacovici of Washington, DC based Eco-Coach. "Financial models and municipal incentives need to reflect how green and intelligent buildings create shared benefits by reducing pressures on municipal water and wastewater infrastructure."

Cities should offer expedited permitting to projects that use green or intelligent features, particularly to benefit those which can reduce taxpayer burden or those which have the potential to reduce municipal capital or operating expenses. Conversely, cities can levy fees on new buildings which don't meet certain usage standards to offset the fact that these costs will be externalized to taxpayers.

For example, in Green School Design, Greg Kats discusses a school in Dedham, Massachusetts, that created a positive externality for the town through its own green construction. Specifically, the school's green design included on-site rainwater storage, which helped the town avoid the $400,000 cost of enlarging an off-site stormwater detention facility.

These sorts of synergies should be encouraged through planning and thoughtful use of incentives. Unfortunately, many of the 'green' incentives and tax credits do not extend to commercial buildings which consume more resources. Going forward, this needs to be addressed by lobbyists and policymakers.

Re-examining assumptions is critical for making investment decisions in green or intelligent building features — in particular crossing the Chinese wall between first costs and operating expenses.

For commercial buildings, it is especially important to take a holistic view of the costs and benefits for an accurate ROI calculation. Barry Katz cites the example of Wal-Mart's EcoMart prototype stores, which incorporated green features. Wal-Mart reported that sales per square foot were roughly 40% higher in departments located beneath the skylights, when compared to the same department in stores without skylights.

"It is a complex calculation," said Katz. "First costs are higher because skylights are more expensive than regular roofing. There is a compound effect on operating costs. Daylighting reduces electricity costs but may result in slightly higher heat losses through the glass — but the real benefit to the stores was the unexpected link between daylighting and higher revenue figures," said Barry Katz. "However, the conventional approach separates capital and operating expenditures. The conventional approach typically doesn't correlate capex and opex with sales per square foot. But if they had not done just that, they would not have established that critical relationship which changes the payback of that investment."

Green and intelligent buildings benefit both tenants and owners

Using converged networks to shortening the construction cycle moves projects more quickly towards revenue generation.

In a competitive market, a differentiated building should command a price premium or have faster market absorption. Rising energy costs may affect tenant leasing decisions, making energy-efficient buildings more attractive. Green and intelligent features can differentiate a property, leading to rent premiums, faster absorption rates, and better tenant retention.

The combination of green and intelligent features can also enhance tenants' experience of being in the space. "In a connected building, there is no delay in getting cable or phone systems set up. Businesses can be operational from move-in," said Habib. Over the course of a tenancy, increased comfort and control leads to higher productivity and satisfaction — which acts as a disincentive for tenants to relocate. This, in turn, reduces owner's costs associated with turnover, such as brokerage fees, tenant improvement allowances, and vacancy loss.

Obstacles to adoption

One of the obstacles to broader adoption is that appraisers, insurers and lenders lack effective methods to quantify and value energy savings driven by green or smart technologies. Combining green features with intelligent features allows monitoring and measurement of performance, which should address this issue going forward.

Split incentives are another obstacle to adoption. "The conventional approach to development has been to minimize the initial capital costs and to deliver buildings that barely meet code," said Rypkema. Rather than addressing building efficiency, developers and building owners have shifted the burden of rising utility prices onto tenants through net leases. Going forward, rising utility prices may influence the decision to choose one property over another.

Under net lease arrangements, tenants are responsible for energy costs. This acts as a disincentive for building owners to make capital expenditures where the savings will benefit another party. Building owners may consider switching to gross leases to reap the benefits of an energy-efficiency retrofit. Or, they may adapt the approach of energy services companies (ESCOs), where the capital investment for the upgrade is repaid using the energy cost savings. For example, the developer could attach a loan for the price of the green or intelligent upgrades to the condo association. The loan could be structured so that 60% of the energy savings could go towards paying off the loan within five years, and the remaining 40% accrue to the residents' benefit in the form of lower utility costs. After the fifth year, the loan will be entirely paid off and the full energy savings of the upgrades will accrue to the residents.

Real estate is a cyclical sector with higher risk factors than the economy as a whole. As a result it tends to be conservative, risk averse, and slow to adopt new technologies. The sector is also highly fragmented, with many local players, some regional players, and a few national players. The regional or national companies have the capacity to adopt new technologies, but they generally have very little budgeted for research or development.

For development companies active across state lines, fragmented building codes can act as another disincentive to innovation. Building codes reflect regional differences and priorities. The building code in a state like Arizona would emphasize water efficiency, whereas a colder locale would focus on energy efficiency. "We either need to rewrite the building codes, or have LEED become more of a national building code," said Kats. "Building codes can affect the energy consumption of entire regions because the individual building stock built to that code will be there for decades."

Besides the sector's aversion to new technologies, there are also technological challenges to integrating building systems. No turnkey offerings are available, and solutions need to be customized to each building. Other obstacles to broader adoption include information security and privacy concerns, a lack of awareness of the benefits of intelligent building features, and the reluctance of vendors and utility companies to release proprietary technologies and standards. Industry groups are, however, working to establish open standards to integrate disparate building systems.

"Mathematics and public policy, not technology, are the underlying issue," said Rypkema. "Subsidized prices for resources such as gasoline, oil, and water obscure the payback period.

"These subsidies act as a disincentive to investing in some energy-efficiency upgrades since it appears that the money can be more profitably invested elsewhere."

Renewable energy sources currently cost more than conventional energy sources. However, technological advances and rising demand will lower costs. Withdrawal of tax subsidies will also increase the difference between the nominal and actual costs, changing the payback horizon and making investments in green or smart building features more feasible.

According to Kats, investments that increase energy efficiency currently yield the highest returns. For example, electricity from a new plant costs roughly $0.10/kWh, while energy-efficiency upgrades produce savings of $0.02-0.08/kWh. "In essence, the savings from energy efficiency is one-third the price of retail electricity," said Kats.

The broader adoption of green and intelligent building features will be driven by public policy, market forces, and public opinion.

Rypkema believes that one of the biggest flaws in the conventional approach to real estate development is the short-term horizon. "The attitude is, 'who cares if it lasts for 30 years or 200 years, if I'm only going to be there for five years.'" Higher interest rates are a disincentive to build for the long-term because developers want to recapture their profit quickly. "We should provide low interest rates for people who are making decisions with a long-term horizon and public benefit, not for those who are building conventional 30 year buildings."

However, the conventional approach is short-sighted. Assuming a 40 year lifespan for a building, first costs represent only 11-15% of life cycle costs, while operating costs represent 50-80% of life cycle costs, according to Rypkema. As a result, developers who pay a slight premium in first costs can achieve significant operational savings over the life of the building. Investments in upgraded energy systems can achieve a 20-30% ROI, according to Energy Star. Investments in energy upgrades can enhance the building's asset value by two to three times the amount invested, according to the Environmental Protection Agency.

Lenders should also offer differential rates for green or intelligent buildings based on lowered risk compared to conventional facilities. Because utility expenses will be lower in a high-performance building, should lenders permit buyers to use smaller downpayments or more leverage? Or should lenders offer buyers of smart green homes a preferential interest rate to reflect a reduced default risk and less exposure to volatile energy prices and operating costs?

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"This is not just a bigger business cycle issue, this is the harbinger of larger changes," said Rypkema. "Forget the cliché part of sustainable development — we're recognizing that the economic model we've been living with for some time is not a sustainable model."

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