The Role of Private Capital in Emerging Building Technologies

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ABSTRACT

With buildings consuming 48% of all energy generated in the United States alone, “arch-tech” is the next frontier for addressing two of the planet's most critical future challenges - energy consumption and global climate change. The dawn of the 21st Century has already brought with it the most explosive period of technological innovation and change in human history. Technology has more potential to alter the energy performance of buildings at a quantum revolutionary level than any other big energy-consuming sector today. Yet buildings are still remarkably analog devices, lacking basic technology integration that could boost their energy efficiency and performance. This lack of technologic integration presents huge opportunities for interactive systems to exponentially improve the energy efficiency and performance of buildings, both new construction and even more critically - building retrofits. Today new building technology startups are in their most nascent stages of development. It is here that private capital can play a pivotal role in catalyzing and developing this new "arch-tech" sector, just as it has done in computing for two generations. Venture capital and other forms of private equity will be crucial to bringing this emerging technology sector to today's building industry.

green building, building technologies, energy co-generation, sustainable building practices, LEED

BIG CHALLENGES

The single greatest challenges of our generation are global energy consumption and the global climate change being caused by this consumption - a now virtually indisputable fact. On the front line of these energy and climate crises are the single greatest consumers of energy in the developed world - buildings. As buildings are the greatest consumers of energy in the United States (48% according to the U.S. Department of Energy), the AECO industry (Architecture, Engineering, and Construction) is on the front lines for leadership in solving the problem. Like all great challenges the human species has encountered in its existence, we have faced and transcended these challenges with technological innovation. The above tests are no different. This presents an exciting opportunity for private equity investment in the U.S. Private equity has played an outsize role in the last 30 years in building the technology edge enjoyed by American startups in high-technology, biotech, and transportation. That opportunity is now presenting itself anew with the sustainable building movement and the rapid integration of technology in much of the new construction occurring around the world today. It is the role of private equity in the development of this new technology sector that I intend to discuss in this paper.

CHANGING PARADIGMS

As it has been many times over the storied ages of architecture, the practice of architecture is once again in the midst of a technological sea change that is creating a perfect storm of new, bleeding edge materials, computer-aided design tools, and automated building systems radically altering the 21st Century built landscape. Technological change is nothing new to architecture. From the first reinforced masonry bricks developed by the ancient Egyptians in 1,400 BCE, the first concrete poured by ancient Romans in the First Century CE, to the soaring tensile steel structures of the 20th Century and its Modernist Age, technological breakthrough has always played a crucial role in the advancement of the human dwelling. The last great period of technological upheaval, Modernism and the Industrial Age, gave birth to wholly new building typologies – the skyscraper, the curtain-wall, the stark geometries of Corbusier and Mies van der Rohe. The International Style swept across the world, redefining the city and its urban fabric with air-conditioned, fluorescently illuminated technologic concoctions of steel and glass.

But things seemed to stall with the advent of the skyscraper, air-conditioning, and the elevator. Since the Modernist period, there has been no real dramatic change in the way we build buildings for 70 years. The AECO industry has failed thus far to take full advantage of the revolution in computing that has transformed other industries over the last 30 years. However, this has begun to change in just the last few years. Today we are gripped with the maturing machinations of the Information Age. Again technological innovations are altering the built landscape with starkly new typological forms and innovations. A dizzying myriad of fantastical new building materials, ever more advanced computer-aided architectural design tools, highly complex feats of engineering, and the arrival of large-scale, automated building systems have begun to marshal in new paradigms in architecture. However, the next phase of technological change may very well move beyond these prodigious forces.

In fact, the next phase change we experience in architecture will have more to do with *how we integrate* technology into our architecture rather than how we use technology to design it. The design *process* becomes the focal point rather than the design tools; the ongoing *behavior* of a building rather the post-construction stasis. Computing has given us the first act in its transformation of architecture and the building through its tools for design and engineering. The second act will be quite different, as *process*, *efficiency* and *interactivity* come to the fore. In this next technical period, the process of understanding how architecture might develop deeper *relationships* to the building and its users, and how technology might facilitate that active inter-relationship is the next frontier. Buildings in the 21st Century will have a much more integrated understanding of the ways they are being used, and how their own function and performance might respond to those uses. This translates in many ways, but the bottom line will be *performance* - and performance will be measured in terms of energy efficiencies and net operational costs.

ARCH-TECH

Sustainable materials and green building systems are already significantly transforming architecture today worldwide. Architects such as Thom Mayne, Norman Foster, Richard Rogers, and many others have built iconic building designs the world over utilizing "green" systems approaches in their building designs.

The Federal Building recently completed at Sixth St. and Mission in San Francisco, CA is a good place to begin this discussion of what makes a technologically integrated building. Pritzker Prize winner Thom Mayne of Los Angeles-based Morphosis designed the Federal Building, with structural engineering design services provided by London-based ARUP. As with many of Mayne's other designs, notably the CALTRANS Headquarters in downtown Los Angeles, the Federal Building features a highly automated, active-skin system that integrates several technologies to regulate both interior climate and daylighting, enabling this 495,000 sq ft office building to be naturally lit and ventilated for several months out of the year. By combining this super-technical building envelope with strategic building siting, thermal massing, and footprint, Mayne's San Francisco Federal Building has become a study in integrating technology throughout the building's living systems to make it more performative and energy efficient.

The window-wall system includes automated/operable windows to regulate interior climate through natural ventilation. The automated window system is computer-controlled to react to radiant heating inputs, as well as changing weather inputs from the outside environment. As the interior of the building heats up during the afternoon, the control system opens windows allowing excess heat to vent through the opened windows to the outside. The skin also employs thermal-massing strategies to passively cool the building interior from morning to late afternoon when the radiant heat begins to taper with the onset of evening. The thermal massing storage in the interior concrete building frame absorbs cool temperatures from the cool San Francisco evenings to be used to passively cool the interior spaces during the daylight hours. Vents in the lower floors also exploit the building's orientation to prevailing offshore winds, creating a pressure differential that forces ram air into gaps between outer skin and interior spaces helping to naturally ventilate the entire building volume.

Additionally, the skin utilizes a sophisticated sun-shading system of perforated stainless-steel panels clad to a tube-steel frame bolted to the concrete building frame. The sun-shading system

Clean Technology 2008, www.ct-si.org, ISBN 978-1-4200-8502-0

is described by ARUP as "multiple planar elements of varying geometry that wrap the south elevation of the building, continue over the roof, and transition to the ground as a series of plaza-level sunshades." This intricate system serves as both daylight and radiant temperature regulator, in league with the automated operable window system.

This heavily weighted *systems* approach to architecture is emblematic of the movement in the industry often termed "sustainable" or "green" architecture. Sustainable architecture is a systems-based approach to design that emphasizes the use of technology to wring higher energy efficiencies out of buildings. By focusing on daylighting, natural ventilation, and other green/energy efficiency issues, this reduces the building's systems footprint on the environment. This is an extremely important development in contemporary architectural practice, as buildings are currently a leading source of this planet's overall energy consumption, accounting for 68% of all electricity used in the United States and millions of tons of CO2 gases. Using technology to design, operate, and manage these sustainable systems gives the building a level of responsiveness, awareness, and efficiency that presents the single most critical front against the rising tides of global warming and runaway energy creation/consumption. It is an integrated systems approach to architecture that will continue to transform 21st Century buildings into true "*integrated living systems*". An integrated living systems approach to architecture and construction will be critical to future buildings.

An integrated living systems process enables the architect, through interactive technologies designed and embedded into the function and performance of the building, to create the conditions and capability for the building to more efficiently manage its energy consumption. It is these interactive technologies – from sensors, automated HVAC control, reactive daylighting, building management systems, and interactive communications that enable the buildings intelligent sensing and response mechanisms. This inculcates the building's many seemingly disparate living systems with responsiveness and relativity down to the individual user. This completes a necessary feedback loop between building and user, enabling the building to interact directly with its user-community in real-time, enabling the building to regulate its energy in real-time according to the real-time needs of its users. Additionally, the interactive systems integration enables buildings to participate in emerging energy regimes such as the demand-response models underpinning new relationships between public utilities, the private commercial sector, and new intermediaries such as Enernoc and Comverge. The incorporation of these technologies into a building's day-to-day systems performance is critical to attain a high level of energy efficiency and cost management.

ENTER THE VULTURES

There have been many obstacles to technological development in the AECO industry. New technology innovations are often created as project-specific solutions for site-specific projects. Essentially this means every building is a prototype, and the technology innovations incorporated into buildings often stay with those buildings and are not expanded beyond the singular application. However in other designed systems – such as cars, airplanes, home appliances, computing – quite the opposite happens. Technology innovations are productized and mass produced, reverberating through multiple product lines, even multiple product typologies. Technological solutions in buildings, on the other hand, largely end up trapped forever in research institutes or shelved indefinitely in engineering firms until the next similar prototype comes along. These innovations largely remain inside service oriented firms without the entrepreneurial infrastructure to productize them, creating new products and companies. Meanwhile, other tech sectors, such as biotech, renewable energy, and computing have produced countless new technologies, products and companies, generating billions of dollars in product revenue and market capitalization. Unlike the building trades, these sectors have a long history and tradition of entrepreneurial innovation, and have thereby attracted tremendous infusions of start-up capital and entrepreneurial infrastructure. Though a long time coming, the same is beginning to happen for the AECO industry.

A new generation of architects and engineers are entering the AECO labor pool. This new generation has a very different relationship to technology than previous generations of architects, engineers, and contractors. This new

generation sees beyond technology merely as a design tool and rightly views technology as an integral factor to their buildings. Architecture schools are beginning to teach sustainable/green building practices as a standard part of the curriculum. Architecture and engineering firms are reaching out to technology companies to help craft more integrated solutions to building performance. But most exciting is the emergence of new start-ups beginning to look specifically at building living systems for new products and services. Lighting management systems, HVAC control systems, building integrated energy co-generation, performative materials, and innovative structural and building envelope component systems are beginning to be developed outside the purview of traditional, entrenched players. In fact, many of the biggest players in these various systems, such as Phillips, Johnson Controls, and GE, are not traditionally innovators but gradual, eventual adopters. Because of the new rash of startup activity in the AECO space, this is creating a huge opportunity for private capital to fill the void.

That is precisely what is happening. Cleantech is a buzz word that has become all to familiar if you read the Wall Street Journal. According to the *Cleantech Group*, it is estimated that $5.2 billion was invested in 268 startups in 2007. This is a 320% jump from 2006! Yet most of this capital is chasing too few deals in bio-fuels and renewable energy. Venture capital and other forms of private equity have a critical role to play in sparking explosive growth in integrated living systems technology investment. Arch-tech startups will be a welcome addition to the clean-tech mix. Levels of investment in the next few years are not going to disappear; if anything they will continue to grow dramatically. With over 72 billion square feet of existing commercial space in the U.S. alone and over 5 billion square feet of new space being added each year, the market for arch-tech products and services is huge. Additionally, over 5 billion square feet of space is being renovated in the U.S. every year, creating huge opportunities for buildings to be retrofit with new, more energy efficient living system technologies. China added over 7.5 billion square feet in new construction in just the last five years. By 2035, 75% of the built environment in the United States will be new or renovated. The opportunities available are staggering. Because energy represents the single largest controllable expense for building owner/operators (typically a third of variable expenses) these same owner/operators are highly motivated to add new innovative systems solutions to their buildings if the capX is relatively low and the ROI within a reasonable timeframe.

The VC community needs new startups to make the mill go around. Venture capital can help turn these prototypical solutions into *productized* building technologies distributed worldwide. Private investment will help transform great ideas into great companies. Infusions of capital and entrepreneurial spirit into arch-tech will create jobs, products, global markets, a lot of wealth, and help to solve the single greatest challenge of our time - runaway energy consumption and its catastrophic byproduct - global climate change. If history in Silicon Valley has shown us anything, it is the power of the hallowed partnership between innovator and investor. The VC community has twice transformed industries (hitech and biotech) almost single-handedly by playing its crucial role as capitalizer of revolutionary ideas. Arch-tech is no different, just late to the game. But opportunities abound, and rarely has such a confluence of innovation, emerging (and re-emerging) markets, global crisis, and available capital come together to create such possibilities for technological innovation, cultural revolution and wealth generation at on time. Hopefully it is a coincidence on which AECO and private equity will fully capitalize!

Clean Technology 2008, www.ct-si.org, ISBN 978-1-4200-8502-0

REFERENCES

Gyula Sebestyen, ed. New Architecture and Technology. (Oxford, Architectural Press, 2003

Boyer, M. Christine. "The Imaginary Real World of CyberCities." Shaping the City. Rodolphe El Khoury & Edward Robbins eds. (New York. Routledge. 2004) 231-251

McDonough, William & Michael Braungart. Cradle to Cradle. (North Point Press, New York, 2002)

Blaine Brownell ed. Transmaterial. (Princeton Architectural Press, New York, 2006)
Mau, Bruce. Massive Change. (Phaidon, London, 2004

Mitchell, William J. City of Bits: Space, Place, and the Infobahn. (MIT Press, Cambridge, 1995)

Mitchell, William J. E-Topia. (MIT Press, Cambridge, 1999)

Taylor, Mark C. The Moment of Complexity. (University of Chicago Press, Chicago, 2001)

Guallart, Vincente. Sociopolis. (Actar, Valencia, 2006)

Steele, Brett ed. Negotiate My Boundary. (Birkhauser, Basel, 2006)

Brown, G.Z. & Mark DeKay. Sun, Wind, & Light. Second Edition. (John Wiley & Sons, New York, 2001)

Wiggington, Michael & Jude Harris. Intelligent Skins. (Elsevier, Oxford, 2002)

Slessor, Catherine. "Building Green." Architecture Record. Aug 2006. 74-105

Snoonian, Deborah, P.E. "Green Grows Up." Architecture Record Innovation. Nov 2004. 42-49

Stauffer, Nancy. "Site to Help Building Designers." MIT News Office. 6 Feb 2002. http://web.mit.edu/newsoffice/2002/building-0206.html

Doscher, Marty. "Morphosis: San Francisco Federal Building – BIM Awards Competition." AIA Technology in Architectural Practice. 11 Apr 2005

"San Francisco Federal Building." ARUP America - ARUP.com. 2006. http://www.arup.com/americas/project.cfm?pageid=1618

Norman, Donald. The Design of Everyday Things. (Basic Books, New York, 2002)

Wurman, Richard Saul. Information Architects. (Watson-Guptill, New York, 1997)

Alexander, Christopher, Sara Ishikawa, Murray Silverstein, A Pattern Language: Towns Buildings, Construction, (New York, Oxford University Press, 1977)

U.S. Census Bureau, 2007 U.S. Statistical Abstract, Washington, 2007

U.S. Dept. of Energy, 2007 Report On Industrial Energy Consumption, Washington, 2007

Peter Schwartz & Assoc., National Lighting Energy Consumption, San Francisco, CA, 2007

Cleantech Group, Cleantech Venture Investment 2007, San Francisco, CA 2008