

## Approaching Innovation

Stephen Kieran and James Timberlake  
Kieran Timberlake

Are we living in an Age of Innovation? The news of the day would have us believe so. As an experiment, we tracked the instances we encountered of the word “innovation” being used during the course of an ordinary weekday morning: an advertisement for a private school promises not just an innovative curriculum, but the teaching of innovation itself as a subject. A radio journalist interviews the new Vice Chair of Business Innovations at General Electric about the company’s global innovation barometer. The local transit authority’s Director of Innovation boasts of the energy-saving, innovative introduction of regenerative braking on subway cars. The Innovation Desk of a local news organization chronicles a student group pitching the use of graphite to enable 700 mile-per-hour transport in tubes. A nondescript plaza at the edge of a local university campus is renamed Innovation Plaza. A radio advertisement touts 55 new innovative senior living units organized in unique community clusters. An email titled “Weekly Survey of Innovative Building Materials and Interior Products” appears in our inboxes.

What gives here? Why can we no longer get through a day without hearing the word “innovation” dozens of times? Is it really everywhere? Or are we confused about what innovation really is?

### Toward a More Precise Definition

The ubiquity of the word does not mean that we are actually living in

an age of pervasive innovation. The inventor Dean Kamen has made the case that we are simply confusing innovation with invention. Invention is certainly difficult to attain in its own right—but compared to innovation, it is exceedingly common. Kamen notes that the world is full of “inventions,” with new ones arriving daily. Very few inventions, however, become true “innovations.”

As an example, Thomas Edison was one of the world’s most prolific inventors, with nearly 1,100 patented inventions. But only a few of them—the electric light bulb, the phonograph, and the moving picture among them—were truly innovations. Inventors can invent new objects and methods, but the wider world—not the inventor nor the legal system—gets to decide whether an invention becomes a true innovation.

It is not enough to be simply new or different. Innovation is rare. It is paradigm-shifting. A true innovation is used by lots and lots of people, all the time. And it fundamentally alters what we can do and how and where we can do it.

### Improvement–Invention–Innovation: A Journey

A more constructive way to conceive of innovation is as the late stage of an epic journey of unfolding possibility. This journey most often begins humbly, with a basic desire to improve something simple. It begins with a sense that something is amiss, that there must be a better way to

do something, to use something, to make something. As the first stage in the journey, improvement requires keen observation and relentless questioning. It is characterized by incremental change, by tweaking and tuning methods, process, form, and substance across time. All of us can improve what we do and how we do it; with persistent effort, we can engage in a virtuous cycle of improvement (Figure 1).

Occasionally, this inquisition and exploration lead to invention—to a new way, a new tool, an altogether different method. Invention is often enabled by incremental advances in other fields and industries that give rise to novel ways to conceive and solve problems in altogether different realms.

Very rarely, those inventions become innovations, events that fundamentally alter the world. While the capacity

to improve and invent is usually within our control, innovation involves a lot of chance. It is unpredictable. It depends upon happenstance encounters, impeccable timing, resources, persistence, and most importantly, a market awaiting a product it does not yet know it needs.

The distinctions between “improvement” versus “invention” and “invention” versus “innovation” are admittedly ambiguous. But it comes down to this: an invention, as distinguished from an improvement, is novel. In the terms of a patent attorney, an invention is distinct from prior art. It crosses a threshold of difference defined by our legal system, which has recorded more than 8 million patents since the founding of the U.S. Patent Office in 1836. By contrast, the difference between an invention and an innovation is arbitrated in the marketplace of life, not in the legal

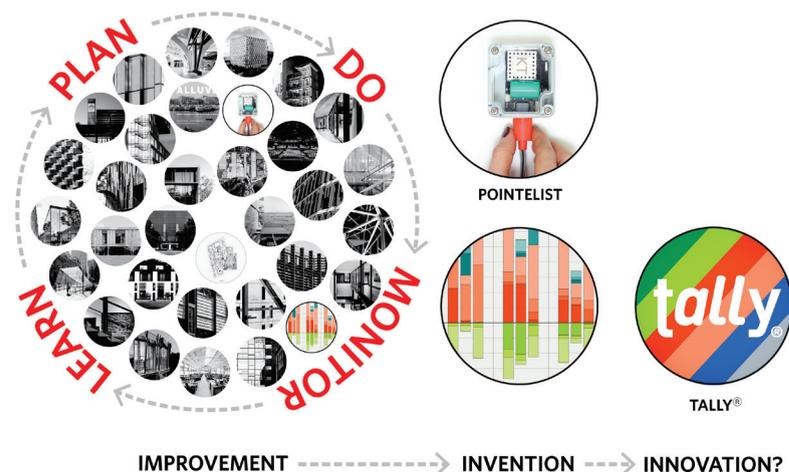


Figure 1. Virtuous cycle of improvement

system. The inventor provides something new, while citizen users get to vote with their feet and pocketbooks on whether an invention's utility is of sufficient scale and consequence to change prior paradigms—to be considered an innovation.

True innovation is rare enough that we believe the present focus on the word is completely misguided. This focus gives rise to too much expectation, leads to excessive disappointment, and degrades the value of the vast, pervasive, and more attainable realms of improvement and invention that must precede all true innovation. Most who have truly innovated will tell you that the journey did not begin with the aspiration to change the world. More than likely, it began with a few seemingly simple but profound observations, followed by uncomplicated attempts at improvement. For those who ultimately do succeed, the recognition of an innovation normally comes into view only later, often much later. Rather than bandying about the term, as is so common in this present moment, we believe our collective focus should be on the creation of personal and organizational cultures of inquiry and improvement. This cannot be done by naming a Director of Innovation. It must be engrained within individuals and organizations. It cannot arrive solely from the top down—it has to also come simultaneously from the bottom up. It has to be habit, a way of observing, thinking critically, asking questions, speculating on improvements, scrapping things that do not

work, and embracing and championing things that do work.

#### **Innovation as a Teachable Skill?**

True innovation is too rare and difficult to be taught. What we can teach, however, are the habits and skills that may, on rare occasions, enable an invention that the public actually takes up and uses and that becomes recognized as an innovation.

Foremost among these skills is the power of observation. Learning how to see is an iterative process. It begins with quiet observation of the way things are and requires careful recording through words, drawings, diagrams, photographs. The act of recording deepens comprehension; it slows and sharpens the senses. Anyone who has ever made a drawing of a thing, a process, or an event knows that the act of tracing by hand transforms observation into an abstraction, a way of understanding. The events of the world are no longer just passing by—they are causal, not casual. This skill of observation has to be repeated again and again to become habit. Improvement can only begin here, after the hard work of seeing and recording.

Second, one needs to master—not merely learn—a discipline or disciplines. Innovation requires a deeply rooted body of knowledge. How one acquires this disciplinary knowledge does not matter. It can be through conventional education, through personal study and observation, through working in a specific field. But to gain

the prospect of improving, inventing, and, just maybe, innovating, there is simply no way around the mastery of a discipline. You cannot buy this expertise from others; you have to do the hard work to own it yourself.

Third, one needs to regain the art of inquiry. We are born with this habit as we first acquire language and confront the world around us. Yet somehow the relentless questioning of very young children gives way to the certainty of fools all too soon in life. But the art of framing questions can be taught, and it can become a habitual, reflexive skill through iteration and practice. No invention, let alone innovation, is possible without a well-crafted question without provocative questions, there are no compelling answers.

Fourth, one needs to learn the skills of collaboration. Very few improvements, inventions, and innovations are the work of an individual. The legend of the lone genius succeeding heroically, against all odds, often masks the messy realities behind the scenes. This reality requires skill sets that today are the subject of countless management seminars and texts: listen more, talk less; know your blind spots, know the blind spots of others; don't take, share; worry about what is done, not who does what.

#### **Approaching Innovation at KieranTimberlake: Three Case Studies**

We believe that invention and innovation most often begin in modest

ways—through creating space for introspection and review of those simple things that we do and use most often. Since the outset of our practice, we have sought to engender and support an intellectually restless culture that is perpetually questioning and seeking ways to enhance the quality and scope of everything we do.

In 2006 we formalized this commitment to quality in our office by becoming certified by the International Standards Organization (ISO) for the research, management, and delivery of architectural services, a certification that we continue to pursue annually. This process gives us a framework to monitor and learn from everything we do. Out of this cyclical self-criticism come proposals for process improvements that we implement in subsequent work. Occasionally, this process of self-criticism suggests opportunities to invent new tools, processes, and materials that are relevant not only to a specific project but also of broader use to the firm in our quest for continuous improvement.

Finally, some of these inventions seem to have utility and promise beyond our firm—and they are then spun off for further development in the marketplace by a subsidiary firm called KT Innovations.

#### **Case Study 1: Tally®**

Nearly ten years ago, we modeled the embodied energy in two completed projects, Loblolly House and



Figure 2. Loblolly House

Cellophane House. While we expected the totals to be substantial, we were surprised that the embodied energy at completion was equivalent to approximately forty years of operational energy. These results caused us to question how we might begin to understand embodied carbon count during design—as opposed to after the fact (Figures 2–5).

At the time, the tools to quantify embodied energy were useful for completed projects but cumbersome in terms of informing the process of material selection during design, when the information could have a positive impact. The Tally software tool was created to provide accounting for embodied energy during design, at the speed of design. It allows for early consideration of alternative system and material choices, providing knowledge to inform ethical decision

making that optimizes overall energy use, not just operational energy. It is now marketed through Autodesk as a plug-in to their Revit software platform (Figures 6–7).

At this still early stage in a rapidly evolving field, Tally is at best an invention. Only the marketplace can determine whether it ultimately becomes an innovation that helps change how designers think and ultimately influences the choices they make to reduce carbon footprints.

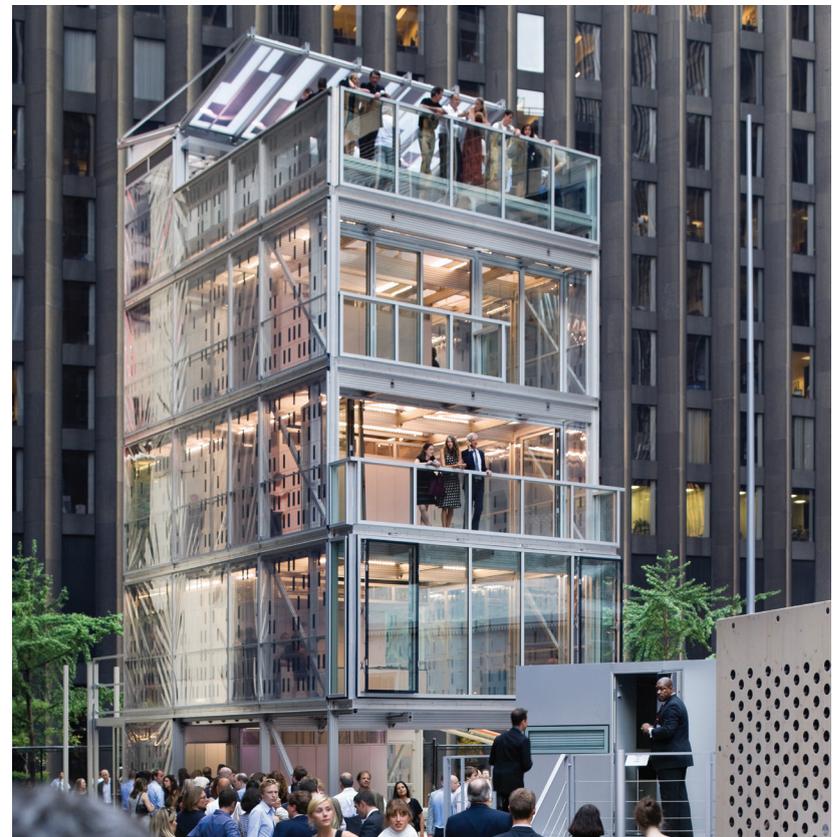


Figure 3. Cellophane House

## LOBLOLLY HOUSE: CARBON FOOTPRINT

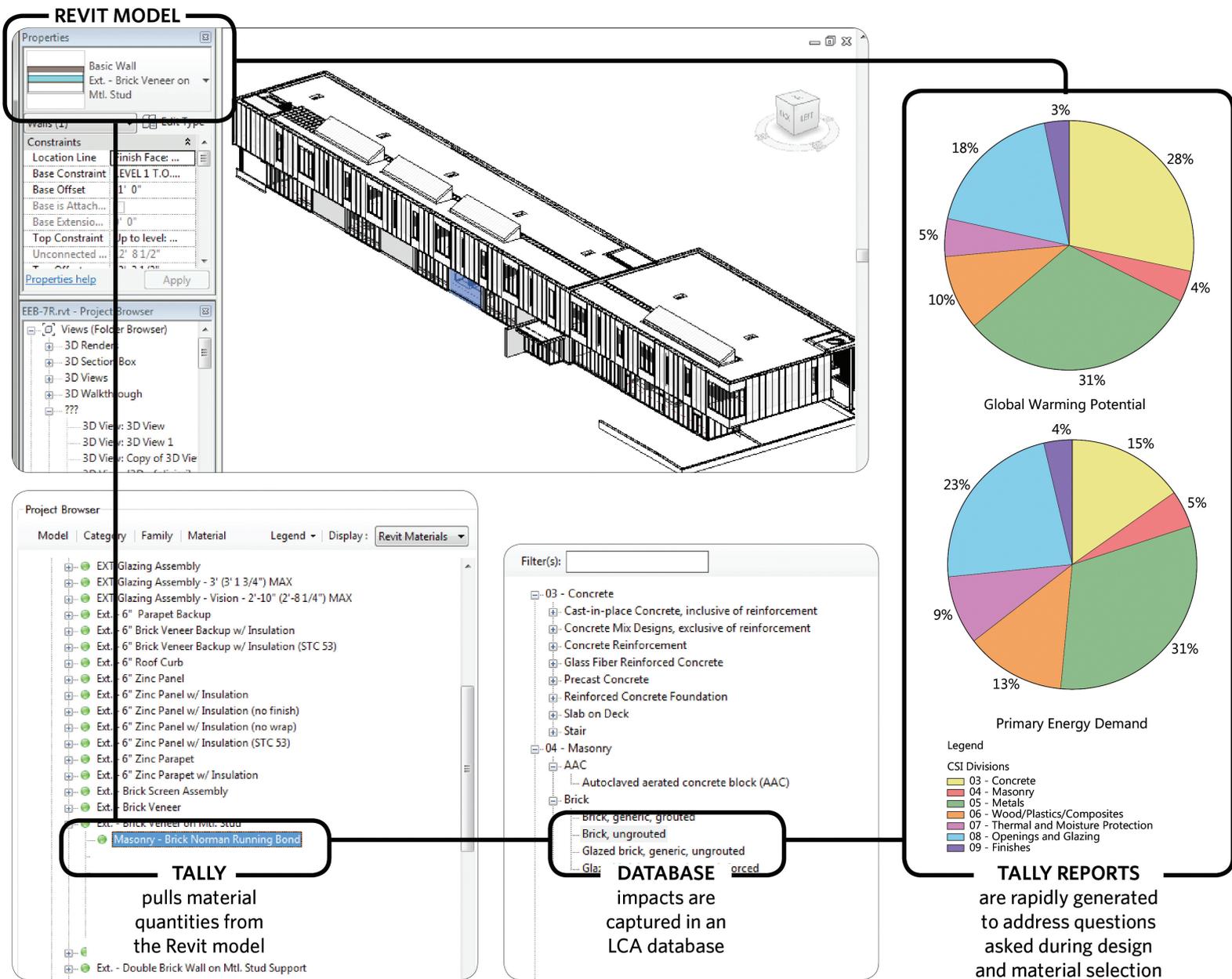
ELEMENTS <sup>1</sup>	Stairs	Rainscreen	Roof Cartridges	West Wall Glazing	Wall Cartridges	Floor Cartridges	Scaffold	Foundation	
MATERIAL									
WEIGHT (LBS)	2,000 lbs. steel	2,896 lbs. cedar	311 lbs. TPO 255 lbs. rigid 7,776 lbs. plywood 1,568 lbs. BATT 1,425 lbs. joist	2,000 lbs. steel 1,369 lbs. acrylic 22,356 lbs. nana wall™	2,862 lbs. glass 12,359 lbs. birch 2,682 lbs. PU foam 713 lbs. cement board 6,672 lbs. wood studs	2,284 lbs. BATT 2,461 lbs. bamboo 238 lbs. cedar 2,974 lbs. birch 2,850 lbs. joist	8,549 lbs. aluminum 1000 lbs. steel	11,402 lbs. piles 5,100 lbs. timber	
EMBODIED ENERGY (Kcal) <sup>†</sup>	4,854,000 Kcal steel	1,135,988 Kcal cedar	* Kcal TPO 3,504,590 Kcal rigid 10,528,704 Kcal plywood 4,926,028 Kcal BATT 558,944 Kcal joist	4,854,000 Kcal steel 13,588,512 Kcal acrylic 33,914,052 Kcal nana wall™	4,340,999 Kcal glass 16,733,620 Kcal birch 383,520 Kcal PU foam 735,884 Kcal cement board 2,616,683 Kcal wood studs	7,175,580 Kcal BATT 399,859 Kcal bamboo 93,187 Kcal cedar 40,226,176 Kcal birch 1,117,888 Kcal joist	177,000,000 Kcal aluminum 2,427,000 Kcal steel	4,471,743 Kcal piles 2,000,110 Kcal timber	
CARBON FOOTPRINT (LBS CO <sub>2</sub> ) <sup>‡</sup>	3,800 lbs. steel	-3,360 lbs. cedar	* lbs. TPO 5,240 lbs. rigid -6,532 lbs. plywood 2,446 lbs. BATT -1,653 lbs. joist	3,800 lbs. steel 4,423 lbs. acrylic 17,885 lbs. nana wall™	2,289 lbs. glass -10,381 lbs. birch 115,357 lbs. PU foam * lbs. cement board -7,739 lbs. wood studs	3,563 lbs. BATT -2,854 lbs. bamboo -276 lbs. cedar -2,498 lbs. birch -3,306 lbs. joist	102,583 lbs. aluminum 1,900 lbs. steel	-13,226 lbs. piles -5,916 lbs. timber	
DESIGN FOR: REASSEMBLY									LBS CO <sub>2</sub> RECOVERED 205,545 LBS CO <sub>2</sub>
RECYCLE									

\* Information not currently available for material  
<sup>†</sup> All information from Granta CES Material Selector for virgin material extraction  
<sup>‡</sup> Bathroom, Kitchen, and Mechanical blocks not included in carbon footprint analysis but would be redeployed in reassembly scenario

Figure 4. Loblolly House carbon footprint

COMPONENT	FRAME	SKIN	GLAZING	WALL PANELS	BATHROOM PODS	FLOORS	ROOF	STAIRS	FOUNDATION	TOTALS
MATERIAL										<b>1,800 sf building</b>
TOTAL EMBODIED ENERGY	955,631 kWh	22,224 kWh	71,423 kWh	22,577 kWh	71,448 kWh	146,008 kWh	8,214 kWh	235,001 kWh	15,264 kWh	<b>1,547,790 kWh 860 kWh/sf</b>
PERCENT RECOVERED	99.99%	100%	100%	100%	100%	100%	100%	100%	0%	<b>98.95%</b>
EMBODIED ENERGY RECOVERED	954,675 kWh	22,224 kWh	71,423 kWh	22,577 kWh	71,448 kWh	146,008 kWh	8,214 kWh	235,001 kWh	0 kWh	<b>1,531,570 kWh 851 kWh/sf</b>

Figure 5. Celophane House carbon footprint

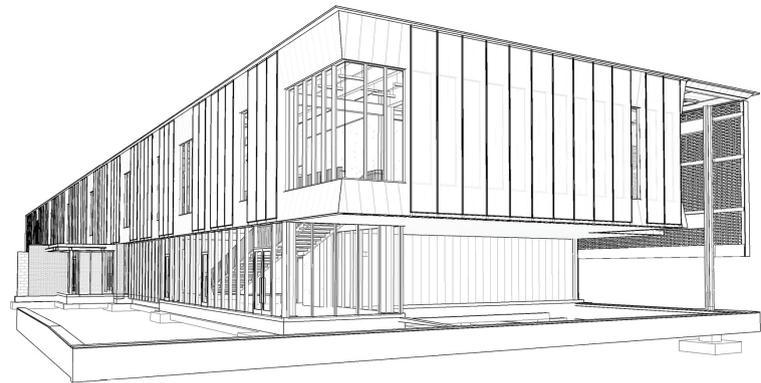


© KT INNOVATIONS

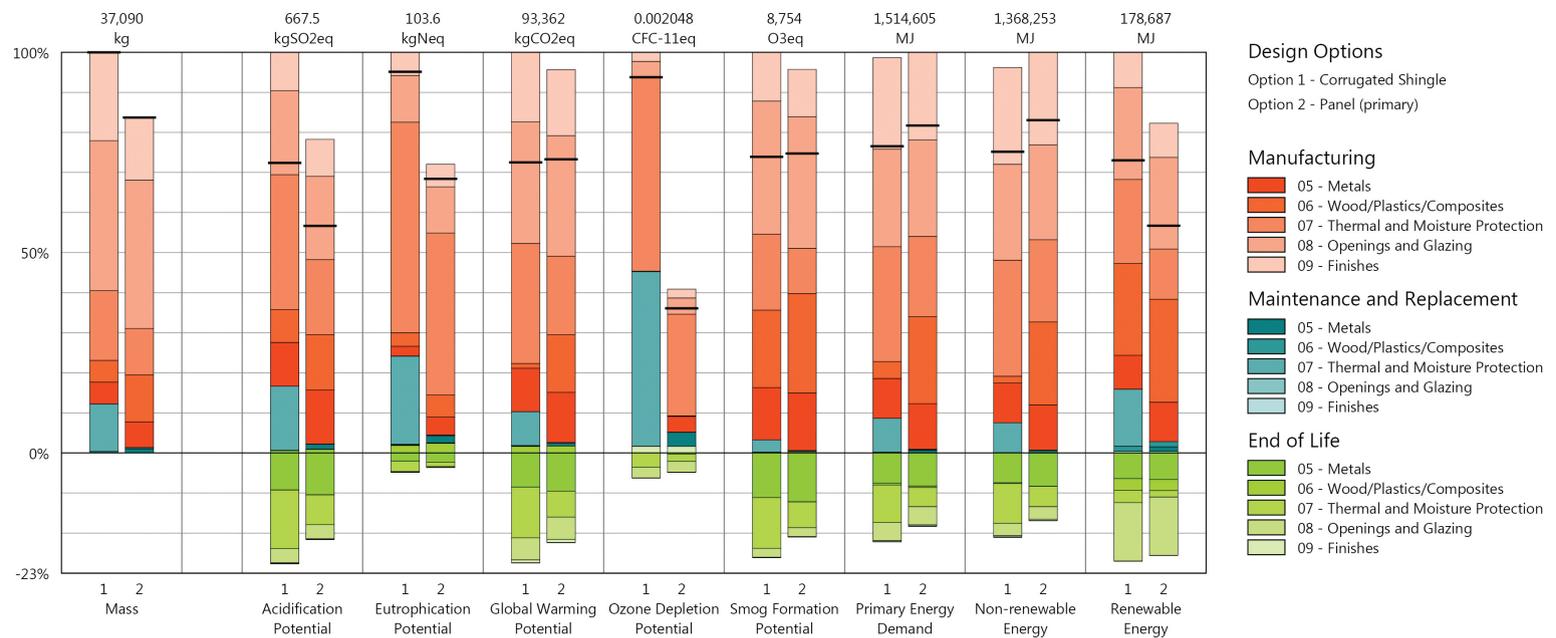
Figure 6. Revit screenshot



Option 1 - Corrugated Shingle Cladding



Option 2 - Translucent Panel Cladding (Selected)



Results Per Life Cycle Stage, Itemized by CSI Division

Figure 7. Revit screenshot



Figure 8. Interior view of Pointelist

### Case Study 2: Pointelist

In 2005–2007 we designed and built a new School of Art building at Yale University. The manufacturer of the building's curtainwall was initially concerned that the temperature might build up in the cavity between an aerogel-filled insulated panel and the outer glazing, damaging product components. We installed sensors in the wall to monitor the temperature build-up. Ultimately, the sensors allowed us to determine that temperatures never approached the level of concern, and the manufacturer warrantied the system (Figures 8–10).

Subsequently, we installed another set of sensors in Loblolly House. The objective there was to determine the passive heating value provided by an operable, west-facing double wall. The sensor system monitored exterior temperatures, temperatures inside the cavity, and temperatures inside the house. The heating of the two-



Figure 9. Exterior view of Pointelist

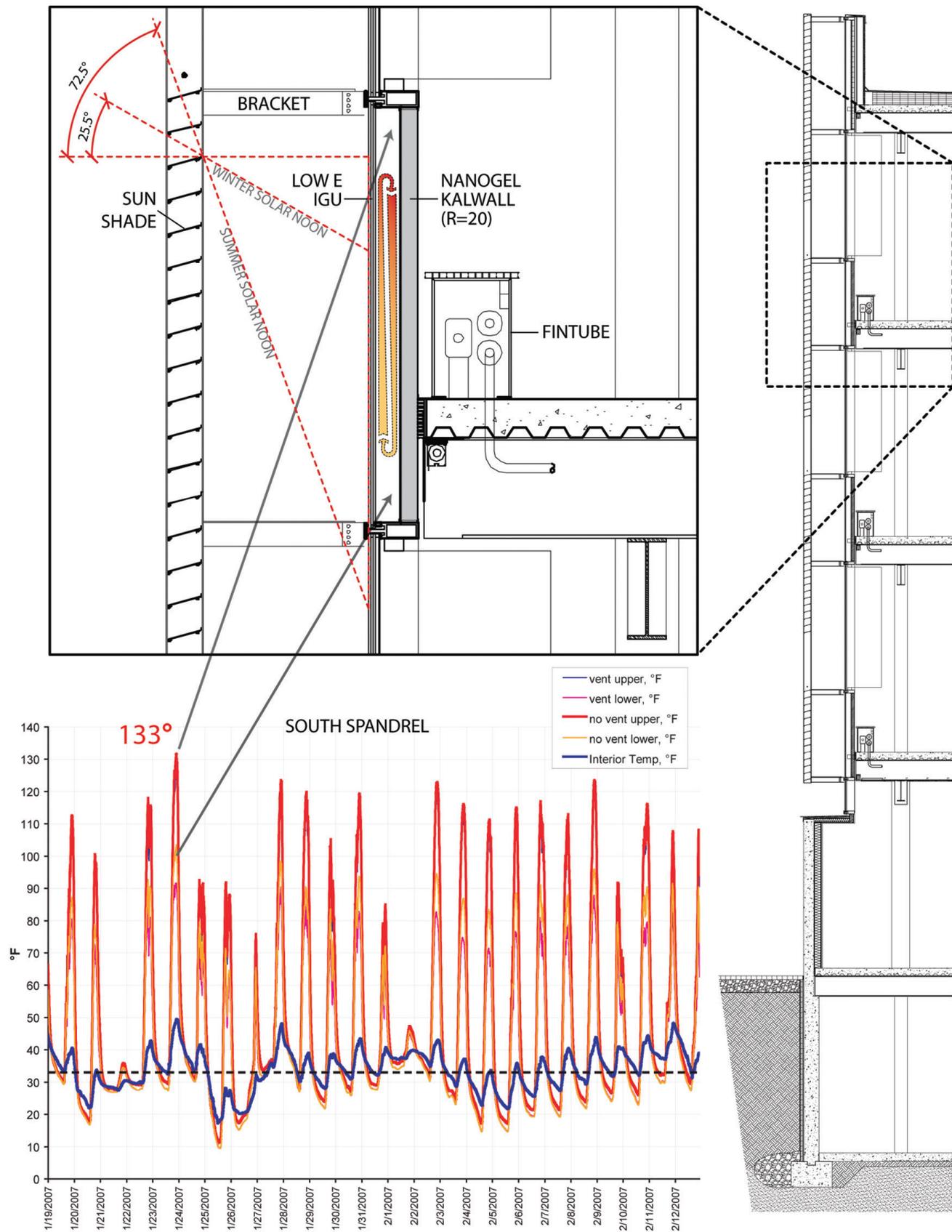


Figure 10. Details of Pointelist cavity and graphic analysis

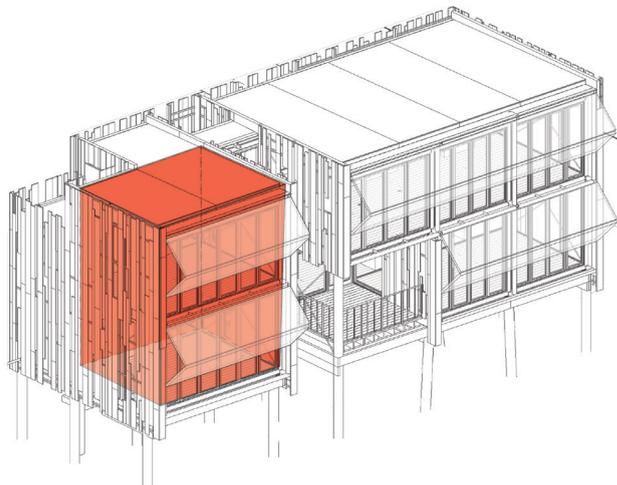


Figure 11. Loblolly House



Figure 12. Loblolly House

foot wide cavity by the setting sun in the afternoon trapped a blanket of warm air, raising the temperature at the face of the glass and lowering the thermal transfer between outside and inside. The effect of this blanket of heated air persisted well into the evening, lowering winter heating loads (Figures 11–13).

These early examples of custom sensor networks required downloading the information at the individual sites. We have subsequently moved to a wireless, cloud-based approach that has proceeded over the past years through several stages of product development. Successive generations

of sensors have been deployed in nearly all our projects to provide detailed design information at the micro-climatic level. Parks and public spaces, existing structures to be renovated, and sites for new buildings have all been tested using embedded sensors (Figures 14–16).

The tuning of architectural performance at very site-specific levels is a new frontier in energy minimization that is opening up to us through the information these wireless sensors provide. The Pointelist system is currently in beta testing with design and engineering firms across the United States and overseas.

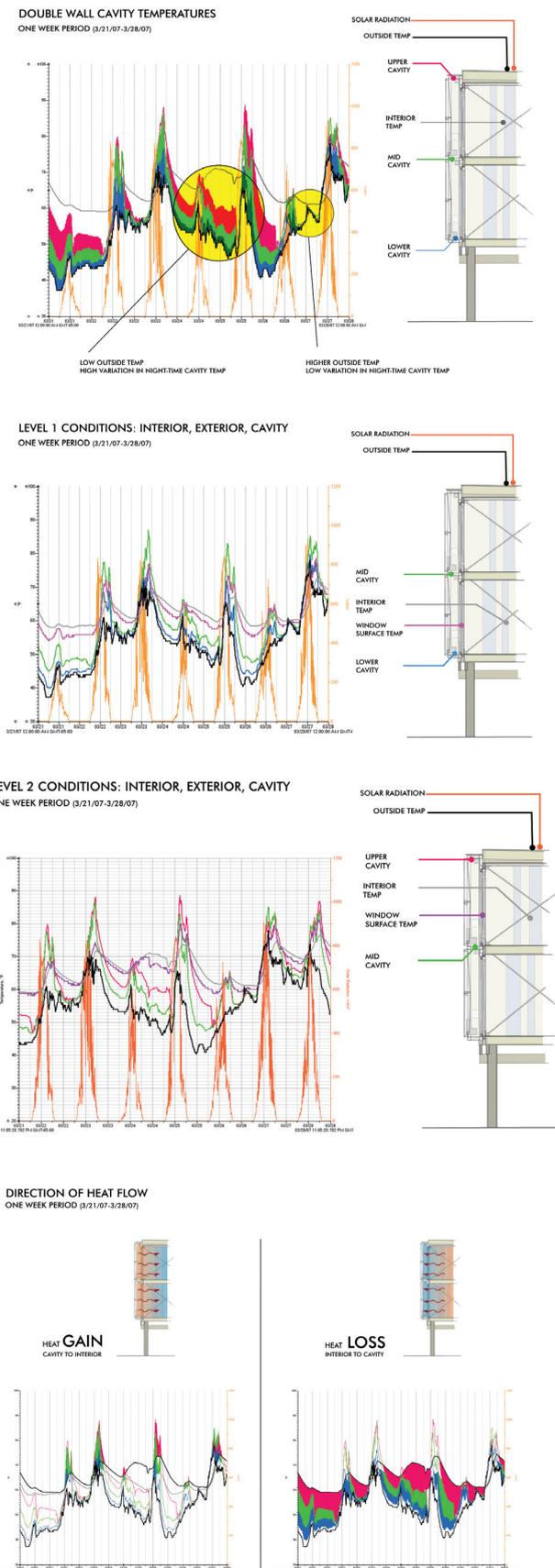


Figure 13. Graphs of the effects of thermal blanket, Loblolly House

### Case Study 3: SmartWrap™

This architectural product concept has its origins in the academic side of our practice as professors at the University of Pennsylvania's School of Design. Beginning in 1999, we transformed the still-pervasive design studio teaching model into a design-research laboratory format. We challenged groups of graduate students to scour other disciplines for materials and processes that might be applied to architecture 50 years in the future. One topic of study across multiple semesters was the transfer of print technologies from other disciplines into architecture. Printed circuitry was already used widely in electronics. However, the enabling science was then just beginning to move toward the transformation of previously inorganic substances and assemblies, such as LED and solar, into organic compounds capable of being printed.

The design provocation that led to the SmartWrap exhibition at the Smithsonian's Cooper-Hewitt National Design Museum in 2003 was based on printing thin-film assemblies of performative materials—circuitry, LED, solar, and storage batteries—onto transparent, flexible rolls of PET. The printed film was then wrapped around an aluminum frame that represented a building. The whole was suggestive of a future world in which architectural envelopes would function not just as weather enclosures but would also generate energy and move it across printed circuits to LED illumination and storage batteries (Figures 17–18).

As the commercial technology evolves, we continue to pursue this vision through both projects and research. In 2008, we developed a demonstration dwelling called Cellophane House for The Museum of Modern Art. The aluminum frame was clad in PET panels with tape circuitry and thin-film photovoltaics

coupled with advanced shading films. At the new United States Embassy in London, to be completed in 2017, the outer envelope of the building is composed of ETFE on aluminum frames that have been designed to both shade the glass facades and serve as an armature for thin-film photovoltaics. Within the Kieran-Timberlake studio, our Research Group works on implementing print technologies as the state of the art advances (Figures 19–20).



Figure 14



Figure 15

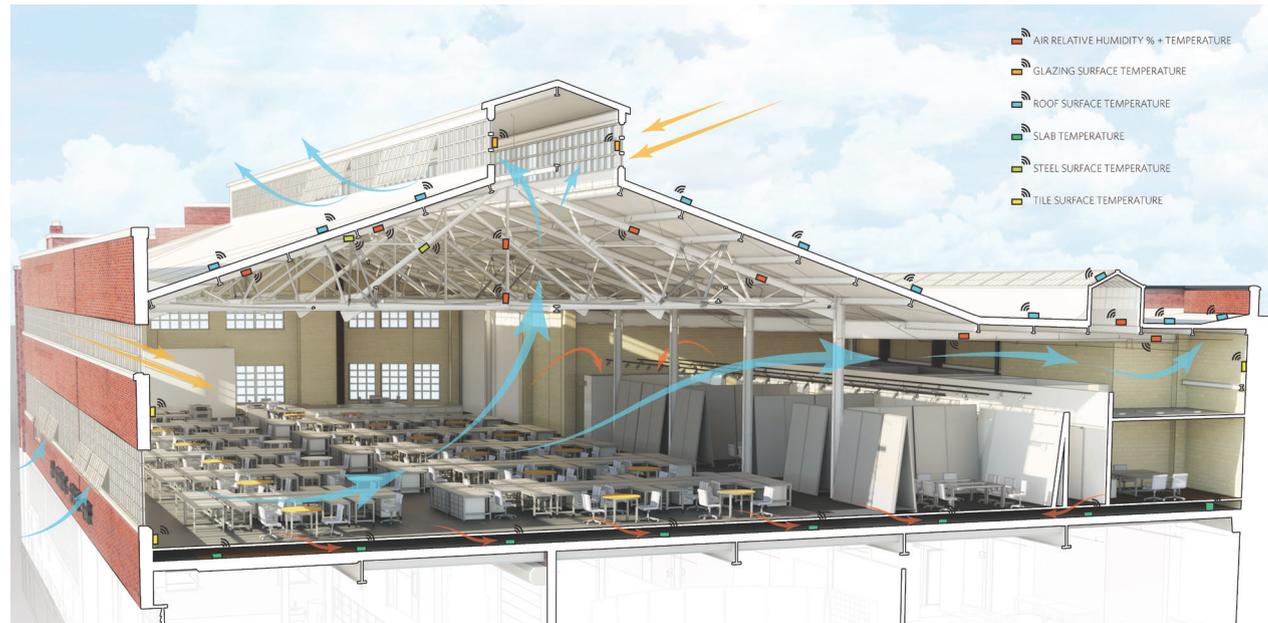


Figure 16



Figure 17



Figure 18



74 | *Figure 19. United States Embassy in London*



Figure 20. United States Embassy in London

### In Conclusion: Ten Essential Precursors to Innovation

1. If you want to innovate, you need first to forget about it.  
Here is the paradox: if you set out with innovation as your goal, you will never get there. Instead, focus day by day on finding problems and fixing them. To borrow a maxim from sports, win the day—the season may or may not follow.
2. Become an insightful observer.  
Stop talking, and start watching and listening. Slow down, be patient. Find a way to record and analyze what you are seeing and hearing. Look. Really look. Take measure of the world.
3. Disassemble what you see.  
Be a tinkerer. Take things apart to see how they work. Stop worrying about how they go back together. Concentrate on what makes them work, and how they could work better.
4. Focus on designing the culture in which you live and work.  
A culture of inquiry must be deliberately created—along with a cohort of travel companions for the epic journey ahead.
5. Question Everything.  
Self-criticism is essential to improvement. If you never improve, you will never invent. If you never invent, you will never innovate.
6. Persist against all odds.  
Sometimes success is just a matter of having the strength and will to persist—and the courage to believe something has merit even though the world around you says no.
7. Be willing to fail fast and often.  
Very few initiatives aimed at improving the status quo succeed in the end. Sometimes, you need to know when to move on—and have the courage to do it fast.
8. Know the difference between what is causal and what is casual.  
Not everything you observe in the world is equally purposeful. Know what causes other things to happen when you see it.
9. Know everything that has preceded you.  
Big changes depend upon lots of prior art, improvements, and inventions. Do the hard work to know the ground trodden by your predecessors.
10. Be artful: substance matters, but so does appearance.  
It is not enough that a thing works. It helps us to want it if it is also elegant. Without desire, the battle is always uphill.