Technology, Design, Culture: Interconnected ingredients for moving beyond best practice in commercial buildings

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Overview

Both the technologies and design concepts exist for a new generation of low-energy buildings that outperform today’s typical high-performance buildings. Cultural barriers, however, are a primary inhibitor of the widespread construction of these buildings. This paper first gives examples of existing technologies and design concepts exceeding today’s best practice, followed by successful built examples from Transsolar’s practice. We conclude with a broader discussion of the cultural barriers we believe prevent broader adoption of similar practices.

Technology

We define technology as the materials, products and systems that make up the construction of a building. The past two decades have yielded many technologies that are now considered best practice for energy efficiency, but are not yet prevalent in existing buildings. Most new construction and renovations include low-e double-glazed windows, variable air volume systems and equipment with variable speed drives.

An excellent example of existing best practice technology is the New York City Urban Green Council’s report, \textit{90 by 50}, which demonstrates that New York City’s carbon emissions from buildings can be reduced 90\% by 2050, through use of technologies such as window overhangs, triple glazing, air sealing, heat recovery ventilation and mini-split heat pumps. Furthermore, they found that the cost is manageable from a citywide perspective.

Although such technologies are critical to performance improvement in new and existing buildings, this paper focuses on the next generation of technologies which are not yet considered best practice. These products and systems often challenge current practice because they are more than a pure product substitution – hence the cultural barriers. For demonstration, we present examples of such technologies which are frequently applied in Transsolar’s practice.

Triple glazing remains difficult to economically justify in many commercial U.S. buildings, which are mostly dominated by cooling rather than heating. In response, manufacturers have developed durable low-emissivity coatings which can be applied to the interior surface of double glazing, resulting in a center of glazing U-value of 0.19 Btu/h-sf-°F compared to values of 0.25-0.30 Btu/h-sf-°F when this coating is not used. These coatings have become available on the market in the last two years and have quickly been applied in many of our projects. They have not seen widespread adoption but are an example of a technology that appears likely to quickly become best practice.

High-performance window frames provide a contrasting example. Thermally-broken frames are specified on nearly all new construction buildings.

\footnote{http://www.urbangreencouncil.org/90by50}
but the improvement in U-value has remained stagnant in the last decade in North America. Compared to typical European frames for fixed windows, which have frame U-values as low as 0.14 Btu/h-ft²°F, frames available in North America average 0.8 Btu/h-ft²°F and up. The technology for dramatically better window frames clearly exists but is rarely used in the U.S., perhaps due to lack of market demand.

Similarly, exterior shades (for example, exterior venetian blinds) have yet to take hold in North America but are ubiquitous in Europe. We see general understanding of the effectiveness of exterior shades and acceptance of their aesthetic in Europe. Meanwhile, in North America, there is a common misunderstanding that interior shades can replace exterior shades – whose reduction of solar cooling loads is often at least twice that of an interior shade. Due to their limited adoption, project teams also struggle with technical integration of exterior shading, further limiting their growth.

There has been a small, but visible, adoption of radiant panel systems in North America, but nearly no adoption of structurally integrated radiant slab systems. This is partially due to poor envelope performance (resulting in high cooling loads which are incompatible with such systems), but also due to reluctance to use unfamiliar systems which are not air-based.

Although adoption of geothermal systems has increased dramatically, their frequent combination with air-based heating and cooling limits their potential. In many climates, free cooling from the ground to a radiant slab system can run nearly throughout the summer, whereas economizer modes in air-based systems have run times limited to the spring and fall.

These examples provide only a small selection of the technologies available today which are rarely applied. However, even widespread adoption of such technologies is not sufficient to achieve exceptional performance. They must be applied in a building design which is not purely dependent on technology.

**Design**

Design, as discussed in this section, refers to the building as an outcome or final product, and does not refer to the design process, which we discuss in the concluding section on cultural barriers. A building design responds to aesthetic and functional goals, can be judged qualitatively, and hopefully evokes some level of appreciation. In a building performance context we often refer to architectural features that control the flow of air, heat and light into occupied space as design. These elements’ combined result is an occupant experience that is greater than the sum of its parts.

Building massing is critical in a successful design. Massing ultimately defines the distribution pathways for air, light and people. For example, narrow floor-plates encourage cross-ventilation and daylight penetration. Similarly, building orientation can facilitate a variety of passive and semi-passive strategies such as wind-driven or stack-effect-driven ventilation and passive solar heating. Thoughtful molding of the building volume can be respectful of surrounding buildings and even create outdoor and semi-outdoor spaces.

Basics of architectural design for building performance are widely taught in architectural schools and described in architectural texts. However, in practice few architects are able to apply these techniques because they are asked to design with emphasis on usable floor area or other economic factors, at the expense of quality of space and performance. This also results in a scarcity of intentionally designed buffer and transitional spaces, which soften the overall occupant experience by providing areas to meet and refresh, add qualitative value to the building, yet still contribute to the building performance.

Design extends beyond the fundamental building massing to detailed components. As noted in the
previous section, exterior shading as a technology is nearly absent in North American building stock mostly due to market factors, but also requires careful design attention in order to increase its acceptance. With careful design exterior shades, fixed or operable, can contribute positively to the visual language of the façade while reducing solar gains in the space. Similarly, while thermal mass is known to significantly shift and reduce peak loads, exposed concrete is often perceived as rough-looking and unforgiving during construction, but careful design of exposed concrete can result in an elegant solution.

Design-based solutions result in energy efficiency by reducing reliance on technical systems such as HVAC or lighting, or in some climates, substituting for them altogether. Where they cannot fully substitute, they also enable the application of high-efficiency systems such as radiant cooling which would otherwise not be technically feasible.

Design solutions have the unique potential to do more than reduce building energy consumption; they can engage the occupant and improve the quality of the indoor environment. Numerous studies have concluded that design-based solutions such as daylighting and natural ventilation increase occupant productivity. For example, the Center for Building Performance and Diagnostics at Carnegie Mellon published a study, *Linking Energy to Health and Productivity in the Built Environment*, concluding that access to the natural environment in the form of occupant-controlled natural ventilation can result in up to a 7.5% increase in productivity.²

People spend most of their waking hours in the workplace, yet many workplaces overlook the design thought required to make these spaces delightful. A design that involves the users in the operation of the building fosters a sense of ownership and responsibility for their space. This can result in reduced maintenance, reduced energy consumption and, in general, a long-lasting interactive relationship between occupants and the building.

**Desirability**

We believe a missing, unquantifiable component necessary for the adoption of these technology and design strategies is desirability. The Tesla Model S illustrates our definition of desirability: it is desirable to consumers not purely because of the environmental benefits of an electric car, but because these are packaged with an improved user experience due to performance (acceleration, handling, etc.) and aesthetics. Similarly, dramatic energy performance in buildings must be coupled with an enhanced user experience (comfort, usability, etc.) and aesthetic quality. These must be combined in a way that is easily understandable by the consumer such that there is almost a design icon that is understood to combine these qualities – even if this is not linked to a particular aesthetic.

There is no example yet that has captured this idea of an icon, which may ultimately help overcome the cultural barriers discussed at the end of this paper. First, however, we present several case studies of projects from Transsolar’s practice which demonstrate successful application of both design and technology innovations.

**Design Innovation**

*Manitoba Hydro Place, Winnipeg, Canada*

*Architect: KPMB, Toronto, Canada*

Manitoba Hydro Place, shown in Figure 1, is an excellent example of successfully executed integrated design concepts in a high-rise office building with monitored energy performance. Current utility bills reveal annual site energy use of 44 kBu/gsf in a climate that is both extremely cold and hot (-31°F to 95°F) with 11,270 heating degree-days. This is a 70% reduction compared to the Canadian Model National Energy Code for Buildings.

The key to its success lies in the 5-point Project Charter established and signed by the design team at the beginning of the project. The first and

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² Loftness et al, 2003 Greenbuild Conference
foremost goal was for Manitoba Hydro, a crown corporation in the Province of Manitoba, to carry out its corporate vision of creating healthy and productive spaces for their staff. The second goal was to reduce energy consumption by 60% compared to Model National Energy Code for Buildings and to achieve LEED Gold certification. Third, Manitoba Hydro was to be a landmark building, with signature architecture at different scales from the street level to the roof. Fourth, the building was to contribute to the revitalization of downtown. The final goal was to achieve a cost effective building design solution that has measurable benefits to Manitoba Hydro in terms of comfort, operations, and maintenance.

In order to carry out these points, the year-long schematic design process ultimately led to a highly integrated façade and building systems design. The architecture reflects the program which includes private offices, open offices, and conference rooms in two towers facing east and west, which are connected by gathering spaces in multi-story winter gardens facing south and an atrium in the north part of the building. The spaces maintain thermal comfort for 1800 employees on 18 floors with an active slab system supplemented by a geothermal heat exchange system.

Since the health and productivity of the employees were a priority, the floorplates were designed to be shallow to provide all occupants with daylight access and the ability to manually open windows. Aside from extremely low temperatures, Winnipeg also has high amounts of solar insolation, which require external shading for solar control.

The double façade was the chosen strategy for the east and west flanks of the office towers mainly because it addressed the need to protect the automated exterior shades on a high-rise building and the desire for the occupants to have access to natural ventilation as shown in Figure 2. Despite Winnipeg’s extreme climate, Manitoba Hydro is able to operate in natural ventilation mode for 38% of the year.

During the intermediate and summer seasons, the double façade cavity is ventilated to remove unnecessary solar gains trapped in the shades which are engaged to block solar radiation as shown in (a) and (b) in Figure 3. Automated openings at the outer façade regulate air pressurization so that the double façade protects users against wind gusts which may be experienced in high-rise buildings. The warm buffer zones in the double façades also preheat the fresh air during the cooler part of the swing seasons, before it enters the space, which both extends the natural ventilation season into the winter and provides occupants with control of their environment.
During the winter, the outer skin of the double façade is closed and fresh air is preheated by direct solar gains in the south atria before being supplied to the offices by floor-by-floor air handling units. The radiant slab is extended into the façade cavity and abuts an outer skin of double glazing as shown in Figure 3. Radiant heating in the cavity prevents frost in the cavity during the most extreme temperatures. A low-e coating on the room-side surface of the inner skin provides additional comfort insurance during the summer. Because the inner skin is uninsulated, the single glazing heats up and the low-e coating prevents the warmth from radiating onto the occupant.

The north atrium gathers the return air from the office spaces and the air is exhausted after passing through the solar chimney and a high-efficiency run-around heat recovery system. The heat recovery system supplements the preheating done with passive solar gains in the south atria. These three 6-story “neighborhoods” form bridges between the east and west office towers and function not only as the lungs of the building, along with the north atrium, but also give Manitoba Hydro employees a pleasant winter garden space year-round.

Each of the design elements, whether it is the double façade or winter garden, is used for a different function depending on the season. These harmonized concepts are a direct result of a driven client and hand-picked design team, including a highly skilled in-house engineer for operations and controls.

Institute for Environmental Sustainability
Loyola University, Chicago
Architect: Solomon Cordwell Buenz (SCB), Chicago
Loyola University’s president has a history of commitment to high-performance building design. In the last 7 years, Transsolar has collaborated on 6 buildings with SCB and Loyola University, all with unique integrated design concepts. The recently completed Institute of Environmental Sustainability includes classrooms, teaching laboratories, faculty office, student life spaces, a 400-bed student residence, and a winter garden / greenhouse the university has dubbed the ‘Ecodome’. Like preceding buildings on campus, the IES was designed to be a state-of-the-art, highly comfortable environment and aimed to foster a unique, interactive, and transformative educational and living experience.
The overall climate concept relies on passive strategies to ensure comfortable conditions in all non-laboratory spaces. Mechanical systems are supplemental to the passive design and use of onsite renewable energy (geothermal and solar thermal) minimizes the net energy demand.

The winter garden (Figure 4), which houses a 3700 ft² greenhouse, is central to both the building’s overall climate concept and the Institute’s program. The need for mechanical cooling in the winter garden is eliminated by taking advantage of the prevailing winds and thermal stratification, allowing natural ventilation throughout the year. A climate-responsive glazed façade with meticulously designed façade openings and automated shades help keep the space comfortable. In the winter, outside air is pre-heated through energy recovery coils running along the inlet trench. Additional heating, if required, is provided by a radiant floor.

This unique passive design also enhances space quality in the adjacent dormitory and increases the natural ventilation potential in the dormitory units facing into the winter garden by 20% (Figure 5).

A passive, architecturally integrated air transfer strategy allows natural cross-ventilation in the classrooms, offices, and the atrium by connecting the air flow path from façade openings to the atrium exhaust (Figure 6). All the regularly occupied spaces (dormitory, offices, classrooms, atrium, and winter garden) are designed to receive excellent direct or indirect daylight.

A unique aspect of this project and others on campus is the fast-track schedule enabled by the university’s streamlined decision-making process and use of the same design team for many projects. This allowed the design and construction of many high-performance buildings in a relatively short time periods. The design of IES started in 2011 and the building opened in 2013. The projected site energy use intensity is 52 kBtu/gsf.
seeking an energy-efficient icon for the law school’s new home. The project also began with a target of LEED Gold, but the design team proposed targeting LEED Platinum certification when it appeared feasible during the design process, and the platinum certification was awarded in February 2014.

The diversity of program types played a substantial role in shaping the architecture and is deliberately visible from the exterior envelope. The classrooms, private offices and clinics, open offices, and group studies share a heterogeneous façade with a unifying glass screen in front, which is referred to as the office/classroom façade. The library stacks and library reading areas are enclosed in a regular checkerboard-like frit pattern, referred to as the library façade. Both are visible in Figure 7. The office/classroom façade has punched window openings with varying sizes in response to the spaces behind them, while the library façade has uniform opening sizes because these areas are more open. To bridge the program spaces, a skylit atrium volume threads its way through the center of the building, providing informal gathering spaces for the students and faculty, and filling in the voids between the two primary façade types.

Similar to Manitoba Hydro, the University of Baltimore has a strong interest in securing high comfort for its occupants. The Angelos Law Center houses a top-ranked law program that greatly benefits from vibrant and productive workspaces for its students.

In response to these high comfort and low energy goals, radiant systems were prescribed and the façade was tuned to support a student-centered experience. Operable windows are provided in all spaces and windows are equipped with locally displayed signals that indicate whether or not natural ventilation mode has been enabled.

The faculty offices and classrooms, most of which face west, have automated operable exterior venetian blinds for solar control. Occupants are able to override the shade position but are educated by building staff to understand that it may affect their comfort. A glass rainscreen is suspended in front of the exterior shades with continuous 4” horizontal gaps at the floor and ceiling of each floor, in order to protect the exterior shades and unify the façade. Stack effect causes air to ventilate the heat trapped in blinds that are engaged during high solar gains as shown in Figure 8(a).

During natural ventilation mode, the stack effect causes cool air to be drawn through the interstitial cavity and into the space through side-hinged
windows. The air then moves through transfer air elements into the atrium, which is maintained at negative pressure with stack effect and supplemented with low-velocity exhaust fans as shown in Figure 9(a).

The library spaces start on the eighth floor and primarily face north and east, which allows for a less aggressive shading strategy. Ceramic frit and a solar control low-e coating provides sufficient solar control for these spaces. The atrium faces north and south, where fixed exterior shades provide solar control.

During the cooling mode, shown in Figure 9(b), and similarly in heating mode, which are triggered based on outdoor temperature and humidity, the ventilation openings are automatically closed and mechanical ventilation turns on along with radiant cooling or heating. On humid days, the windows are locked closed to avoid condensation on the radiant slabs. Otherwise, students and faculty retain the ability to open their windows, regardless of the local window signal, and understand that this may affect their thermal comfort.

The combination of design strategies responsive to program and climate and the president’s push for an exemplary low-energy building result in a predicted site energy use intensity of 40 kBTU/gsf. The building was occupied in fall 2013 and commissioning to ensure the energy target is met is ongoing.

North Campus Residential Hall and Dining Commons
University of Chicago, Chicago
Architect: Studio Gang Architects, Chicago

The North Campus Residential Hall and Dining Commons (Figure 10) will house 800 undergraduates and is designed around the University’s distinctive House System, with an emphasis on building community. Each of the eight houses occupy 3 stories which are visibly delineated from the exterior façade, and are distributed between 3 towers ranging from 5 floors to 15 floors. The first two floors of each residential tower are reserved for community commons, classrooms, practice rooms and retail. The dining commons building is housed in a transparent double-height space, connected at the entry portal and nestled between two towers.

This project advances the University’s goal of a
cohesive, sustainable campus populated by great architecture and creates a new gateway to the Hyde Park community. The goal of the building design is to encourage more connections and more interactions between people by creating indoor and outdoor spaces that are designed for optimal comfort.

The overall climate concept is centered on the student experience in the dormitory. The unique fixed exterior shade was designed to carry out multiple functions: solar control, maximize natural ventilation flow rate, and fall protection. This allows for a high-comfort, low-energy solution wherein a radiant slab provides heating and cooling and minimum ventilation is supplied for air quality.

The NCRHDC provides an uncommonly clear demonstration of a successful integrated design process in the development of the fixed screen. The initial target was to maximize the natural ventilation period for students. Due to fall protection, the crack opening for a casement window was limited to 4 inches, which meant a cross-flow scheme would be needed to sufficiently ventilate the rooms and transfer air devices would be needed for exhaust into the corridor. This posed privacy, fire protection, and cost issues. In parallel, it was determined that an exterior shade was required for solar control that complemented the neo-gothic architecture of the campus. The design team finally devised a solution which placed a patterned metal screen at an inward-swinging window opening (Figure 11), addressing fall protection, solar shading, natural ventilation and architectural style. This is a product of a concentrated period of idea exchange and discussion between the designers and university. The fixed metal screen was offset 4 inches from the façade of the building, further increasing the natural ventilation period to 34% of the year, compared to 10% of the year for one of the initial approaches, as shown in Figure 12.
project is smaller scale but demonstrates the same kind of success in achieving energy efficiency.

Like most buildings in Western Europe which are subject to aggressive envelope standards, both the office complex and the warehouse are highly insulated, highly airtight, and appropriately shaded. As a result, much of the remaining energy savings comes from smart mechanical design. The high-performance envelope allows for a radiant slab system to cool and heat the offices, with individual temperature control provided near the façade through radiant panels while minimum outside air is supplied via displacement ventilation after heat recovery. Since radiant slab systems require relatively neutral water temperatures, the geothermal heat pump system efficiency is maximized. In particular, the geothermal system allows for a free cooling mode, in which the heat pump does not run at all, further boosting the efficiency of the overall system. Additionally, the geothermal system is used to cool the IT rooms and the rejected heat is used in the remainder of the building, which removes the need for separate split units common in these spaces.

Successful implementation of the geothermal system and high efficiency equipment was the result of close collaboration between an active client and the design team, from the beginning of design through construction and, further, the first year of operation. The monitored site energy use intensity is 32 kBtu/gsf.

**Technology Innovation**

While the previous case studies focus on design innovation, we also wish to highlight a few examples of nearly pure technology innovation – where a new technology was developed in response to a specific project, but with broader potential applications in some instances.

**Zollverein School of Management and Design**

*Essen, Germany*

*Architect: SANAA, Tokyo*

The Zollverein design school is an unusual example of technology innovation because it takes advantage of a local situation and makes use of otherwise wasted resources through an integrated façade design. It is located adjacent to an unused mine, the Zeche Zollverein, which must be continually pumped to keep them from flooding, and the water was originally dumped directly in the Emsch River.

In this integrated façade design, the pumped water, which has a consistent temperature of 84°F, is fed to an active insulation system. Radiant tubing is embedded in the exterior concrete wall (Figure 14) so that the warm water running through this layer eliminates the need for insulation and allows extremely thin walls. This would be wasteful in any other location, but minimizes resources in this specific location where abundant, low-grade waste heat is available. Figure 15 shows the resulting unique architecture and façade temperatures.
Novartis Campus Human Resource HQ and Auditorium
Basel, Switzerland
Architect: Gehry Partners, Los Angeles
This project consists of a main building with an above-ground restaurant and an underground auditorium seating 630 people. The building skin is composed of triple-glazed windows with ceramic frit. The vertical façade is covered with low-e internal shades, shown in Figure 16, which maintain comfort by keeping solar heat gain from radiating on the occupants. The internal low-e shades are automatically controlled per façade section and orientation. The low-e coating on the interior surface of the shade prevents the warm shade from radiating heat to the occupants, was developed by the textile manufacturer specifically for this project, and is now marketed as a general product.

The entire roof glazing is equipped with semi-transparent photovoltaic modules integrated directly into the glazing construction. The PV modules are perforated via laser drilling in order to improve the view through the roof, addressing a common aesthetic concern associated with building integrated PV. The electricity yield from PV compensates for the entire energy demand for artificial lighting of the building.

Swarnabhumi Airport, Bangkok, Thailand
Architect: Murphy/Jahn, Chicago
Another façade technology includes non-glass alternatives such as ETFE, PTFE and other polymer-based materials. The new airport in Bangkok (Figure 17) is designed with a triple membrane envelope to protect against the extremely hot climate. The outer membrane is PTFE coated glass fiber, the middle membrane is perforated plastic that is sound absorbing, and the inner member is low-e coated.

To meet thermal comfort criteria without massive energy input, cool and dry air is provided only where it is needed as shown in Figure 18. The translucent triple-membrane roof reflects most of the sun’s energy, yet ensures sufficient daylight for the waiting areas. The floor is equipped with a radiant cooling system that acts as a heat sink. The low-e coating on the inner membrane prevents the warm roof from radiating heat to the interior, and instead reflects the cool temperatures of the radiant...
floor. This unique triple membrane construction was developed by the fabricator and design team in response to the specific conditions of this project.

Each of the above technology innovations has one element in common: none are in North America! Our experience is that technology innovation which is closely integrated with building design occurs much more frequently outside of North America. North American technology applications that are considered innovative tend to be of products or systems which have already been applied elsewhere in the world, and are considered an innovation when first applied here. This is one more reflection of the culture barriers to innovation discussed in the following section.

Cultural Barriers
We define culture as the human factors related to building design, construction, and occupancy, in contrast with building technologies or designs themselves. The above examples show that the technologies and design strategies exist today for a new generation of high-performance buildings when cultural elements combine to enable their use.

However, more frequently the cultural barriers remain. Some of these we have been successful at addressing directly through our own design practice, while others remain unsolved and are more likely addressed through industry change or public policy. As a conclusion, we present examples of these cultural barriers in the hope that the symposium audience will consider new solutions for overcoming these barriers.

Sufficiency and User Expectations
Sufficiency is the cultural idea that quality of life – defined as human happiness, satisfaction, and well-being, can be maintained while reducing reliance on material inputs – in other words, less is more. The term is mostly strongly associated with the Swiss environmental vision of a 2,000 Watt Society, expressed in buildings in such material reductions as less office and living space per person.3

The concept of sufficiency can easily be extended to the general design approach of buildings. Do all spaces in a building, even those with highly transient occupancy, need to be fully conditioned? Do systems need to be capable of maintaining the exact same comfort levels year-round, including the hottest day of the year? Is complete automation of all building components required - treating the user as incapable of taking responsibility for their own comfort?

Our experience is that a culture of ‘fear of the occupant’ in commercial buildings has led to a desire to minimize both seasonal and spatial variation in the indoor environment and direct user control over the environment. In those buildings where such variations and user controls are deliberately designed, however, occupants value the increased comfort and connection with the environment they provide.

Integrated Design Process
The need for an integrated design process in which all members of the design and construction team, the client, and even the community collaborate on the building design from the beginning to the end is widely recognized in the high-performance building design community. Although design processes are advertised as being integrated, truly ‘boundary-free’ processes remain highly unusual. In all cases, we worry that some key aspects of an integrated process often remain overlooked.

First is that the project goals are agreed upon by all collaborators before beginning design. These goals are most successful when driven by the client rather than the design team.

Second, the process benefits from deeper consideration of the occupant. Although architectural programming to determine space requirements is a standard part of any design

process, a new form of ‘energy and comfort’ programming to more precisely define user expectations is emerging. This includes defining acceptable variations in environmental quality, determining realistic expectations for occupant control or engagement, and better understanding of occupancy patterns within the building.

Lastly, we believe that design tools such as building performance simulation and building information modeling are increasingly used a substitute for an integrated process, perhaps in the belief that using the tools will inherently generate an integrated process. Although such tools are critical to high-performance building design (and building performance simulation is the foundation of Transsolar’s practice), they exist only to support an integrated process, which is driven by human interaction and thoughtful generation of design questions. For this reason we have deliberately excluded such tools from our discussion of design in this paper.

Industry Reluctance to Change
The buildings industry is often recognized as one of the slowest to change or innovate. Compared with manufactured products, experimentation is difficult because there is no opportunity for prototyping and correcting mistakes - each commercial building essentially is a unique prototype. In addition, construction is a highly regional activity, with ‘lessons learned’ not easily transferring over distance.

The above challenges are somewhat inherent to the industry and require more than cultural change to overcome, but we experience related challenges which are more cultural. Many North American project teams begin a project with the intent of duplicating as many design features as they used in the last project, to minimize time and risk. European project teams are more likely to begin each project ‘from scratch’, considering what the appropriate set of solutions is for the exact situation.

The regional nature of construction also leads to a so-called ‘perception of new’. Project teams – especially owners – are reluctant to use a technology or system which has not already been used in their region – even if it has been applied in other locations with a similar climate. Visiting reference projects, sometimes at international locations, can be very helpful for overcoming this barrier, but is not practical for many projects.

Reluctance to change even carries over into design tools – despite the increasing use of new performance simulation tools. For example, nearly all MEP engineering firms calculate cooling loads with software marketed by cooling equipment manufacturers using 20-year old calculation techniques, which are often ill-suited to handle advanced passive strategies.

Talent
Lastly, the availability of high-quality engineering talent dedicating their careers to the solutions presented in this paper remains strikingly low in the U.S. Approximately 80% of applicants for full-time and internship positions at Transsolar are non-residents or international graduate students.

We worry that undergraduate engineering programs in the U.S. do not present the buildings industry as a technically advanced field with room for innovation, and those students that show an interest are generally encouraged to pursue advanced study or careers focusing on technology-based solutions (HVAC, controls, lighting) rather than also considering the integration of design and technology.

Here we offer the fewest possible solutions – but perhaps if our industry can create the cultural desirability of high-performance buildings we have imagined, we will one day be overwhelmed with qualified talent eager to take on our challenges.