Strategic Information for the Climate Change Industry

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Green Building To One Day Become the Norm, But Some Trends are Slow to Develop

The architecture profession has been transformed in the last 12 to 15 years from an industry that didn't recognize the climate impacts of the structures it designed to one with a high degree of sophistication and passion for energy efficiency and GHG mitigation. As a result, in the United States alone, energy consumption in the building sector has actually dropped by about 5% since 2005, "a period in which we added about 20 billion square feet of building stock," according to sustainable building champion Ed Mazria (see Q&A with Mazria on page 40).

Energy codes continue to be tightened in many developed countries and even some developing countries (although enforcement lags). Many states, provinces and cities have enacted rigorous requirements for energy and water efficiency and green building certification.

The market-transforming practice of requiring mandatory building energy rating disclosures at sale or lease has taken hold in about a dozen major U.S. markets and will soon be required in the UK. (See feature on the UK starting on page 36.)

Energy Efficiency Still Not a Major Priority for Developers

But demand for energy-efficient and low-greenhouse gas (GHG) dwellings and commercial, industrial and institutional space is not yet the potent market driver that it must be to put the United States, Canada and other developed countries on track to cut GHGs fast enough to stabilize the climate by mid-century. Traditional market drivers still dominate in real estate development, and every architect who is passionate about green building can tell stories of clients who lock in decades of energy waste in their buildings because they weren't willing to sacrifice short-term return on investment or take a risk on unconventional designs.

U.S. real estate investors, lenders and other professionals surveyed by the **Urban Land Institute** and **PWC** for Emerging Trends in Real Estate 2014 ranked green building last of 12 real estate and development issues. The most important were construction and land costs, vacancy rates, refinancing, infrastructure funding and

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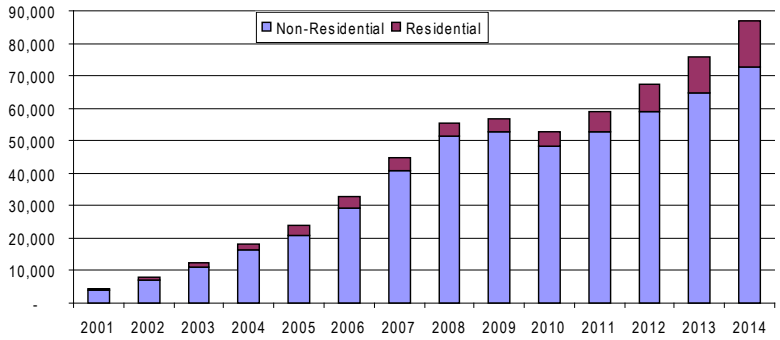
The U.S. Green Building Industry 2001-2014 ($mil)



The U.S. Green Building Industry 2010-2013 ($mil)

	2010	2011	2012	2013
Value of Construction Put in Place				
Residential Put in Place	249,114	252,658	286,523	337,834
Non-Residential Put in Place	346,488	336,438	354,202	355,412
Green Buildings: Residential	4,733	6,316	8,309	11,149
Green Buildings: Non-Residential	48,162	52,821	59,152	64,685
Green Building Services				
Green Building Planning & Permitting	316	358	407	467
Green Building Design & Architecture	1,741	1,970	2,236	2,566
GB Construction Management	1,108	1,254	1,423	1,633

Source: Climate Change Business Journal derived from a variety of sources

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future home prices. The report only mentions energy efficiency (EE) once in 100 pages, describing Toronto's policies.

Many buildings designed to achieve low- or mid-level certifications from **U.S. Green Building Council**'s (USGBC) LEED or other standards end up being energy hogs. This happens because building systems are operated poorly, because designers earned points on non-energy items or because design choices were dictated by aesthetics and perceptions of buyers' and tenants' preferences rather than efficiency.

Graham Smith, veteran sustainable building architect and educator in Vancouver, points to the common practice in Vancouver high-rise apartments of "expressing floors on the building exterior as an extended horizontal that can serve as a shading device or brise soleil... This creates a thermal bridge to the outdoors, radiating heat out of the building," Smith said.

Sustainable design expert Christoph Reinhart of **MIT** described a recent visit to Abu Dhabi where he attended an event describing progress on the new airport terminal, slated to be the world's largest when it opens in 2017. Designed to win three pearls—out of five—from the **Estidama** green building rating system, the airport's designers claim it will be 12% more energy efficient than a comparable airport.

Yet Reinhart points that the extensive use of glazing and glass curtain walls in the desert will mean, "that building will necessarily have very high cooling loads."

Reinhart infers that designers specified what travelers expect in an airport: lots of glass. And he says the fact that such an energy-intensive building can be certified energy efficient highlights the "self-referencing" nature of all the green rating systems. "Designers can win energy points by investing in special glazing and other features that exceed the efficiency of standard materials and equipment—even though the building's overall design might not be the best overall solution possible," he said. "I'd favor ratings based on overall annual energy use per square meter."

As further discussed in the UK market overview, a 2012 study revealed major discrepancies between the modeled energy ratings of buildings and actual energy consumption. Buildings with poor ratings performed better than dozens of highly rated buildings, leading sustainable building advocates to support requiring disclosure of actual energy performance data, now required only for public buildings.

While these observations provide a sobering perspective on how far the building industry has yet to go, there's no denying that it has already come a very long way. Robust market drivers—as well as increasing passion, expertise and technology on the supply side—are propelling sustainable and energy efficient design.

"Today, you can't pick up an industry magazine without articles about sustainable buildings, LEED certified buildings, high performance or zero-net-energy buildings," said Mazria. "The annual Greenbuild Conference attracts 20,000 to 30,000 people. There have been two major zero-net-energy conferences in just the past few months."

CCBJ estimates the U.S. green buildings market to be growing at 12-14% a year from 2011 to 2015 and beyond (see chart and table on page 9), after an understandable hitch in 2099-2010. In value of construction put in place the market is $75.8 billion of $690 billion in 2013 (or 18% of non-residential and 3% of residential). In terms of specialty services, CCBJ estimates the market at $4.7 billion and growing at 15% in 2013. Construction and materials make up most of the gap between $5 billion and $75 billion. CCBJ estimates that overall penetration of green buildings in new construction has gone from 1% in 2002 to 11% in 2012 and will

hit 16-18% in 2020 with residential again holding down the numbers.

Office Buildings and Hotels the Highest Growth Segments

The leading segment in green building continues to be commercial office space, or at least corporate-owned commercial space when compared to institutional and residential space. When **McGraw Hill** surveyed architects, engineers, contractors, owners and consultants for its 2013 report World Green Building Trends, the number of professionals who expected to sponsor or work on a green office or hotel within three years was the highest for all building types. And the percentage of firms anticipating such work jumped from 48% in 2008 to 63%. World Green Building Trends 2013 presented statistically valid response data from the United States, Australia, Germany, Norway, UK, Singapore, South Africa, the UAE and Brazil.

World Green Building Trends also reported an evolution of business drivers in office and hospitality to include more concern with lowering energy costs. "Energy efficiency pays dividends in the commercial office sector," said Peter Busby a leader in sustainable and energy efficient design who merged his Vancouver firm with A&E firm **Perkins+Will** in 2004. "If you can save energy for your tenants, you can earn more net rent revenue."

"Tenants are also getting smarter about energy, looking around for the best opportunities and comparing gross rents which include net rent plus all operating costs," said Busby. "Many commercial office tenants, especially in the IT industry, are also driven by the concerns of their employees who are thinking more and more about healthy workplaces and the environmental impacts of buildings."

"We do a lot of interior design for a wide variety of clients, and they're all looking for sustainable design," said Busby. "When we talk to major developers and owners about sustainability, they're there. They're not investing at the most extreme end, but they're certainly investing in all the strategies that have ROI."

"The private housing industry is behind office and hotels, although in the Pacific Northwest, California, New York, Pennsylvania and other markets, most new residential developments, especially condos, have a sustainable design aspect because many younger buyers are environmentalists," Busby told CCBJ. "They're also more sophisticated about looking at energy costs."

Puget Sound Energy's multifamily program director affirms Busby's point on the energy awareness of Eastern Washington renters. "In the Pacific Northwest, people are pretty savvy about energy efficiency," said John Forde. "If a prospective tenant comes up to your building and sees old single-pane windows with metal frames, they may not rent due to having experienced those in the past. If the windows have been upgraded, they'll know that the apartment will be quieter, with less condensation on the windows, not to mention lower energy costs."

Still, there's ample greenwash in the marketing claims of some housing developers. "There are some housing developers who are committed, but there are also lots of business-as-usual outfits that are touting their sustainability," Smith told CCBJ. But this critique notwithstanding, Smith says that in general, the development community in Vancouver has "really jumped on board."

States and Cities Drive Green Push

Indeed, the Province of British Columbia, City of Vancouver and other

ENR Top Green Design Firms in 2012

	Accredited Staff	Green Design Revenue ($mil)
URS CORP., San Francisco, Calif.	916	494
GENSLER, San Francisco, Calif.	1158	409
AECOM TECHNOLOGY CORP., Los Angeles, Calif.	556	243
ARUP, New York, N.Y.	204	191
HOK, St. Louis, Mo.	752	180
CH2M HILL, Englewood, Colo.	262	177
PERKINS+WILL, Chicago, Ill.	908	135
NBBJ, Seattle, Wash.	213	106
HKS INC., Dallas, Texas	350	103
SKIDMORE OWINGS & MERRILL LLP, New York, N.Y.	225	85
EYP, Albany, N.Y.	193	71
JACOBS, Pasadena, Calif.	649	71
STANTEC INC., Irvine, Calif.	671	68
SMITHGROUPJJR, Detroit, Mich.	349	65
BURNS & MCDONNELL, Kansas City, Mo.	267	56
FENTRESS ARCHITECTS, Denver, Colo.	46	56
PAGESOUTHERLANDPAGE, Houston, Texas	93	52
DLR GROUP, Omaha, Neb.	178	52
WSP USA, New York, N.Y.	146	52
Hammel Green and Abrahamson, Minneapolis, Minn.	162	50

Source: ENR, McGraw Hill. Accredited Staff is the number of people employed by the firm who have been certified as knowledgeable in green construction by a third-party accreditation organization.

provincial, state and local governments are having a huge influence on the growth of the green building segment in North America and Europe with new requirements for private buildings. California's energy codes continue to tighten up and bode well for declining energy intensity of buildings in the Golden State.

Leading cities include Seattle, Portland, San Francisco, New York, London, Amsterdam, Toronto, Philadelphia, Boston and Copenhagen. For example, the Greater London Authority mandated in April 2014 that new buildings meet energy consumption targets 40% below the 2010 codes. The UK as a whole bumped up energy codes 9% for commercial/industrial and 6% for residential nationwide.

Massachusetts has adopted a Stretch Energy Code, with more aggressive standards than the state's base code. As of May 2014, 137 municipalities representing just over half the state's population had done so.

"The City of Cambridge has a task force looking at how to make a net zero carbon statute part of their zoning code," said Jana Silsby, associate principal in the Boston office of Perkins Eastman. "And the City of Boston has an ordinance requiring new buildings of 50,000 square feet and above to be LEED certifiable."

"Energy rating disclosures for property are just starting to happen," said Silsby. "Many people in the state are very conscious of energy and climate change and really want to know about building performance."

Institutions Leading in Canada

In Canada, British Columbia and Quebec are the most advanced provinces, according to Busby and others. "In the Province of Quebec, there's a high level of energy performance required by law," said Busby. "This is encouraged by the power utility which would rather save power at home, where they sell it cheaply, and have more to sell to New York for a profit. It's also a bloody cold place, so good envelope requirements go a long way toward better comfort."

Aside from Toronto, which has progressive water and energy conservation policies, the rest of Ontario—Canada's largest market—is "driven by more conservative business interests," said Busby. "Green building is only now catching on, although it's happening quite quickly."

In BC, aggressive policies for green and energy-efficient public buildings have led to several landmark green projects, especially in the public sector. The **Insurance Corporation of British Columbia** (ICBC), a Crown corporation established to provide universal auto insurance in the province, has built two LEED Gold buildings, both of which included heat recovery ventilation, according to Smith, who administered and advised on the projects. (For more on heat recovery ventilation, see the feature on Stanford University later in this edition.)

At least two public buildings in BC—the VanDusen Botanical Garden Visitor Centre and the Centre for Interactive Research on Sustainability at **University of British Columbia** (UBC)—are attempting to achieve the avant garde Living Building Challenge, which requires net zero energy and water consumption as well as compliance with rigorous materials guidelines.

Net Zero the Ultimate Goal

Net zero status is achieved when buildings are designed to be ultra-energy efficient, then use onsite renewable energy to produce at least as much as the building uses. "Net zero starts with highly efficient building design, with high levels of thermal performance in the walls, good windows, a good roof, good shading on the window, lower levels of glass, daylighting, LED lighting fixtures and energy-efficient appliances," Busby explained.

"Then, when you buy equipment that does mechanical ventilation, both AC and heating, you can use well-known energy efficiency strategies such as groundsource heat exchange, radiant chilled ceilings, radiant heated slabs in colder climates," Busby said. "Using all the strategies that are there for very energy efficient buildings, we can reduce energy requirements by 75 to 80% against a typical building. If you want to get to net zero, you need to supply the remaining 20% to 25% with carbon-free sources."

CCBJ's research only turned up one net zero energy certification scheme, that administered by the **International Living Future Institute**, which also runs the Living Building Challenge. TreeHugger.com's Managing Editor Lloyd Alter praised the release of this standard last year, saying it transformed net zero from a "useless metric [by] defining and refining the concept of a building that gives back more than it takes." In May 2014, the organization listed 17 certified Net Zero Energy buildings, nine of which also met either the Living Building or Petals standard, which include net zero. (For more on the Living Building Challenge see below.)

Busby, whose firm worked on two buildings that are currently pursuing the Living Building Challenge, told CCBJ that the rapidly declining cost of solar PV is making net zero energy increasingly easier to attain. "In most parts of North America for buildings up to two stories, we can put enough PV on the roof to match the remaining requirement," Busby said. "With the price of PV down to about $2 a watt installed today, the ROI is there. Or you can go with private third-party financing, which is what our firm is going to do with our new San Francisco office to get to a net zero solution."

Education: Long On Will, Short On Means

Educational institutions, both higher education and K-12, have been strong

markets for green building for close to a decade. "Universities and school districts own their buildings for a long time, so they see the benefits of long-term energy savings," said Silsby. "Many also are concerned about social responsibility."

School funding levels have constrained growth of the overall education construction market, while the green proportion of school projects has grown in relative and absolute terms. McGraw Hill's data show a large jump in the percentage of education projects with a green flavor from 15% in 2008 to 45% in 2012. But during that time, total spending on education-related construction dropped from $58 billion to $36 billion.

One exemplary project designed by **Perkins Eastman** is Cambridge, Massachusetts' Martin Luther King Jr. K-8 school, which is targeting net zero energy and LEED Platinum (the highest LEED standard) certification. The facility, on target for completion in August 2015, was designed for natural lighting and includes high-performance roof and wall assemblies—all of which add up to anticipated energy savings of 60% when compared to typical New England schools.

Supplying heating and cooling will be 65 geothermal wells and heat pumps—back-up boilers are expected to provide about 10% of the heating during the coldest periods each year—and PV panels for electricity.

Busby sees opportunities for net zero buildings on many universities that are or will be looking to upgrade infrastructure constructed in the 1970s and 1980s without much focus on EE. "In northern climates, a common technology choice for campus heating was high-temperature steam loops fueled by oil or gas boilers," Busby said. "Those need to be changed, and as universities begin replacing and phasing out their 1970s-era central plants they can look to many potential energy sources on campus, including heat recovery from sewage, anaerobic digestion from food waste."

Gen Y Shifting American Demands for Housing and Planning

Percentage ranking at top (6–10)	Gen Y	Gen X	Baby boomers	War babies
Short distance to work/school	82%	71%	67%	57%
Walkability	76%	67%	67%	69%
Distance to family/friends	69%	57%	60%	66%
Distance to shopping/entertainment	71%	58%	67%	69%
Convenience of public transportation	57%	45%	50%	56%
Current and desired size of community	Gen Y	Gen X	Baby boomers	War babies
Currently in medium-sized or big city	39%	30%	30%	22%
Want to live a medium or big city	40%	23%	14%	25%
Percentage doing nearly every day	Gen Y	Gen X	Baby boomers	War babies
Driving	90%	95%	94%	85%
Taking public transit	20%	7%	10%	4%
Walking to a destination	47%	46%	43%	31%
Biking	19%	16%	12%	6%

Source: ULI. America in 2013. Generation Y is the people born between 1979 and 1995. There are 72 million gen Yers in the United States—approaching the size of the baby boom generation of 73 million (born 1946-1964).

From Sealed Buildings to Open Plan

Operating buildings optimally is key to achieving the efficiency for which buildings are designed. This has been a growing focus within the green building design industry, as heralded in 2008 with USGBC's release of LEED ratings for Existing Buildings: Operations and Maintenance (EBOM).

Smith reported that proper commissioning is a continuing challenge for the consultant and construction team. "Even within our own company we've had issues with commissioning HVAC systems that are designed to be green but don't really perform to specifications," He said.

"Some of this has to do with human thermal comfort, something that is very tricky to get consensus on. And part of it is the learning curve of using new technology or synthesizing hybrids of old-school passive solar with more state-of-the-art things like heat recovery ventilation and/or geoexchange," Smith said.

"Historically we just sealed buildings off and completely controlled air intake and outflow mechanically. Now we're trying to open buildings up to the natural world, to sunlight and natural ventilations. That's a different game, as we don't have complete control over all the variables."

The Martin Luther King Jr. School is designed to tackle the energy optimization challenge with, "fine grain metering at the classroom level and even within classroom from lights, plug loads and HVAC systems, so maintenance staff and teachers can take action," said Silsby, principal in charge of design and construction for the project.

"The school is expected to perform within an energy budget, and the data can tell school staff whether their systems are or are not performing well and help them understand how they can get them back in alignment. Teachers and students can also see how their behavior choices directly affect energy consumption." Building energy management will also be featured as a curriculum resource for students at the MLK and to educate parents and community members.

"One of the things that is so important to reaching net zero is for the users of the building to live within an energy budget," Silsby explained. "The design team can only take things so far. The behavior of users, managers and maintenance staff are the keys to staying within the energy budget."

Smart is The New Green

Using big data to optimize energy is a major theme in EE covered elsewhere in this edition. As described in the story on page 42, FirstFuel, RetroEfficiency and other firms can now use building energy meter data and weather data to evaluate a building's energy consumption patterns remotely and produce energy audits more quickly and cheaply than traditional audits that require site visits. In the first phase of a massive remote auditing contract, FirstFuel has enabled the General Services Administration to identify $15.6 million in annual energy savings.

The cutting edge in building energy management is an approach known as smart building systems. Smart building systems use sensors, controllers and software that enable "a facility to sense its own environment, and to react to real-time and historical data in order to maximize operational efficiency," according to the executive summary of **Frost & Sullivan**'s 2014 report on smart buildings.

Smart building systems are projected to grow from $2.5 billion in U.S. sales in 2013 to $4.3 billion in 2018, a CAGR of 9.4% according to the summary. Frost Research Analyst Pramod Dibble explained that the smart building system market is a subset of the market for building automation systems (BAS). BAS manages lighting, HVAC, security and other building services, and **Navigant Research** forecasts the overall BAS market will grow worldwide from $58.1 billion in 2013 to $100.8 billion in 2021.

"Smart buildings are an evolution of building automation systems," Dibble told CCBJ. "An automated building is getting to the net zero concept, while a smart building is bringing net zero together with the Internet of things to develop a responsive and reactive building that not only incorporates building systems but also processes, occupancy and any sort of workplace eccentricities or changes in scheduling and work flow."

By tying into scheduling systems, for example, a smart building can turn on the AC for a conference room 20 minutes before a team has booked it, then shut it off before the last person leaves the room, according to Dibble.

Smart building systems are ideally specified in the design phase, where they can piggyback on the building information modeling (BIM) process. "Building information modeling creates a comprehensive virtual map of the physical infrastructure," said Dibble. If BIM is used with a vision of evolving to a smart building system, the model "can be kept current as things move or change in the building all the way through its lifecycle to decommissioning and deconstruction."

However, few developers want to put up the extra cash for these systems, according to Dibble. "They can be much more expensive at the beginning. While it will lower the cost of ownership over the life of the building, because its ROI is more than two or three years, a lot of building owners won't consider it." So the smart building market is primarily a retrofit market.

Redevelopment Trends

In some segments of the North American real estate market—both sectoral and geographic—redevelopment is becoming a more significant market driver. The ULI/PWC Emerging Trends report quotes professionals working for developers, real estate investment trusts and other types of firms predicting growth in redevelopment of commercial and residential space in Canada, especially Montreal and Toronto.

In both Canada and the United States, redevelopment of retail space is a growing trend in many geographies. Internet shopping has made retail leaner, leading retailers to "rethink size requirements," according to the CEO of an investment firm cited in Emerging Trends. "Less square footage per site and the gradual decline of big-box stores is where many interviewees predict retail is headed in the near future."

There's a suburban to urban shift in retail as well. Millennials (those born between the early 80s and early 2000s) are "focusing on urbanism" while "a combination of private developers and government programs [are] pursuing the redevelopment of infill locations," according to the president of a retail REIT.

At the same time, babyboomers "want walkable cities with retail nearby," said Silsby of Perkins Eastman. This trend helping drive more development of mixed-use projects combining retail, office and residential uses.

"The retail industry is moving toward mixed-use development, which is a sustainable design trend," Busby told CCBJ. "Mall owners who own vast parking lots realize they're sitting on big assets and they're looking at rezoning their properties and developing mixed use residential, retail and entertainment projects. We're seeing projects in which as much as 2 to 3 million square feet of mixed-use is being put on what used to be parking lots."

"This is occurring in the inner suburbs and downtowns more than the remote suburbs where land values and housing costs are still relatively low," Busby said. "Many inner suburban malls that were built in the 1970s or 1980s are in communities where land values have appreciated, neighborhoods have densified and aged. Empty-nesters are giving up their houses and buying condos, increasingly in mixed-use developments."

Redevelopment is a potent opportunity to improve the EE a building, which is especially important in retail, where efficiency is just beginning to catch on. When redevelopment is done prior to leasing or sale, requirements for energy rating disclosures can heighten the incentive for owners to invest in deep efficiency features.

Living Building Challenge Extends the Frontier Past Net Zero

Pushing the envelope furthest in green building is the Living Building Challenge, which requires not only net zero energy and water usage but compliance with other rigorous criteria, from incorporating agriculture on-site to enabling car-free living.

"It's more aggressive than LEED Platinum, and unlike LEED you have to demonstrate that [sustainability features] are actually working," said Smith. "You have to measure for a year and produce data showing you have not exceeded zero net water or energy consumption. Of course, you use water and energy, but you have to put back an equal amount into the system, hence the term net zero."

Busby attested to the difficulty of obtaining Living Building certification. "I've done two projects that are seeking certification at the moment, the VanDusen Botanical Garden Visitor Centre and the Centre for Interactive Research on Sustainability at University of British Columbia, and it's very challenging," he said.

"For zero net energy and zero water, the technology is there and we know how to do it," said Busby. "But the so-called 'red list' of prohibited chemicals and materials is very challenging."

"Most manufacturers don't really know or don't want to reveal what's in their materials," Busby explained. "We spend hundreds of hours of our time asking manufacturers what chemicals and compounds are in their materials."

"But we're starting to see more disclosure as more living buildings are coming forward," said Busby. "We're starting to see suppliers provide product information if you ask for, and there are organizations like PHAROS and the Healthy Building Network who publish lists of products that meet the red list."

Perkins+Will has on its website a precautionary list based on peer-reviewed and published governmental lists of chemicals, assisted by the **Yale University** School of Green Chemistry. "These are materials that we will not supply in our buildings," said Busby.

"People have started to understand that sustainable building is not just about energy and water consumption but also about resource extraction and manufacturing."

"The healthfulness of buildings is very important to us, and becoming more important to others as the babyboomers age and more young environmentalists come into the marketplace," said Busby. "Google has its own equivalent of the red list because it has made a commitment to its employees that these dangerous chemicals will not be found in their workplace."

Healthcare Environments: "Unhealthy"

Busby laments that hospitals have been among the most resistant to change in their use of unhealthful materials because alternative materials are more costly and have less proven performance records. "They don't use fresh air for fear of germs, and their ventilation ducts can't be cleaned because they're buried under ceilings." The worst practice in hospitals, in Busby's judgment, is the extensive use of vinyl floor and wall coverings that "release dioxins and contain phthalate plasticizers that are linked to cancer."

"Post-natal units for premature babies are seas of vinyl," he said. "The most vulnerable people on the earth absorb these chemicals and it changes them for life."

Silsby points out that hospitals are also very energy intensive with robust air handling systems and heavy plug loads for equipment. But therein she sees "more opportunities to find synergies."

"Heat recovery for ventilation is becoming more common in healthcare because they produce so much waste heat and need a lot of fresh air," said Silsby. "While there are challenges to solve, in cold climates, the payback can be short. It has been my experience with two community hospital projects that the payback was about five years.... "On one of our hospital projects, we worked with the energy provider NSTAR as a pilot project for their Advanced Building Program, which has since changed names," said Silsby. "They paid for the energy modeling for the project and helped offset costs for the heat recovery unit and a more advanced chiller. "

Technological Edges Getting Narrower

As emphasized at several points in the text above, the challenge to implementing the deepest green and energy efficient features in buildings is not a technical one but an economic one. Still, there's technological innovation that is offering new and emerging opportunities.

Heat recovery is still a largely untapped opportunity in higher education, as discussed in detail in the story in this edition about Stanford University's new combined heating and cooling (CHC) system. Silsby reported to CCBJ that at a recent meeting of the Northeast Sustainable Energy Association, she attended a seminar on vacuum insulation panels (manufactured by Dow Corning and others) provide "super high R value with just 1 inch of insulation thickness."

"One of the things we struggle with now is how thick the walls are getting as we increase the R value of the envelope," said Silsby. "Also, when you use a lot of material for insulation, you're increasing your carbon footprint from embodied energy in the product. If we can get the same R value in 1" or 2" of vacuum panels that we can get from 4 inches or 6 inches of conventional insulation, we'll be able to design for more usable space with a lower carbon footprint."

"Measuring the carbon footprint of materials due to their embodied energy is going to be looked at more and more closely," she predicted. "People have started to understand that sustainable building is not just about energy and water consumption but also about resource extraction and manufacturing."

"We had to do a carbon footprint analysis before we were allowed to take down the existing structure to make way for the new net zero energy Martin Luther King Jr. School in Cambridge," said Silsby.

Adaptation and Resilience

Another emerging trend—although at this point it's probably more accurate to call it nascent—is designing buildings to adapt to climate change. The UK has taken the biggest steps forward in this regard, creating forward-looking building codes that reflect climate models. "I'm unaware of this happening anywhere else but in the UK," said Chuck Khuen, executive vice president and co-founder of **Weather Analytics.** "They have built their own climate model for what's going to happen in the UK," said Khuen, who also sits on the ASHRAE climate committee." The model has been very well received in the architectural and engineering community as being as good as you're going to get for what weather will be like in 2030, 2040 and 2050."

In the United States and Canada, the focus is more on resiliency to extreme weather events. "The emphasis on resiliency started in the U.S. in New Orleans and Florida," after devastating hurricanes in the mid-2000s, said Busby. "Florida changed its codes to promote resiliency to include much stronger glazing, more secure envelopes, roofs that are bolted to the walls and also things like emergency generators and water storage.

The resiliency of new buildings and public infrastructure is getting much more focus in New York after Superstorm Sandy. "Outside of these vulnerable areas that have been forced to incorporate climate resiliency, the rest of the country is just starting to think about it," said Busby.

Khuen reported that modeling climate change impacts on building is only an emerging specialty for his company, which is more focused on modeling building energy usage and providing data for the risk models of insurance companies and farmers. "We have some products now that can help with climate change impacts and much more what we're working on," he said. "We are alpha testing the ability to statistically profile the weather at any given location and then produce the probabilities of extreme events like extreme heat and winds, as well as the trends," said Khuen. "So the client can look at the year to year and five-year trending and have bottom-up, statistically valid trend data for temperature, humidity, wind and other variables at a particular location."

According to Khuen, this will help fulfill a desperate need for more accurate location-specific climate change models. "The climate models that predict how the earth will respond with higher sea levels and altered weather patterns are good, but they're global, and you can't downsize them accurately. With our data, you can produce a bottom-up localized view, then you can integrate that with whatever version of global climate models you choose."

Like the environment around them, buildings will increasingly have to have the capacity to adapt. Treated almost like living creatures or ecosystems, buildings will be managed by both the green building and energy efficiency industries that will have to evolve and adapt much like their surroundings. ☼