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Market Intelligence on Climate Change

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Institutions Step Up on GHGs, Dig into Resilience

While national, state/provincial and local governments and corporations represent the lion's share of the market for services related to climate change, institutions such as colleges, hospitals and prisons constitute a significant and growing source of revenues to firms that provide services and products to cut greenhouse gases (GHGs) and enhance resilience to the extreme weather, rising seas and other impacts of climate change.

As the stories and profiles in this issue show, the institutional space is dynamic and diverse. It includes colleges that have made aggressive commitments to achieve net-zero GHGs within the decade and healthcare systems that are planning to ride out the next superstorm with clean-energy microgrids that will also reduce their ongoing carbon footprints.

It also includes prisons, a vast potential market but one that has been slow to open due to understandable concerns about security, as well as the politically conservative nature of prison administrations in most states. As veteran green prisons consultant Paul Sheldon reports in the prisons feature, the key to working with prisons on climate change in most states is not mentioning climate change but emphasizing cost savings and pointing to the success of other prisons that are not based in a blue state like California, Colorado or Oregon.

Microgrids for GHG mitigation and resilience

A common theme among institutions and their host communities is the emergence of clean-energy microgrids as a technology for GHG mitigation and resilience. A confluence of factors are shaping a market for microgrids in the institutional space that would have been hard to imagine just three or four years ago:

Institutions are making aggressive energy and climate commitments that require deeper investment in new energy sources:

- State policies are supporting microgrids, especially in the Northeast where there's an imperative to build resilience against the next Sandy;
- Solar PV prices keep coming down;
- There are more onsite energy storage options, including batteries and thermal storage;
- There's increasingly sophisticated energy management controls and software available; and
- Regulatory initiatives promise to further open electricity markets to distributed energy resources (DERs), including storage and demand response.

"Particularly on the East Coast, we have a lot of interest in microgrids," by higher ed campuses and other institutions, said Clay Nesler, spokesman for **Johnson Controls**' Building Efficiency business. "It's driven by efforts to increase resiliency, but also by the changing utility regula-

Climate Change and Sustainability Consulting for the Institutional Market

Colleges, healthcare systems, K-12 schools, prisons, cultural organizations and other institutions are ramping up their sustainability and resilience investments, providing community leadership and significant source of revenue for consulting & engineering (C&E) and design firms. In general, institutions are taking on energy management and GHG mitigation first, with most just beginning to evaluate resilience. The Northeast is an exception, with growing investment in resilient power infrastructure. Utility market revisions and technology advancements are driving new markets for microgrids with onsite energy storage.

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tory landscape," especially the Reforming the Energy Vision (REV) proceedings in New York.

It's increasingly common for colleges and other institutions to configure a microgrid with multiple clean energy and storage sources, instead of using only the traditional gas or diesel generators or gas-fired combined heat and power (CHP) plants. "Institutions are evaluating integrating technologies such as CHP, PV, battery energy storage, and thermal energy storage," said Carmen Henrikson, associate vice president, **TRC**.

"This is the most exciting time in my professional career, and I've been in the electric power game for 40 years," said Joe Camean, VP and director of Power and Utility engineering who leads several microgrid projects for **van Zelm Engineers**. Among the microgrid projects van Zelm is working on: a Bronx project to leverage existing steam generation plants and create a hybrid microgrid using multiple other technologies for four hospitals.

One consulting firm told CCBJ that it is working with a developer in New England to evaluate a 20 MW PV array integrated with a 40 MW, 10 MWh battery. (Lots more on microgrids in the higher ed feature in this issue.)

Local governments, utilities as partners

While there are some famous cases of institutions with microgrids staying online during Sandy, resilience planning and funding is increasingly focused on integrating institutions' self-generation capabilities with those of their communities, and vice versa. "In higher ed and other institutional settings, you have a resident population that you have an obligation to keep warm, fed and able to communicate, but you also often have great facilities for hosting surrounding communites," said Neil Webb, director of project development, with **OBG** (O'Brien & Gere).

"A campus can become a shelter-in-place for the community," in future events like Sandy or the swarm of tornadoes that ripped apart the Southeast in 2011, affirmed Michael Mondshine, who leads **WSP | Parsons Brinckerhoff**'s corporate climate preparedness practice. "If the community is down but we have a microgrid at the college, it's not just to keep the college running, it's to provide a shelter-in-place, ideally including food and water."

For the City of Jamestown, New York, Webb and his colleagues at OBG have helped city staff develop a microgrid plan for the city-owned power and heat utility. While the utility meets most of its own energy needs, and a good deal of heating with its district energy network, it is tied to the regional grid to supply peak loads—and thus vulnerable to regional transmission outages.

"We are exploring a way to island their system from the larger grid transmission network in the event of a regional outage due to an ice storm or other disaster," said Webb. "The microgrid would supply about half of their community, which is served through underground wiring and infrastructure."

Community assets like the local hospital, community arena, water and wastewater treatment facilities, as well as commercial entities like grocery and building supply stores would be connected to the microgrid, according to Webb. The Jamestown project would be a contender for a grant of up to $1,000,000 from the New York Prize as part of a Phase II solicitation due in October of 2016.

Community and regional planning needed

Susan Asam, principal at **ICF International** points out that the resilience of power, communications and transportation networks are especially critical for healthcare. "Some earlier projects [on climate change and healthcare] were

somewhat isolated, looking at particular facilities and particular routes," she said. "As we engage more in these broader conversations about resilience, we're seeing local and institutional leaders recognizing the need to take a more integrated view of resilience.

Rural areas in particular can be overlooked in transportation vulnerability assessments, says Asam. "Sometimes when one does a data-driven analysis of critical routes, they may focus for data or resource reasons on the major roadways and end up overlooking local roads. This came to light in our work with some clients on HUD's National Disaster Resilience Competition. Rural residents can face long detours or even complete lack of access to healthcare [in extreme weather events] while urban areas have more options."

WSP | Parsons Brinckerhoff is working with communities where institutions engage with local governments and other stakeholders in regional resilience planning efforts. "Quite often we start off working with a planning agency, then there are multiple stakeholders in that process, such as the local housing authority and the local college and university campuses," said Mondshine.

"In our experience, most of the risks and vulnerabilities around these institutions are associated with public infrastructure," said Mondshine. "So we get these folks around the table and they share what their needs and concerns are. Sometimes some of these individual stakeholders then become a client."

"We recently assisted the State of Connecticut in securing a grant from the **Department of Housing and Urban Development** National Disaster Resilience Competition and look forward to supporting their efforts to make Bridgeport a resilient community," said Mondshine.

As noted by consultants at **Woodard & Curran** (see profile), **FEMA** has one grant program for which colleges and universities are eligible: the Hazard Mitigation Grant Program (HMGP). But colleges, hospitals and other institutions can seek funding for a broader set of FEMA grants in cooperation with local governments.

"It's very wise of colleges and universities to participate when their local community is doing a hazard mitigation plan, to become a strong partner and advocate for their projects to be incorporated in the plan," said Woodard & Curran's Mary McCrann, senior planner. "Should the plan get approved by FEMA, then the municipality could apply for project funding on the institution's behalf."

Along with local governments, electric and gas utilities are increasingly interested in partnering with institutions on microgrid projects. "Some of our utility clients are now interested in owning some of the CHP plants at their customer sites," said Jason Abiecunas, microgrid technology manager for consulting engineering firm **Black & Veatch**. "They get a grid benefit from those projects, while the customer gets a benefit from a more economical energy supply without the capital outlay."

"Energy utilities are showing a keen interest in integrating climate change into their operations and planning," added Anne Choate, senior vice president at ICF International. "Our work in partnership with **San Diego Gas & Electric**, funded by the **California Energy Commission**, provides a good example of how climate change information can be translated to be relevant to energy utilities and support their resilience efforts."

The business model depends a great deal on the electricity market structure in the relevant state, notes Abiecunas. "In some states, utilities are allowed to build or own CHPs, while in other markets we see independent power producers and other third parties pursuing CHP investments."

The Opportunity for University Microgrids

Improves reliability of campus utilities

Enables use of green technologies

- Solar, Wind, Geothermal
- Battery Storage
- Thermal Storage
- Anaerobic Digestion
- Others

Reduces energy costs

- Reduced raw fuel consumption
- Optimize load profile management

Creates opportunities for student engagement

Typical Project Drivers

Need for infrastructure renewal

Resiliency or hardening requirement

Problems with existing infrastructure

Problems with uncertainty

Savings/ROI

Somebody got a grant

Assessment & Business Plan

Existing conditions assessment

Scope boundaries of microgrid (lab building, athletic center, etc.)

Parametric modeling of options & costs

Qualitative and quantitative ranking of options

Identification of fatal flaws

Defining success: know your project drivers

Courtesy of SourceOne, a Veolia Company

Tallying the market

It's difficult to estimate climate change consulting for the institutional space, but CCBJ puts the figure at about $50 million. While large multidisciplinary consulting engineering firms like WSP | Parsons Brinckerhoff, **Arcadis** and **AECOM** earn a very small portion of their revenues from institutions, firms such as **Brendle Group**, with 20 employees, and **Four Twenty Seven**, with 10 employees specialize in institutional clients.

Brendle Group has won deep credibility in the higher Ed space and K-12 space (see the higher ed story), and CCBJ estimates 30% to 40% of the firm's revenue comes from institutions. Four Twenty Seven's Emilie Mazzacuratti estimates that healthcare work keeps two of her 10 employees busy on a full-time equivalent basis. Woodard & Curran, a mid-sized firm with about 900 employees, has many higher ed clients which it assists with everything from big-picture GHG mitigation strategy to energy systems procurement and operations. Resilience and adaptation have become larger parts of the firm's higher education business, with large projects for the University of Massachusetts and Connecticut State Colleges & Universities. Woodard & Curran's Mary House estimated colleges and other institutions will account for 5% of the firm's revenues in 2016 (2015 revenues were $162 million.)

Mondshine told CCBJ that WSP | Parsons Brinckerhoff has about 10 full-time equivalent employees working on climate preparedness. "It may drop down at any one time to 8 and then peak at 13 or 14 depending on the project cycles," he said. At firms with the largest resilience practices, ICF International and Abt Associates, CCBJ estimates 25 to 40 full-time equivalent employees work in climate change resilience and adaptation.

The GHG mitigation side for most large and medium-sized firms is much larger than resilience and adaptation, as it involves the fast-growing renewable energy segments, GHG inventories and mitigation plans for traditional clients in power and oil & gas, and services related to supply chains for large global companies. Evans from WSP | Parsons Brinckerhoff says his firm has a group of about 25 employees in North America working on "enterprise-focused sustainability services," and similarly sized groups in Europe, the Middle East and Australia.

But again, institutions are a very small slice of the business in GHG mitigation and resilience for larger firms.

ESCOs score well in education, healthcare

For renewable energy and energy efficiency projects in the insitutional market, the ESCOs are the leading revenue producers. Firms like Johnson Controls, **Ameresco**, **Energy Systems Group**, Siemens, ConEd Solutions and many others contract with hospitals, higher ed, K-12 schools and housing authorities along with their government clients.

Their performance contracts, which enable investments in energy efficiency and renewable energy to be paid over 10-20 years with cost savings or energy revenues, are ideally suited for institutions; and institutions, with their longevity and long-term view, make good clients for ESCOs.

As described in the Johnson Controls profile, JCI and other ESCOs are increasingly integrating new technology like ventilation heat recovery and smart energy management into energy projects for institutions. And where resilience is a priority, the capacity to island onsite energy systems provides new measures of long-term value.

These outfits provide consulting and project development work—on an increasing scale, assuming others are following Johnson Controls' model—but most of their revenue comes from equipment sales and installation; engineering and construction services; O&M services; and for many, sales from energy in the forms of electricity, gas, heat or chilled water from plants they own and operate.

In specialties like stormwater management and mechanical/electrical engineering, some smaller firms specialize in institutions. van Zelm has done mechanical/electrical engineering for scores of colleges in the East. Planning and stormwater specialist firm **Nitsch Engineering** also has many higher ed clients—clients often more able to fund cutting-edge green infrastructure than local governments. The firm's green infrastructure planning director Nicole Holmes sees higher ed providing leadership for many communities that want large property owners to manage more stormwater onsite."

"Colleges and universities are willing to do these pilot and demonstration projects that make the municipalities happy but also help the institutions themselves meet the [sustainability] demands of their students and donors," said Holmes. "Their campuses become more beautiful and the projects serve to educate students and the community about how this approach can work."

K-12 opportunities and challenges

Johnson Controls' Clay Nesler highlights opportunities for K-12 schools to use microgrids powered by combinations of gas-fired cogeneration, solar PV and batteries to keep running during an outage—or at least powering critical loads. He even predicts that with the further decentralization of electricity markets to accommodate DERs, K-12 school districts could someday start coordinating and aggregating their loads to provide grid ancillary services—as **ENBALA** and other firms have done with water treatment plants.

Judy Dorsey, president of Brendle Group, is enthusiastic about work her home state of Colorado has done with K-12 schools. "The Colorado Energy Of-

fice's Energy Savings for Schools program helps rural schools save energy and money," she said.

In California, voter-approved Proposition 39 provides for a multi-year dedicated funding stream for energy upgrades at K-12 schools, according to Cyane Dandridge and Stephen Miller from California NGO **Strategic Energy Innovations**. This has led energy service providers to ramp up their marketing focus on K-12 schools. "Those that have been the most successful have to a large degree helped make the connection between energy performance and the mission of education, preparing students to be leaders in the new green economy," said Miller.

Solar power project developers, ESCOs and solar PV EPC firms are getting more sophisticated at helping education clients integrate PV projects with curricula and public relations. Ameresco, for instance, offers custom solar dashboards that can be "fully branded and customized to reach specific audiences." Projects highlighted on the ESCO's website include **Arizona State University's** Campus Metabolism web dashboard, which tracks energy uses and sources in real time.

In addition to branded and standard dashboards, Ameresco also offers kiosks displays for lobbies, K-12 solar curriculum materials and professional staff to appear in schools and at public events to explain "how your [solar PV] system was developed and how much energy it is expected to generate." These kinds of offerings increasingly find receptive audiences in K-12 and higher ed institutions.

"School boards and administrators listen to their constituents, including students, more and more of whom are interested in clean energy and sustainability," said Dandridge. "And many schools are now leveraging the linkages between their facilities' energy usage and what's taught in the classroom."

Dorsey points out that school districts are also "politically dynamic" with frequent turnover in boards and superintendents. "K-12 school districts are not necessarily a long-term stable environment around climate friendly values. We have seen school boards change and their values and priorities shift away from climate and energy concerns."

Colleges will need more help

As detailed in the higher ed story in this issue, the GHG targets of many colleges and universities will ratchet up sharply over thethe next five to 15 years, and that will make them growing markets for solar PV arrays, including off-campus systems. Many will need battery and thermal energy storage, as well as geothermal heat pumps, and consulting services to design and manage such deep energy retrofits. "As colleges get beyond the relatively easily accessed savings, they're going to require more significant support, creative, programmatic and financial expertise," said SEI's Miller.

Because of public-sector capital budgeting constraints, and the fact that only for-profit institutions can monetize federal RE tax benefits, campus PV will grow mostly through projects owned by third-parties that contract with schools for solar-generated power.

Long utilized in the commercial and residential segments, solar power purchase agreements (PPAs) are relatively new in higher education, which has relied mostly on renewable energy credits (RECs).

Using solar PV to meet a big chunk of institutional electricity needs will require more storage and flexible demand response. Some extraordinarily large projects are underway in Arizona, developed by **E.On** and **NextEra** (and further described in the higher ed story). And Stanford's large deployment of ventilation recovery systems to capture heat and thermal energy storage to shift cooling loads away from peak periods—a shift which also gives the college an opening to sell clean electricity from its enormous PV systems to the grid—is getting lots of attention in the institutional energy management field.

Engineers CCBJ has spoken with laud Stanford SESI as a great leadership project but a model that's hard to replicate because few regions have the climatic characteristics of Palo Alto, Calif.

Johnson Controls' Nesler is more optimistic about the potential for Stanford's approach to spread. "We're getting a lot of interest in [similar systems] by large institutions, including universities," he said. "I can say that many of these are not in the temperate climate of the San Francisco Bay Area."

Given the ambition of many institutional commitments to GHG mitigation and climate change resiliency and the technical, economic and regulatory transformations in electricity technology—plus the rivalries between universities—it's a good bet that projects even more audacious than Stanford's will be announced in the next 18 to 24 months. ☼

Ameresco's Largest Institutional Customers in 2015

- Auburn Community School District (Illinois)
- Community College District No. 508 (Chicago)
- British Columbia Housing Authority
- Federal Bureau of Prisons
- Knox County Schools (Tennessee)
- Marana Unified School District (Marana, Arizona)
- New Mexico State University (Las Cruces)
- Newport News School Board (Virginia)
- The Housing Authority of the Birmingham District (Alabama)
- University of Illinois
- University City School District (Missouri)

Colleges Go Long for Sustainability & GHG Mitigation

Colleges nationwide make audacious pledges to cut GHGs, while resilience factors most strongly in the Northeast

Colleges and universities have always been hotbeds of activism and innovation, so it's no surprise that many of these institutions have made commitments to reduce their greenhouse gases (GHGs). What is surprising is just how deep many of these commitments go. "All the colleges and universities that we're working with have very strong commitments to being environmentally responsible and reducing their carbon footprints," said Dave Madigan, VP of **van Zelm Engineers**, an MEP firm that has worked for scores of colleges and Universities in the Northeast.

At the same time, the decreasing costs of distributed energy resources (DERs)—especially solar PV and battery energy storage—rapidly evolving energy management software and controls and pro-DER policy initiatives are creating a perfect storm for campuses to invest in clean power, both onsite and offsite. "There are environmental, economic and a geopolitical drivers all happening at the same time," said Madigan.

More than 700 institutions have signed the American College & University Presidents' Climate Commitment (ACUPCC), pledging to get to zero GHGs, most of them before 2050. And some have much more ambitious targets, most notably the **University of California**. Under President Janet Napolitano, the UC system, with 238,000 students and 10 campuses, committed in 2013 to achieve carbon neutrality in scope 1 (GHGs from direct fossil fuel combustion) and scope 2 (mostly GHGs from purchased electricity) GHG emissions by 2025.

The major drivers behind this movement are top-down policies from state and private colleges system trustees and bottom-up momentum from students and parents. "A campus's sustainability commitments are an increasingly important motivator for prospective students," said Julian Dautremont-Smith, director of programs for the **Association for the Advancement of Sustainability in Higher Education** (AASHE). He points to the annual surveys of incoming freshmen and their parents conducted by **Princeton Review**. In the 2016 survey, 6% of respondents said a prospective college's "commitment to environmental issues" would figure "strongly" in their decision about which school to attend; 15% said it would matter "very much" and 40% said it was "somewhat" important.

Like sustainability rankings for corporations, the higher ed space has seen growth in the number of organizations offering to rate colleges' environmental credentials.

- AASHE has its STARS ranking program (Sustainability Tracking, Assessment & Rating System), in which some 300 colleges and universities—the vast majority in the United States and Canada—have submitted reports and received rankings similar to those for LEED for buildings.
- **Second Nature** is a separate nonprofit that supports the ACUPCC and has recently rolled out new categories of climate pledges, rebranding ACUPCC as the Second Nature Carbon Commitment and introducing a new Resilience Commitment.
- Princeton Review publishes a Guide to Green Colleges and ranks the Top 50 Green Colleges.

Perhaps responding to confusion about the multiple green campus ranking systems, Princeton Review recently began collaborating with AASHE, and Sierra magazine to "streamline the reporting process for institutions that choose to participate in various higher education sustainability assessments," according to its website.

Green campuses transcend the usual red state-blue state divide in climate change politics, with many universities in red states making the boldest pledges and ranking highest on AASHE's STARS system. "We see some campuses in conservative states such as Oklahoma, Texas, Florida and Arizona leading on sustainability," said Dautremont-Smith. "**Arizona State University** was one of first signatories of the Second Nature Carbon Commitment and the first to create a school of sustainability offering undergrad and graduate degrees."

Top 10 Campuses by Total PV Capacity

#	Institution Name	Total Capacity (kW)
1	University of Arizona	28095
2	Arizona State University	23567
3	Rutgers State University	17417
4	Mount St. Mary University	17400
5	Colorado State University	6754
6	California State University Fullerton	6565
7	West Hills Community College District	6000
8	U.S. Air Force Academy	6000
9	Arizona Western College	5105
10	Butte College	4616

Source: Association for the Advancement of Sustainability in Higher Education

ASU and **University of Arizona** are the top two campuses for net solar PV capacity by far, according to AASHE. (see chart). And in May 2016, the University of Arizona was announced as the site for an enormous new solar PV-battery electric storage project sponsored by **Tucson Electric Power** and **E.On** Climate & Renewables. The university's Science and Technology Park southeast of Tucson will host E.On's 2 MW solar array and 10 MWh lithium titanate oxide battery storage facility.

This and a comparable system at a TEP substation, developed by **NextEra** Energy Resources, will be used to maintain the balance between electricity supply and demand in a distribution network where variable PV resources are growing rapidly and to mitigate outages during periods of peak demand.

Resilience work just beginning

This type of partnering with electric utilities and electricity suppliers is an important trend for campus energy efficiency and clean energy projects—and these partnerships often open the door to integrating disaster resilience and climate change adaptation, concerns which are thus far not as high on the college sustainability agenda as GHG mitigation.

"Resilience and adaptation are definitely lagging behind carbon mitigation," said Dautremont-Smith. "Some campuses are beginning to integrate resilience thinking and trying to understand what kinds of impacts they can expect from climate change and how they can prepare for those."

"A challenge is that the solutions are a lot less portable from one campus to another," said Dautremont-Smith. "LED lights are going to save energy wherever you use them, but resilience is really site- and region-specific. The work we see happening in resilience tends to be more at the research level, trying to understand how a region is going to be impacted by rising sea levels and other expected consequences of climate change."

Microgrids growing in Northeast

Where resilience thinking is beginning to figure into campus leaders' planning and investment scenarios is in the assessment of onsite microgrids capable of islanding. "Particularly on the East Coast, we have a lot of interest in microgrids," by higher ed campuses and other institutions, said Clay Nesler, spokesman for **Johnson Controls**' Building Efficiency business. "It's driven by efforts to increase resiliency, but also by the changing utility regulatory landscape," especially the Reforming the Energy Vision (REV) proceedings in New York.

After Hurricane Sandy, research on backup power system performance by consulting firm ICF showed that combined heat and power (CHP) systems were more reliable than stand-alone backup generators. And few people in higher ed on the East Coast missed the story of how New York University—with its CHP-driven microgrid—stayed up and running while most of the rest of the city went dark.

The Sandy experience has caused some campuses to evaluate CHP more favorably as they weigh the benefits of remaining open, functional and safe in extreme weather events against the lower costs of backup diesel or natural gas generators without CHP capabilities.

Neil Webb, director of project development, with the consulting and engineering firm **OBG** (O'Brien & Gere) reports a related trend in which campuses in the Northeast are considering microgrids in the context of energy master planning. "This approach involves taking a more holistic view of the GHG audits and individual energy measures and wrapping them into a vision for making major strides on GHG reduction and developing stronger resilience to extreme events like Sandy," said Webb.

Factoring in the benefits of future resilience can change the perception of investing in a new CHP system, according to Webb's colleague Rob Neimeier, a senior project manager at OBG. "The **University at Albany** had considered CHP in the past and determined it wasn't financially feasible. They have since re-evaluated CHP under different financial models while considering lifecycle costs as well as benefits from source energy reduction, resiliency, and redundancy, which can help support its adoption if the costs are essentially cash neutral or even slightly cash negative."

"In the East, we're seeing universities exploring how they can set up their CHP or cogen facilities as microgrids to be able to operate as an island during emergency conditions" affirmed Carmen Henrikson, associate vice president with **TRC**.

And with the rapid decrease in prices for solar PV and more availability of battery electric and thermal energy storage systems, it's increasingly common for colleges and other institutions to configure a microgrid with multiple energy and storage sources—or to expand an existing CHP and district energy system with PV and storage. "Institutions are evaluating integrating technologies such as CHP, PV, battery energy storage, and thermal energy storage," said Henrikson.

One consulting firm told CCBJ that it is working with a developer in New England to evaluate a 20 MW PV array integrated with a 40 MW, 10 MWh battery.

Local governments, utilities as partners

Since Sandy, state and local governments in New York and Connecticut have ramped up support for campus and community microgrids—not only for regional energy diversity but also to outfit the campuses as shelters for the next weather disaster.

The $40 million New York Prize for local power infrastructure drew 83 proposals which have been winnowed down to 13, according to Joe Camean, VP and director of Power and Utility engineering for van Zelm Engineering. van Zelm is working with developer **Gotham 360** on a short-listed New York Prize project for a network of four healthcare facilities in the East Bronx. It will leverage existing steam generation plants to create a microgrid that may include "combustion turbines, PV arrays, battery systems, steam turbine generators, heat recovery steam generators, etc.to provide on-site generation for local loads in both grid-tied and islanded modes of operation," according to a project sheet from Gotham 360.

"This is the most exciting time in my professional career, and I've been in the electric power game for 40 years," said Camean. (For more, see the van Zelm Engineers profile and microgrids story in this issue.)

TRC's Henrikson proudly pointed to her alma mater, **Wesleyan University**, as a clean microgrid pioneer. The college used a $700,000 grant from Connecticut's Department of Energy and Environmental Protection to install a 676 kW CHP system in 2014 to power a microgrid capable of keeping its Freeman Athletic Center heated and powered to shelter students and residents of Middletown during future disasters; the center will serve as the **FEMA** distribution center for first responders, according to Wesleyan's news release.

Then last year, Wesleyan contracted with **Greenskies Renewable Energy** to bring on an additional 750 kW of solar PV capacity, which will be tied into the microgrid—and at the same time, the microgrid will be expanded to serve several other campus buildings.

Attending Wesleyan's March 2014 celebration of its CHP microgrid's commissioning were Connecticut Governor Daniel Malloy, Middletown Mayor Dan Drew, state legislators and senior executives from both of the state's regulated electric distribution companies, **Connecticut Light and Power** and **The United Illuminating Company**. This kind of cooperation is emblematic of the trend in microgrid investment in the Northeast, according to Henrikson and her colleague William Moran, senior electrical engineer with TRC.

"Both city planners and investor owned utilities are actively seeking new microgrid projects to increase the power grid's reliability, improve energy efficiency and incorporate renewable sources," wrote Moran in a recent blog.

"Some of our utility clients are now interested in owning some of the CHP plants at their customer sites," agreed Jason Abiecunas, Distributed Generation Service Area Leader for engineering and construction company **Black & Veatch**. "They get a grid benefit from those projects, while the customer gets a benefit from a more economical energy supply without the capital outlay."

The business model depends a great deal on the electricity market structure in the relevant state, notes Abiecunas. In some states, utilities are allowed to build or own CHPs, while in other markets we see independent power producers and other third parties pursuing CHP investments.

"We expect distributed energy resources, whether renewable or fossil fueled generators, to become a much larger part of the electric system," Abiecunas said. "There is a confluence of energy consumers, utilities, and regulators seeing benefits of more distributed resources while the economic, environmental, and resiliency drivers for distributed resources are becoming stronger."

"We're going to see more and more investment in innovative microgrids as technologies continue to evolve," said TRC's Henrikson. "This is a perfect win-win particularly for technical universities, providing opportunities for both research and applied learning. I think you will see a lot of universities going in that direction. Bringing the students into the planning and design for these traditionally physical plant projects."

Connecticut State Colleges & Universities Multi-Campus Hazard Mitigation Plan

- Goal 1: Protect existing and future assets from known hazards by implementing mitigation projects to minimize potential losses.
- Goal 2: Maintain a continuity of campus business operations during and after a hazard event.
- Goal 3: Create and maintain a safe, secure environment for the campus population before, during, and after a hazard event.
- Goal 4: Communicate natural and human hazard information to the campus community and improve education and outreach efforts regarding their potential impact.
- Goal 5: Proactively protect existing and future campus assets from known hazards by incorporating mitigation activities into capital improvement and infrastructure planning.

Stanford model not just for Silicon Valley

Discussions of campus microgrids and renewable power-driven district energy systems inevitably touch on Stanford University's $485 million Stanford Energy Systems Innovations (SESI) project. SESI replaced the university's gas-fired CHP central plant with a new central heating and cooling system that uses grid power and solar PV, and recovers energy from evaporative cooling towers.

SESI also renovated its district energy system to use hot water instead of steam and built thermal energy storage systems that allow it to meet cooling loads at off-peak periods and earn peak revenues by selling energy into California's electricity market (It won a rare direct access lottery several years ago). And in a deal with SunPower, Stanford is deploying over 70 MW of solar PV capacity, 68 MW off campus.

Most consultants and higher ed sustainability experts that CCBJ spoke with say few other colleges and universities will invest in a comparably ambitious system anytime soon. "Stanford is trailblazing with SESI which is also aligned with its ongoing grid modernization research. They are demonstrating how it can be done," said TRC's Henrikson. "At the same time, other universities are pursuing other innovative paths given their unique constraints."

"Stanford can do some pretty incredible things because of its size and resources," agreed Dautremont-Smith. "Most campuses are not in that position. Not that they couldn't do something like that given the right circumstances, but any project that involves re-doing your central heating system is going to take some time to spread. I think other campus leaders are waiting to see how it evolves."

Some also say that while Stanford's heating and cooling system can work in its temperate climate, that more conventional systems are needed to heat and cool campuses in most of the country, where winters are much colder and summers much hotter and more humid.

Nesler of Johnson Controls—Stanford's supplier for many of SESI's major components and its partner in the Energy Optimization Solution (EOS) software for energy dispatching and control—is more optimistic about the potential for this type of centralized heating and cooling system to spread. "Every system is going to be different, needing different amounts of heating and cooling at different times and different places on their campus depending on where they are in the country and the design and configuration of their facilities," he said.

"We're getting a lot of interest [in systems like Stanford's] by large institutions including universities [and] many of these are not in the temperate climate of the San Francisco Bay Area," he said.

As further discussed below, while Stanford's ambitious post-CHP energy system may not be affordable today, something like it will be necessary to reach the net-zero carbon pledges in future years.

Charting the growth curve

The growth rate of new college climate commitments has tapered off in the last few years. AASHE's membership grew rapidly in the mid- to late-2000s before stabilizing at around 1,000 members—about 20% of the approximately 4,700 U.S. 2-year and 4-year colleges. Dautremont-Smith says AASHE has plans for deeper engagement by existing members, including changes to the STARS system that will incentivize more campuses to join and create advantages for existing members to update their ratings annually instead of every three years.

But even though the rate of new schools making sustainability and climate change commitments has tapered off, the work of implementing those commitments is in many ways just getting started. "Our work is not flattening in higher education as some of the earliest institutions to commit to goals continue to figure out implementation," said Judy Dorsey, president of the **Brendle Group**, a sustainability consultancy HQ'd in Fort Collins, Colo.

On many campuses, there's still a need to refine existing GHG inventories or extend them to sectors that have been hard to quantify, like procurement, food services and waste or—even more difficult—commuting by staff and students; and as these are completed, there will be new opportunities to develop and analyze the costs of GHG reduction opportunities in these sectors.

As an example, Dorsey's firm is working with **Colorado State University**, the first campus to achieve a STARS Platinum rating, to refine its GHG inventory for housing and dining services. "They're actually developing a housing and dining services climate action sub-plan, looking at strategies ranging from upgrades to lighting and HVAC, continuous commissioning, sub-metering, refrigeration upgrades and renewable energy installations," said Dorsey.

For the University of California's Office of the President, Dorsey and other staff from her 20-person firm, recently completed a series of half-day planning charettes on eight UC campuses. Conducted with the UC's Climate Change Working Group, the project was funded by the Office of the President in support of the above-mentioned commitment to achieve carbon neutrality in scope 1 and 2 emissions by 2025.

"There are opportunities to move toward carbon neutrality by working across the system as well as on individual campuses," said Dorsey, noting that the UC has its own energy procurement

unit that is looking to exceed the mandated 33%-by-2020 renewable energy content—and that last year it created its own wholesale power program to supply several campuses. "Also because they're a system, they're able to achieve greater demand-side management incentive rates from their utilities."

UC forms own ESP, seeks biogas for CHPs

According to the UC websites, the university switched in 2015 from buying about 12% of its approximately $122 million in purchased electricity from a private energy service provider (ESP) and created its own ESP to supply its Irvine, San Diego, San Francisco, Santa Cruz and Merced campuses.

Meanwhile its Energy & Facilities Management Service is looking to replace all or part of the system's natural gas supplies—now purchased under contracts negotiated by each campus—with biogas. This is driven not only by the UC President's sustainability goals but also by the GHG compliance obligations under the state's Cap and Trade system for campus CHP facilities at Davis, UCLA, Irvine, San Diego and San Francisco. These cogens burn about 71% of the UC system's total natural gas consumption.

Documents also show the division is negotiating with fuel marketers to procure biogas from a landfill in Keithville, Louisiana; although the actual gas molecules won't make it to California, the university is looking to acquire the environmental attributes, represented by Renewable Identification Numbers (RINs). "Environmental attributes have to make it to California. We do not expect to get the actual molecules to California," states an April 2016 RFI for firms that had expressed interest in the contract.

UC's sophistication in tinkering with its energy mix may represent something of a barrier for consulting firms looking to help it with its energy and GHG management plans.

Another disincentive to engage consultants is the fact that normal capital replacement cycles tend to lead to reductions in energy usage simply because newer generations of lighting, office equipment and HVAC systems are more energy efficient (thanks to federal and state energy policies and regulations). Vehicle fuel efficiency is on a similar upward curve, so as campus fleets are changed over, they use progressively less fuel.

And in many states, power grids are getting greener as coal generation is phased out, natural gas generation

Top 50 Green Colleges

1. Lewis & Clark College
2. Green Mountain College
3. University of California–Santa Barbara
4. State University of New York–Stony Brook University
5. Dickinson College
6. Cornell University
7. American University
8. College of the Atlantic
9. Middlebury College
10. University of Vermont
11. Portland State University
12. Colorado State University
13. Willamette University
14. University of Washington
15. Pomona College
16. University of California-Irvine
17. Warren Wilson College
18. Mills College
19. Santa Clara University
20. University of Maryland, College Park
21. University of Massachusetts-Amherst
22. Stanford University
23. Georgia Institute of Technology
24. University of Illinois at Urbana-Champaign
25. Columbia University
26. University of Maine
27. University of Colorado–Boulder
28. Iowa State University
29. Washington University in St. Louis
30. California State Polytechnic University, Pomona
31. University of North Carolina at Chapel Hill
32. University of California–Santa Cruz
33. State University of New York–College of Environmental Science and Forestry
34. University of New Hampshire
35. Oberlin College
36. Colgate University
37. Emory University
38. Oregon State University
39. Saint Michael's College
40. University of California–Davis
41. University of Northern Iowa
42. University of North Texas
43. Loyola University of Chicago
44. University of Puget Sound
45. Washington State University
46. Randolph College
47. Chatham University
48. University of Texas at Austin
49. Northeastern University
50. Ball State University

Source: Princeton Review

becomes more efficient and more wind, solar, small hydro, geothermal, landfill gas and other clean energy sources come online. (Some climate policy wonks would remind campus climate and sustainability leaders that keeping nuclear plants online, including California's sole remaining plant, 2.2GW Diablo Canyon, will be important to keeping electricity emissions factors low.)

Early days for this market

Still, it's early in the cycle of planning and investment for campus's long-term GHG commitments, and there's a lot left. for consultants to help with "As colleges get beyond that first level of relatively easily accessed savings, they're going to require more significant support [and] creative, programmatic and financial expertise," said Stephen Miller, deputy director of **Strategic Energy Innovations** (SEI), a Bay Area NGO that works with institutions and local governments.

Reaching goals like UC's scope 1 and 2 net-zero pledges, **California State University**'s 2040 goal of 80% cuts below 1990 levels and other carbon neutrality pledges, will require large investments and internal changes in how universities budget and finance their operations.

"There will need to be structural changes in terms of how projects are financed and how departments are incentivized," said Miller. "There needs to be more financial incentives, shared savings, less of a firewall between capital projects and ongoing operation and maintenance budgets."

"In the higher ed sector, we often find that the departments that have responsibility for operating expenses don't have any control over capital budgets," said Evan Evans, senior vice president of **WSP | Parsons Brinckerhoff**. "So there's a disconnect there, because the operational cost savings that result from energy efficiency or onsite renewables don't necessarily flow to pay off the capital investment. That's a pretty common structural problem that needs to be addressed. It exists in private enterprises as well."

One solution Evans hopes more colleges will explore is internal carbon pricing. WSP | Parsons Brinckerhoff helped **Microsoft** design and implement its internal carbon pricing scheme. Under that system, each Microsoft business unit is assessed a "carbon fee" based on an assigned carbon price and the amount of GHG emissions attributable to the unit's operations.

The carbon price is set to reflect the cost of measures Microsoft will implement to achieve its carbon neutrality goal, including energy efficiency and renewable energy projects, carbon offsetting community projects, e-waste recycling, water stewardship, and research for innovation. These fees go into a dedicated fund, to which operations managers can apply for financing for emissions-reduction projects.

Evans was happy to see Yale adopt an internal carbon pricing system last year. "While we're not directly involved in their carbon pricing pilot program, we have influenced their thinking," said Evans. "We were an invited participant on a panel that Yale hosted on the topic of carbon pricing, and because of our work with Microsoft, I think our perspective added a lot of value." Evans affirmed Yale's claim to be the first higher ed institution—and only one as of CCBJ's early June deadline—to adopt such a carbon pricing program.

For most campuses, achieving carbon neutrality probably will require large PV arrays, including off-campus systems, coupled with onsite battery storage and use of heat pumps—in many cases with geothermal loops to lessen cooling and heating loads—to shift to all-electric heating. And unless there's some kind of revolutionary breakthroughs in advanced biogas production, it means shifting entirely away from gas combustion—which must raise concerns about investment in new or upgraded CHP facilities.

"To reach carbon neutrality, we're really going to have to kick natural gas which now accounts for about one-third of our total emissions, including scopes 1, 2 and 3," said Morgan King of **Humboldt State University** (HSU).

HSU, whose President Lisa Rossbacher signed earlier this year the Second Nature Carbon Commitment, provides a good example of how early efforts to pick low-hanging fruit must eventually mature into more transformative changes.

As described in the sidebar story, the college of 8,800 students has a long history of clean energy innovation, investment in highly efficient buildings and mitigating GHGs associated with waste. It has done a GHG inventory and created a list of 62 GHG reduction strategies. In the early years, many can be accomplished without major costs. But to reach its more ambitious long-term targets, deeper energy retrofits and a complete transition to carbon-free electric power and heat will be needed at the campus.

PPAs in the cards for solar PV

Because of schools' capital budgeting constraints, and the fact that only for-profit institutions can monetize tax credits and accelerated depreciation for solar, campus PV will grow mostly through projects owned by third-parties that contract with schools for solar-generated power.

Long utilized in the commercial and residential segments, power purchase agreements (PPAs) for renewable energy are relatively new in higher ed, according to AASHE's Dautremont-Smith. "You can see the trajectory of how campuses are buying renewable energy. Historically, and still today, it has mostly been through buying renewable energy certificates. With PPAs they can contract directly with a renewable energy developer and often do it in a way that saves money."

Dautremont-Smith cites George Washington and American universities in DC as recent examples of contracting for off-site solar power from a power plant in Virginia. "Of course you can do PPAs for onsite power, and lots of folks are doing that. But the potential scale is much larger with offsite projects."

"Unless a campus has a lot of excess land, it's unlikely it can meet a large percentage of its electricity needs with onsite solar," he said. To encourage more campuses to take advantage of PPAs, AASHE has launched the Green Gigawatt Partnership, which aims to catalyze at least one gigawatt of new green power in higher education through long-term, large-scale, power purchase agreements.

Using solar PV to meet even 10% of electricity needs would be a huge achievement, but getting to 50% or beyond—as some campuses hope to achieve eventually—will inevitably require storage, either onsite in battery systems, thermal energy systems or hydrogen electrolyzers; or regionally through grid batteries like those being commissioned in Tucson; or with more mature transmission-scale technologies like pumped hydro.

Thus far, significant onsite battery storage projects are rare on campus. "There are some campuses beginning to move in that direction, but it's still fairly new," said Dautremont-Smith.

But that will change, facilitated by DER-favorable power market policies, partnerships with electric utilities and other electricity market participants (like E.On and NextEra, developers of the Tucson projects mentioned above), emerging vendors of onsite storage systems like Solar Grid Storage and STEM, and energy service companies (ESCOs), which already have a large business in higher ed.

As highlighted in the Johnson Controls profile, that firm expects to see more performance contracts with institutions incorporating battery storage. "As energy becomes more distributed and as buildings, institutional and other, no longer just consume energy but also produce it, there will be a lot of opportunity to monetize additional capabilities," said Johnson Controls' Clay Nesler.

Nesler even predicts that K-12 school districts will someday start coordinating the control of their loads and aggregating the impact to provide ancillary services like frequency regulation and spinning reserves to regional grid operators and utilities.

ESCOs a "huge help"

"ESCOs can be a huge help to many campuses," in achieving their GHG goals, said Dautremont-Smith. "At the same time, when colleges have resources in-house, they usually prefer to do energy projects themselves, which allows them to capture more of the savings. For those who don't have internal capacity, working with an ESCO can be a significant opportunity to generate savings without a big upfront cost."

"Many facilities departments are short-staffed," he continued. "They've had budget cuts, and every facilities manager I've met is running from one thing to the next, with lots of urgent issues to deal with. Unfortunately, things like carbon reduction can sometimes get pushed back, especially when they feel they don't have all of the expertise required to make big changes. Here's where an ESCO can provide the solutions."

"On the other side, however, because these contracts can be quite complex, even institutions that could benefit from working with an ESCO can be hesitant," said Dautremont-Smith. This is where hiring a full-time sustainability officer can help, according to Dautremont-Smith.

TRC's Henrikson points out that ESCOs, consulting engineers and other firms that bring energy saving technical and financial solutions will have new opportunities with California's colleges and universities as these institutions prepare to accomplish the steeper energy efficiency requirements enacted in 2015.

"As result of California's SB350, the energy efficiency savings goals for 2030 were doubled," said Henrikson. "The statewide college and university partnership programs administered by the investor owned utilities will continue to be an important contributor to the energy savings needed to achieve these aggressive goals."

And not only private firms are in the mix. Nonprofit Sustainable Energy Innovations (SEI) offers energy and sustainability advisory services, including its ClimateCorps and Energize Colleges programs, which train students and recent graduates to assist with energy transformation in higher education and the broader community. "We leverage students and recent graduates to be the technical, on-the-ground implementers for planning and upgrade projects for institution that don't have the staff capacity or expertise to be doing this work on their own and don't have the wherewithal to attract an ESCO."

"We're in the process of expanding our ClimateCorps from 40 fellows in the Bay Area to more than 50 statewide," said Miller.

Engaging students, faculty

As highlighted below, energy consultants and vendors are offering education and PR measures as part of their value proposition for colleges. And students and recent graduates who engage in transitioning their schools to low-carbon, clean energy institutions also get real-world training that benefits themselves as well as the institutions. With the goal of career development in mind, SEI places ClimateCorps fellows at private firms as well as with academic and public agency partners.

Connecticut Microgrid Award Winners

ROUND 1			
Project	**Facilities**	**Generation**	**Grant Amount**
UConn Depot Campus/Storrs	Campus buildings	400 kW fuel cell, 6.6 kW PV	$2,144,234
City of Bridgeport-City Hall/Bridgeport	City hall, police station, senior center	(3) 600 kW natural gas microtrubines	$2,975,000
Wesleyan/Middletown	Campus, athletic center (public shelter)	(1) 2.4 MW and (1) 676 kW natural gas CHP reciprocating engine	$693,819
University of Hartford-St. Francis/Hartford	Dorms, campus center, operation building	1.9 MW diesel (existing), 250 kW diesel, 150 kW diesel	$2,270,333
SUBASE/Groton	Various buildings and piers	5 MW cogen turbine, 1.5 MW diesel	$3,000,000
Town of Windham/Windham	2 schools (various public purposes)	130 kW natural gas, 250 kW solar, 200 kWh battery; (2) kW diesel	$639,950
Town of Woodbridge/Woodbridge	Police stations, fire station, Dept. of Public Works, Town Hall, high school, library	1.6 MW natural gas, 400 kW fuel cell	$3,000,000
City of Hartford-Parkville Cluster/Hartford	School, senior center, library, supermarket, gas station	600 kW natural gas	$2,063,000
Town of Fairfield-Public Safety/Fairfield	Police station, emergency operations center, cell tower, fire HQ, shelter	50 kW natural gas recip. engine, 250 kW natural gas recip. engine, 47 kW PV	$1,167,659
ROUND 2			
City of Milford	Parsons complex, middle school, senior center, senior apartments, city hall	(2) 148kW natural gas CHP units, 120KW PV, 100kW battery storage	$2,909,341
University of Bridgeport	Dining hall, rec center, student center, 2 res buildings as shelters, police station	1.4 MW fuel cell	$2,180,898

Source: Clean Energy Group

"We have fellows working at SunPower and Optony in roles ranging from technical research and design to training and outreach," said SEI's Executive Director Cyane Dandridge. "These and other private companies are seeing the value of a turnkey, low-risk model for trying out new talent."

Solar power project developers, ESCOs and solar PV EPC firms are getting more sophisticated at helping education clients integrate PV projects with curricula and public relations. **Ameresco**, for instance, offers custom solar dashboards that can be "fully branded and customized to reach specific audiences." Projects highlighted on the ESCO's website include Arizona State University's Campus Metabolism web dashboard, which tracks energy uses and sources in real time.

In addition to branded and standard dashboards, Ameresco also offers kiosks displays for lobbies, K-12 solar curriculum materials and professional staff to appear in schools and at public events to explain "how your [solar PV] system was developed and how much energy it is expected to generate."

Transport solutions slow to develop

Cutting the emissions associated with commuting trips to and from schools is one of the thorniest problems for folks in higher ed who are charged with meeting net-zero GHG pledges. Campus fleets can be transitioned to electricity and other alternative fuels, but making students and faculty drive clean-fueled vehicles—or ditch their cars in favor of feet, bicycles or transit—is a challenge of a different order.

"Student and staff commuting patterns is an area where we see significant focus and support is needed," said SEI's Miller. "One of our fellows, a recent graduate, supported **Skyline College** in San Bruno, where students and staff have very few options for public transit, to study transportation patterns and recommend alternative commuting strategies. These will probably include expanded transit service, which the college community will have to campaign for with local transit authorities.

Colleges routinely offer discounts on transit passes, encourage bicycling and walking and promote ride-sharing services like **ZimRide**—but campus sustainability experts agree that transport GHGs are high-hanging fruit for which effective harvesting strategies still need to be developed.

Over the next five to 10 years, as new solutions to transport GHGs emerge, colleges and universities will no doubt be in the forefront of developing and adopting cutting-edge solutions. ☼

Consultants and vendors are offering education and PR measures as part of their value proposition for colleges.

Climate & Energy Services Vendors in Higher Ed

Consulting / Planning / Financing

AEI / Affiliated Engineers, Inc
Altenex
Ameresco
Brendle Group
Buildpulse
Celtic Energy
Class 5 Energy
CustomerFirst Renewables
EcoMotion
Energy Solutions Professionals
Energy Systems Group (ESG)
Fovea
GreenerU
Green Building Services
Optony Inc.
RideLinks, Inc.
SAIC
Schneider Electric
Sightlines
Texas Solar Resources, Inc.

Energy Conservation

Carbon Cash
Fovea

RECs / Offsets

Altenex
Carbonless Community
Clean Currents

Renewable Energy Systems

CarrierClass Green Infrastructure
Clean Currents
Coupus
Customer First Renewables
DC Solar Freedom
EcoMotion
PowerMyCampus
Springboard Biodiesel

Source: Association for the Advancement of Sustainability in Higher Education, Business Member Product & Service Directory

Humboldt State University Embarks on Long Journey to Zero Carbon

To reach carbon neutrality, HSU will have to kick natural gas

Nestled in the redwood covered hills in a remote corner of Northwest California, **Humboldt State University** is justifiably proud of its track record of environmental sustainability. The campus houses a pioneering energy research center, is home to a demonstration residence with composting toilets and boasts a long history of producing graduates who lead energy and sustainability projects regionally and nationwide.

Solar panels have sprouted on some college buildings, and all construction and renovation is done in line with California's strictest-in-the-nation energy codes. Still the campus of 8,800 students has a long way to go to cut GHGs 80% (over 1990 levels) by 2040, as required of all CSUs, and meet the 2050 net-zero carbon goal its President Lisa Rossbacher committed to in January 2016. Its building stock is among the oldest in the California State University system, and it lacks the financial resources of many of California's iconic green campuses, such as University of California, Davis, California State University, Northridge, and Stanford University.

Last fall, with a fresh inventory of all three scopes of emissions in hand, HSU's Sustainability and Waste Coordinator Morgan King convened four working groups—energy and utilities; transport; waste, purchasing and food; and curriculum and research—to come up with climate action strategies.

The groups built on an initial list of strategies that the campus had already begun to implement, including energy efficiency projects sponsored by student fees collected for a Humboldt Energy Independence Fund.

They researched other colleges' GHG strategies and integrated data from their facilities managers to come up with a list of 62 strategies for cutting GHGs. At CCBJ's deadline, the HSU teams were refining their cost-benefit analyses and preparing a final draft of their climate action plan. But King reported that, in the early years, many strategies can be accomplished without major investment, including:

- Contracting for a cleaner electricity mix from its current provider, Shell North America, or finding new power sources with lower emissions factors when its contract with Shell expires.
- Tweaking course schedules so after-hours and summer programs can be consolidated into a few buildings.
- Incentivizing transit use, car-pooling, biking and walking instead of solo trips by private vehicles.
- Requiring double-sided copying.
- Tinkering with its existing CHP facility to make optimum use of waste heat.
- Upgrading lighting to LED fixtures.

To reach its more ambitious long-term targets, deeper energy retrofits and a complete transition to carbon-free electric power and heat will be needed at the campus. Said King: "To reach carbon neutrality, we're really going to have to kick natural gas which now accounts for about one-third of our total emissions, including scopes 1, 2 and 3."

King and his team have their hands full implementing near-term upgrades and projects like those outlined above. But with help from the campus's Environmental Resources Engineering faculty and its Schatz Energy Research Center, they are also looking farther ahead. "We've looked at multi-split airsource heat pumps for heating," he said.

Located on the windy, foggy northwest coast, the campus doesn't need AC. King and his colleagues recognize that may change, but instead of buying new cooling

equipment, they plan to rely on enhancing passive ventilation. An interesting quirk of the university's electricity purchases is the fact that Shell, while required to comply with the state renewable energy mandates, doesn't have to disclose its mix of conventional sources, according to King. So HSU could only estimate its emissions factors for purchased electricity.

The local investor-owned utility, **Pacific Gas & Electric**, reports its power mix, and King and his advisors think it's probably cleaner than Shell's—but since Shell doesn't disclose, they can't be sure. "When our contract with Shell comes up for renewal, we may request a greener mix or decide to go with PG&E or a new Community Choice Aggregation provider that local governments are seeking to create," he said.

Aiming at long-term carbon neutrality, HSU might eventually expand the campus's district energy system and convert it from gas-fired central stations to something like the separate heat and power/combined heating and cooling system that Stanford University has implemented. Although the college community is aware of Stanford's projet, it's something the university hasn't studied yet, according to King.

PV not a priority (for now) due to costs

HSU has one 10 kW PV array—relatively large when it was bolted onto a campus roof back in 2008, the system is tiny in today's market, where universities and other institutions routinely install systems in the hundreds of kilowatts.

King and his team aren't in a hurry to recommend investing in new solar PV arrays because of the costs. "We really want to achieve emissions reductions at the lowest cost per ton, so solar is not the top priority," he said.

For long-term net-zero carbon goals, however, more PV is inevitable; and when the time comes, panels will almost certainly be installed by a private sector third party that can monetize the tax credits and will sell energy to the campus through a power-purchase agreement (PPA), according to King.

Getting a large proportion of energy from solar PV will inevitably bring up the need for battery or thermal energy storage, but studying such things in detail will wait, according to King. With a big chunk of its emissions from commuting, HSU has to work on getting students and staff to kick the driving habit.

But like other colleges (see main story), HSU hasn't developed a winning strategy for this. The campus is on a hill and located in a region that averages 36 to 40 inches of rainfall. King suspects that this topography and weather are disincentives for many students and staff to leave their cars at home; indeed, many already complain about lack of parking. Like other campuses, reducing transport GHGs associated with commuting will be one of the college's toughest long-term obstacles for meeting net-zero GHG goals.

"We're looking at increasing the number of electric vehicles in our campus fleet and also looking at renewable diesel," he said.

The university's food services division already implements LeanPath and other systems to reduce over-purchasing of food, according to King. And thanks to student activists, the university has joined the Real Food Challenge, that aims for 20% of food provided on campus to be "local, fair, ecologically sound, and humanely produced," according to an HSU news release.

But before it can claim GHG reductions associated with these changes, complex lifecycle analyses on existing food purchases must be performed. And here, students again are engaged in the process. "The Real Food Challenge requires students to conduct the analyses, and they have already gone far with it," said King. ☼

van Zelm Pushes the Boundaries of Sustainable Design, Clean Microgrids

With about 100 employees, **van Zelm Engineers** is a small firm that has built a high-profile reputation in the Northeast and Mid-Atlantic for the design and engineering of highly energy-efficient buildings, particularly for colleges and universities. The firm has recently worked on leading-edge clean energy and microgrid projects. "It's somewhat unusual for a firm of our size to do the kinds of high-end sustainable design work we do," said Vice President David Madigan.

Academic Science buildings have been a specialty for more than 10 years, and the firm has some landmark projects to its credit, including **Dartmouth University**'s Life Sciences Center, which won LEED Platinum certification in 2012.

The 175,000 sf building includes dedicated outdoor air systems, chilled beams in all laboratories, heat recovery using high-efficiency enthalpy wheels, active air quality monitoring for airflow reset, condenser water domestic hot water heating and other features. "This was one of the first LEED platinum science buildings of that scale," said Madigan—and it achieved that status without additional funding. "It shows you can get to LEED Platinum with good engineering and good collaboration among the design team," which included the architectural firms of **Bohlin Cywinski Jackson** and **Atelier Ten**, Marc Rosenbaum, as well as sustainable design consultants and the active collaboration of Dartmouth staff.

van Zelm built on its Dartmouth reputation—burnished by the fact that actual energy use closely mirrored the models—to win other high-performance science building projects for campuses including **Harvard**, **Tufts** and Amherst. In 2013, Tufts commissioned a "high level

utility/energy master plan" from van Zelm, according to the university's sustainability report. The project resulted in the development of a new campus energy plant which included a 4 MW cogeneration system, along with boilers, chillers and a new campus electrical service—in part to accommodate load increases from a new science and engineering center.

"The most exciting time"

The Tufts project brought in van Zelm's power and utility experts, a team that has seen growing demand for advanced microgrids in the northeast, according to Madigan's colleague Joe Camean, VP and director of Power and Utility engineering. "This is the most exciting time in my professional career, and I've been in the electric power game for 40 years," said Camean.

Camean and Madigan say that a confluence of campus energy and climate commitments, the imperative to become more resilient in the aftermath of Hurricane Sandy and state policies in New York and Connecticut are creating demand for projects that were unimaginable even five years ago.

In New York, the Reforming the Energy Vision (REV) regulatory proceedings are shaping an overhaul to the existing electric utility model to enable growth of distributed energy resources (DERs), while the state's renewable energy and Greenhouse Gas (GHG) goals are providing incentives like renewable energy credits (RECs) and funding from programs like NYSERDA's Clean Energy Fund.

Winning the prize, combining mitigation and adaptation

And that's just on the energy and GHG mitigation side. On the resilience side, The $40 million New York Prize for local power infrastructure drew 83 proposals which have been winnowed down to 13. van Zelm is working with developer Gotham360 on a short-listed project for a microgrid network of four healthcare facilities in the East Bronx. It will leverage existing steam generation plants to create a microgrid that may include "combustion turbines, photovotaics (PV) arrays, battery systems, steam turbine generators, heat recovery steam generators, etc., to provide on-site generation for local loads in both grid-tied and islanded modes of operation," according to a project sheet from Gotham360.

In Connecticut, the Department of Energy and Environmental Protection (DEEP) is funding advanced renewable energy and microgrid projects. "Connecticut has been ahead of the curve in allowing town centers to develop microgrids," said Camean, who lives in the state. "One of our larger towns has established the capability to run a sheltering facility, and in October snowstorms last year, it was used during three intervals of almost a week when many residents lacked power."

A microgrid project for the Parkville neighborhood of Hartford will see **Constellation** deploying **Bloom Energy** fuels cells to create a 800 kW microgrid designed to power an elementary school, library, senior center, health center, grocery store and gas station. During grid operation, the microgrid will offset energy costs for four local schools. Part of making these economics work, according to a Constellation news release, is the fact that the project will produce RECs needed by regulated electricity suppliers to meet the state's renewable energy mandates.

Camean, whose firm did preliminary engineering work on the Parkville project, highlighted the importance of including a grocery store and gas station in the microgrid system. "When you lose the grid, people can't get food or fuel," said Camean.

PV and batteries for resilience

Camean says he and his colleagues are trying to encourage local governments and institutions to incorporate PV and batteries in microgrids whenever possible for greater energy diversity and resilience. "One of the projects we're putting together now is looking to set up a PV microgrid with 20 megawatt capability with batteries to keep a town center operating" in power outages.

"We're looking at all the options for battery technology," said Camean. "The two that seem to be the most in play are lithium-ion and sodium sulphur. We're looking for providers that have enough bench depth of experience and can warrant their technology for 20 years. I've had vendors tell me, 'it has a 15-year life but they'll only warranty it for 10 years.' In truth, nobody has been doing this technology long enough to really know how long these systems will last."

In addition to reducing fossil fuel emissions, other reasons for the incorporation of PV and batteries are energy diversity and resilience, according to Camean. "A lot of the backup generators rely on diesel," said Camean; and as Sandy demonstrated, a severe storm can quickly disrupt fuel logistics.

Even natural gas compression stations could be disrupted by floods, ice storms, hurricanes and other extreme weather events, leaving the reciprocating engines, turbines, fuel cells and other generators high and dry. "PV arrays with batteries for storage could get you through when other supplies are not available," said Camean.

"If a building is in a high-density urban area of New York City, trying to incorporate PV is a challenge," said Camean. "We primarily do a lot of combined heat and power plants in high density areas, but we're starting to learn how to squeeze in PV."

"Each project we try to take to the next level," said Madigan. "We know what we did on previous jobs. We know what did work well, and what didn't work well."

As it pushes the edge of innovation for its higher ed clients, van Zelm has paid close attention to **Stanford University**'s pioneering energy systems, which replaced an aging natural gas CHP and steam distribution system with a centralized heating and cooling system that recovers heat from ventilation stacks, uses onsite and offsite PV and stores thermal energy to mitigate peaks demands for cooling.

At least one higher ed client in the Northeast is examining a similar system, but Madigan declined to name the client because planning is in the early stages, and final decisions have yet to be made.

He did, however, share that the college sought to replace an aging oil-fired central steam plant and hired a European design firm and van Zelm to study the feasibility of converting to a low-temperature hot water system and "installing large scale heat pump chiller/heaters as was done at Stanford," according to Madigan.

Also in the feasibility mix: using sustainably harvested wood chips to drive an Organic Rankine Cycle biomass power plant—one that uses working fluids other than water to improve cycle efficiency—for electricity and district heating; as well as several MW of solar PV capacity. "The idea is that the biomass boiler(s) and heat pump chillers would handle thermal requirements, while the ORC cogen would pick up 20% to 30% of the electrical demand with the balance made up by PV," said Madigan, adding: "There's also the potential that they'll be incorporating large-scale battery storage systems."

What works, what doesn't

Madigan wasn't shy about telling CCBJ that advanced heating and cooling technologies have sometimes needed refinement and fine tuning. "We're doing a lot of work with radiant cooling, which requires that the air be dehumidified to below the dew point of the chilled water that's being circulated in the floors or ceilings," said Madigan. "In some early projects, we found that you really do need to control the volume of dehumidified air properly both to control humidity and prevent overcooling. As a result, we've gotten better at control strategies."

A lecture hall fitted out with a combination of radiant cooling and displacement ventilation at the Dartmouth Life Sciences building needed modification of control strategies because of its location at the campus's periphery: "Students would arrive hot from walking or jogging there," said Madigan. "Because the displacement ventilation system responded to CO2, there was some overheating in the space until we could modify the control strategies to respond more quickly based on occupancy."

One client considers a Stanford-style system augmented by an ORC biomass plant.

As mentioned in the higher ed feature story in this issue, Madigan observes that serious resilience planning and investment hasn't yet taken hold at most Northeastern colleges and universities. "They want to be leaders in sustainable design, but the focus on the resilience side has varied considerably from institution to institution."

One exception is the new Science and Engineering Complex for Harvard University. Built in the Allston neighborhood of Boston—on the opposite side of the Charles River from Harvard's main Cambridge campus—the facility will be the centerpiece of a massive new campus area Harvard expects to build out over the next couple decades.

"In addition to a great deal of innovative design technology in the building, the university is very concerned about backup and standby power for resiliency and flood protection since it will be close to the Charles River," said Madigan.

The project was originally designed with a new CHP and chiller plant to be housed 40 feet below grade, according to Madigan. The 2008 financial crisis derailed the project for a few years, but when the university renewed the design and engineering work, resiliency concerns had become more prominent.

"Even though the below-grade space for the energy plant was already developed, as the University got more and more into resilience thinking, they decided they shouldn't locate such valuable assets below grade, and would instead build a new stand-alone energy plant," said Madigan.

"Additionally, all the main building spaces will be above the 100-year floodplain and the entire building will be protected by a berm around the perimeter of the site," said Madigan. "There will be no openings below grade except inside that bermed area, and there are going to be flood mitigation pumps at lower levels to handle any leak in the building or breach in the flood prevention dikes."

We're in the middle of designing all that right now, and we're about a year away from completion," said Madigan. The project team includes van Zelm as the mechanical and electrical engineer, while the architect is **Behnisch Architekten**. The landscape architect is **Stephen Stimson Associates**, and stormwater engineering is being designed by **Nitsch Engineering** (see profile of Nitsch in this issue). ☼

Healthcare Systems Prepare for Climate Change

From facility resilience to changing patient needs, hospitals and healthcare systems have a growing climate change agenda

Hospitals and healthcare systems worldwide face growing risks from extreme weather events and climate change; and at the same time, they are also facing the prospects of major changes in their patients' needs due to the spread of mosquito-borne disease, increasing heat in temperate regions, worsening air quality and other consequences of climate change.

"We're seeing hospitals and healthcare systems in almost every country recognize that climate change is a serious threat to human health and to their operations and financial viability," said Josh Karliner, director of Global Projects for **Healthcare Without Harm** (HCWH), a nonprofit that promotes environmental responsibility in hospitals and healthcare systems.

At the same time, as large organizations that are usually very energy intensive, hospitals and healthcare systems are under growing pressure to mitigate their own greenhouse gas (GHG) emissions.

It would be a stretch to say that climate change has become a primary driver of planning and investment strategies for healthcare systems—especially on the resilience side. "In developed and developing countries, healthcare is woefully unprepreprepared to adapt to climate change and become resilient," said Karliner. "We're really at the beginning."

Yet it's a growing concern, and one that is the focus of a growing number of national and international initiatives led by healthcare providers—initiatives that often include advocacy and education of populations and governments. "We're seeing healthcare providers engaged in educating the public around the health impacts of climate change and the need to transition to clean, renewable energy to protect public health," said Karliner. "And we're starting to see national ministers of health play roles in the climate policy debates in their own governments."

DFID, USAID other donors support hospitals in poor countries

Donor country aid agencies are increasing their support for climate change adaptation in developing countries' healthcare systems. Karliner cites the **Pan American Health Organization**'s smart hospitals initiative for the Caribbean—funded with about $12 million by the UK's **DFID** aid agency.

According to PAHO, "a hospital is considered 'smart' when it links structural and operational safety with green interventions, at a reasonable cost-benefit ratio." Participating smart hospitals have reinforced roofs and windows, installed rainwater-collection tanks and solar panels, improved disabled access, installed LEDs and upgraded old, inefficient air conditioners.

HCWH's Global 2020 Healthcare Challenge—which emphasizes GHG mitigation, climate change resilience and leadership and education around climate policy—has been joined by more than 80 entities, representing more than 9,000 hospitals and health centers in 23 countries—including Brazil, Chile, Colombia, Costa Rica, Ecuador, Morocco, the Phillipines and other developing countries.

CDC, HHS, CA create climate-informed decision-making tools

In the U.S., the CDC partnered with the **Association of State and Territorial Health Officials** on an Extreme Weather and Climate Readiness toolkit. And Health and Human Services produced a Sustainable and Climate Resilient Healthcare Infrastructure Toolkit and a "best practices document": Primary Protection, Enhancing Healthcare Resiliency for a Changing Climate, co-authored by Robin Guenther from **Perkins+Will** and HCWH.

Some U.S. states are funding climate change and healthcare work. For example, climate change adaptation consultancy **Four Twenty Seven** recently won a $200,000 contract with the State of California to develop a decision-support tool to help California's local public health officials better anticipate and prepare for heat waves.

> *"Everybody know the stories of what happened to certain hospitals during Katrina and Sandy, and nobody wants to be that hospital,"*
>
> *- Emile Mazzacurati, Four Twenty Seven*

"The goal is to educate non-expert users in how to use climate data, and how to understand other drivers of vulnerability from a socio-economic and demographic standpoint," said Emilie Mazzacurati, CEO.

The project builds on Four Twenty's Seven's earlier work with HCWH to create the Resilient Hospital Dashboard, an application that enables healthcare systems to identify key drivers of risk and climate impacts they're likely to face. Mazzacurati says healthcare is a specialty of her 10-person firm, representing about 20% of its business.

Arcadis tackles resilience for NYC hospitals

At the other end of the project spectrum in terms of scope and budget would be **Arcadis**'s 2013 contract to provide damage assessments, flood protection planning and sustainable design services to help the New York City Health + Hospitals (NYC H+H) survive the next hurricane or superstorm more resiliently than it did 2012's Sandy.

According to Edgar Westerhof, Arcadis's national director for flood risk and resiliency, his firm played a central role in helping the healthcare corporation secure $1.7 billion in **FEMA** funds last year. "The FEMA funding now allows us to work with individual New York hospitals like Coney Island and Bellevue, facilities that had to be evacuated during Sandy."

Private healthcare networks are also commissioning studies of climate risks. **Arup**'s Boston office announced in October 2015 that it was assessing climate risks for 30 hospitals, community health centers, clinics and research labs owned by **Partners Healthcare**. Arup's Boston office also hired a new associate principal for climate risk and resiliency, Lisa Dickson.

Partners Healthcare, a nonprofit network of hospitals and healthcare providers that had revenues of $11.7 billion in 2015, was also behind the new Spaulding Rehabilitation Hospital in Boston. Designed by Perkins + Will, the 132-bed hospital located at the water's edge in the Charlestown neighborhood incorporates deep energy-efficiency features like triple glazed windows with exterior shading, extensive daylighting, green roofs and a gas-fired CHP and other measures that yielded a LEED Gold rating.

Boston hospital built 30" above 500-year floodplain

But the facility, which was designed after Hurricane Katrina disabled hospitals in New Orleans, stands out more for the innovative ways it has been designed and configured for resilience to sea level rise, storm surges, flooding from precipitation, heat waves and other impacts of climate change. Its first floor is 30 inches above the 500-year floodplain and all mechanicals, including the CHP and a diesel backup generator, were installed either on the roof or in a penthouse, according to a report on the project by Urban Land Institute.

Building Healthcare Sector Resilience

- Do you maintain a database of extreme weather losses from past events on your campus(es), city or region?
- Have you mapped the intensity and probability of extreme weather events across all your campuses (today, 2050, 2080)?
- Have you identified the vulnerabilities and hazard exposures your community may face?
- Have you determined the degree of vulnerability and exposure to the hazard your campus or buildings may face?
- Have you assessed the impact of community vulnerabilities on patient surge and non- traditional needs the community may expect a medical facility to provide?
- Have you identified the capacities and resources available within your organization, neighborhood or community to provide redundancy?
- Have you determined the potential to mitigate extreme weather impacts through enhanced ecosystem adaptations?

Source: U.S. Climate Resilience Toolkit

High-voltage electrical service to the main transformer in the penthouse is protected in a concrete chase, and diesel fuel storage, while in the basement per fire codes, is housed in a flood-proof vault and equipped with a pump to move it to the penthouse. Windows in patient rooms can be opened with keys to avoid indoor overheating. (A USGBC article about Spaulding notes that after Katrina, indoor temperatures exceeded 100 degrees in some New Orleans hospitals, leading to staff to break them open.)

According to Partners' project manager (as quoted by USGBC), many of the features enhancing resilience in the $140 million facility would have been incorporated even without concerns about resilience, so their added costs were minimal. About $700,000 went to strictly resilience features, mostly the added costs of elevating electrical switchgear and the concrete-encased electrical cabling.

Partners and Perkins+Will estimate the energy efficiency and resilience measures will return about $500,000 a year in operating costs, enhanced reputation, reduced future losses and the availability of a resilient landscape that provides space for rehab therapy.

Along with Perkins+Will and Arup, **Mazzetti** is another planning, engineering and design firm prominent in the healthcare segment, and its CEO Walter Vernon has been increasingly vocal about the challenges and opportunities presented by climate change. At the American Society for Healthcare Engineering's March 2016 Planning, Design and Construction Summit, he presented on changing U.S. laws and regulations for climate change and dealing with airborne contaminants.

And in a blog post last year, he celebrated the **International Federation of Hospital Engineering**'s approval of its "first-ever environmental policy." IFHE recognizes that, "Global trends in disaster management indicate that catastrophic events associated with extreme weather events linked to the effects of climate change are having a considerable impact on healthcare facilities," wrote Vernon, who sits on IFHE's council.

Flooding at the top of the list

Flooding is at or near the top of many hospital's vulnerability concerns. "Everybody know the stories of what happened to certain hospitals during Katrina and Sandy, and nobody wants to be that hospital," said Mazzacurati.

Sandy highlighted the lack of preparedness at many hospitals in New York, New Jersey and Connecticut. According to a 2014 assessment by the HHS Inspector General, the majority of 172 hospitals surveyed had been cited within the prior three years for "deficiencies related to emergency preparedness and response," according to an AP story. "In many cases, the issues cited by accreditation organizations were exactly the same ones that caused problems during the storm."

Every hospital's flood risks are different based on their location and proximity to water bodies. But many in New York were vulnerable because of how near they were to the waterfront, according to Westerhof. "Many hospitals in New York are located in the proximity of New York's open water and exposed to storm surge and climate change," he said.

Developing resilience plans for New York's healthcare system began with the kind of risk assessment that Arcadis applies for any public sector client.

"We bring all available relevant data, data projections and local circumstances to the table," said Westerhof. He added that Arcadis, a platform partner for Rockefeller's 100 Resilient Cities initiative, embraces the 100RC's holistic view of resilience, which incorporates leadership and strategy; health and wellbeing; economy and society; and infrastructure and environment.

"The second step is a vulnerability analysis in which we overlay these risks with assets the client has in a certain area," said Westerhof, noting that many healthcare institutions have "a variety of buildings that have evolved over time. Then we assess the broad range of possible solutions, which can vary by location," said Westerhof.

According to Real Estate Weekly, the variety includes the challenging low-lying **Coney Island Hospital**. Slated to get $923 million of the FEMA grant, a new "critical services" building will be built to house Coney Island's ER, its imaging, pharmacy and labs—and it will be outfitted with backup generators and pumps.

HHC's **Coler Specialty Hospital** on Roosevelt Island in the East River also has unique challenges due to it being surrounded by water and located where the waters of Long Island Sound and New York Harbor come together.

According to MainStreetWire.com, Coler is receiving $181 million after getting badly damaged during Sandy to incorporate flood protection measures to protect critical parts of the campus from a 500-year flood. (Amounts cited for both hospitals include some reimbursement for repairs already made.)

Consultants also point out that a hospital or healthcare system's resilience is dependent on its community's resilience.

"Once you start looking at the physical impacts of climate change on a hospital, you quickly realize you can't just look within the walls of your facility," said Mazzacurati. "You're dependent on transportation, the electric grid and other infrastructure. One of our clients in New Jersey came through Sandy with just a little bit of roof damage, but their employees couldn't get to work because of the gasoline shortage. They were able to find a solution to provide gasoline for their employees."

"It's not just about making sure a building will stand up, it's making sure the staff can get there, that there are enough supplies to ride out a disaster, that the backup generation is going to last long enough," said Mazzacurati.

Long before Sandy and far from New York, the **Texas Medical Center** in Houston was inundated during Tropical Storm Hollister in 2001, according to Karliner's colleague Scott Slotterback, Global Green and Healthy Hospitals policy director. "Afterward, in addition to relocating essential electrical equipment from the

Air Quality Effects of Extreme Weather and Climate Change

Immediate Effects from Exposure to Extreme Weather Events	Long-term Effects of the Changing Climate
▪ Multiple exposures (e.g., urban heat island, pollen, pollution) leading to more severe negative health outcomes among vulnerable populations. ▪ Disruptions in utilities leading to temporary improvements or deterioration in outdoor air quality. ▪ Building structure flooding leading to mold growth. ▪ Exposure to carbon monoxide during power outages due to increased use of on-site generators.	▪ Increased exposure in urban areas to climate-related environmental hazards due to impaired outdoor air quality. ▪ Long-term exposure to increased outdoor air pollution leading to respiratory diseases and premature mortality. ▪ Increased incidence of impaired indoor environmental quality due to modern buildings' exclusive reliance on mechanical heating and air conditioning systems.

Source: Association of State and Territorial Health Officials, Extreme Weather & Climate Readiness

basement, they recognized that that part of the reason the river was flooding was because natural riparian habitat had been denuded with development," said Slotterback. So the hospital began a program of increase green and pervious area on its campus and "worked with their community to increase green areas upstream from the hospital as well."

Heat waves can bring health crises

Heat waves don't disrupt a hospital in the way a flood does, but they "can have high impacts on the health of the community, particularly vulnerable people," said Slotterback. "A lot of hospitals are looking at what continued high heat events will do, particularly in places that haven't experienced these very often in the past."

Mazzacurati concurred. "Our work also involves looking at how a change in heat waves over time could drive a change in demand for medical care," she said. "Heat-related health impacts of climate change are going to be among the first we see in many communities."

UK's NHS prepares for more heat, without more GHGs

Europe and the United Kingdom lost more than 50,000 people in the 2003 heat wave—and the UK's Health Protection Agency predicts a 70% rise in heat-related mortality by the 2020s (from a 2000 baseline), according to the BBC.

There's also a chance that the Gulf Stream which transports heat from the Gulf of Mexico to the north Atlantic will slow down—as it did in the last Ice Age—causing a dangerous drop in winter temperatures, according to the BBC. But the consensus forecast is that the heavily populated southern counties will have hotter summers and more intense heat waves.

According to Slotterback, the **National Health Service** is conducting heat resilience studies and looking for solutions that don't rely on increasing air conditioning capacity in NHS facilities—which would increase the NHS's scope 2 GHGs. "They recognize they need to retrofit their buildings to use more passive ventilation and mixed HVAC solutions so they can withstand high heat events and at the same time decrease their carbon emissions."

Interestingly, many older buildings—built 50 or more years ago when energy in the UK was less abundant and more costly—performed better in heat studies, according to Slotterback. "They had much more passive solutions, passive ventilation and were built with masonry that delayed the time it took for heat to penetrate from the outside."

Mazzacurati also reports that her firm's research shows that many hospitals have the opportunity to use white roofs, green roofs, porous pavement and other approaches to reduce their own contribution to urban heat island effects—and to cut their AC load and GHG emissions. "Hospitals can be real drivers in community resilience efforts, especially around local urban heat islands."

Solutions can combine resilience, GHG mitigation

As Mazzacurati points out, there are obvious synergies between GHG mitigation and resilience in a number of approaches and measures available to hospitals: improving energy efficiency, creating microgrids that use solar PV and batteries alongside diesel or gas generating units for backup power, water efficiency measures. "We always look for these kinds of co-benefits," she said.

"There's definitely a sweet spot between mitigation and adaptation," agreed Karliner. "Low-carbon healthcare systems can be more resilient systems. The ones that can function with greater energy efficiency and through using CHP are the ones that will stay operational in an extreme weather event."

Effects of Extreme Weather and Climate Change on Vector-borne and Zoonotic Disease

Immediate Effects from Exposure to Extreme Weather Events	Long-term Effects of Changing Climate
▪ Outbreaks triggered by extreme weather events and/or the resulting breakdown of services such as trash collection, standing water, etc.	▪ Vector and wildlife ranges may shift north and to higher elevations.
▪ Warmer temperatures and heavy precipitation can lead to faster development of vectors and pathogens, expanded vector ranges, and lengthened outbreak seasons.	▪ Possible increase in human-wildlife contact due to changes in natural habitat and land use configurations.
▪ Humans and wildlife are more likely to come into contact with each other during and after natural disasters.	▪ Possible increase in the emergence of new infectious diseases as a result of the faster pathogen and vector lifecycles triggered by warmer temperatures and changing patterns of precipitation.
	▪ Unintended consequences of climate change mitigation (e.g. water storage containers that may allow mosquitoes to breed close to dwellings).

Source: Association of State and Territorial Health Officials, Extreme Weather & Climate Readiness

Different equations in developing countries

Slotterback is quick to clarify that healthcare systems have different relationships to onsite power resources in many developing countries. "In Nepal, we're working with a series of hospitals and health centers that are powered by solar and backup batteries," he said. "Part of their motivation to do that was that the grid wasn't reliable in normal conditions, and with extreme weather, the grid is even more stressed."

"If hospitals and health centers can become solar powered with battery backup, that enables them to disconnect from the grid when there's an outage in normal operations, and it makes them more resilient when they have an emergency situation." In most cases, the Nepali hospitals also have diesel generators. But overall, their power needs are so much lower than a typical western hospital that solar panels can provide a significant portion of their energy needs.

Driving the climate change conversation

Summing up, HCWH's Josh Karliner remarked on the potential for healthcare to influence markets around climate change. "Globally healthcare is between 8 percent and 10 percent of GDP, in the U.S. it's about 18 percent," he said.

"Healthcare can be a driver of sustainability in the supply chain and it can be a driver of markets," he said. "As healthcare starts to address climate change, it can have a significant impact on what's produced and consumed within hospitals and health systems but also beyond the hospitals' walls." ☼

Johnson Controls Offers Much More than Controls and HVAC Equipment

Firm's sustainability leader says institutional energy markets are being transformed by technology and policy

Clay Nesler, **Johnson Controls**' vice president for global energy and sustainability for its Building Efficiency business, describes a dynamic and rapidly evolving market for energy management and resiliency services and products among institutions. Nesler says energy management controls and software are empowering institutions to accomplish their increasingly ambitious clean energy and greenhouse gas (GHG) reduction goals. At the same time, technology and business models for distributed energy resources (DERs) are becoming more sophisticated, while utility decentralization prospects hold out the possibility of additional revenue streams for many institutions.

Resilience became an important market driver for institutions like hospitals and colleges after Hurricane Sandy in 2012, giving Johnson Controls an opportunity to add new value to its performance contracts. "We believe performance contracting is an interesting way to be able to invest in not just energy efficiency and renewable energy but also the infrastructure for facilities to be more resilient," said Nesler. "While the resiliency aspects may not have as short a payback as LED lighting or other improvements we'd make to improve energy efficiency, certainly there's tremendous value to the community."

Recalling that in his youth, K-12 schools were viewed as shelters or sources of aid during emergencies, Nesler told CCBJ that after Hurricane Sandy, "a lot of people on the East Coast actually thought to go to their local schools." But most schools had lost power, just like their communities—a rude surprise to many school leaders with solar PV systems who expected these would provide some electricity.

"For the lack of a transfer switch and some dedicated circuits for critical loads, these schools couldn't operate in an island mode," said Nesler. "Ideally, they also would have had some battery storage to store energy during the day to use at night. But had they been able to use their solar PV during the day, they would have been able to heat or cool critical areas, refrigerate food and medicines and do things like charge cellphones."

Hindsight is always 20-20, as the saying goes. "The work done through energy savings performance contracts could have provided additional benefits to these organizations," said Nesler. "The opportunity is to use some of the energy cost savings to pay for infrastructure upgrades which improve facility resiliency.

Resilience becomes a major driver

The resilience driver has heightened the interest of K-12 schools, colleges, hospitals and other institutions in onsite generation and microgrids that can go into island mode and use combinations of gas-fired cogeneration, solar PV and batteries to keep running during an outage—or at least powering critical loads, as Nesler describes.

"Particularly on the East Coast, we have a lot of interest in microgrids," said Nesler. "It's driven by efforts to increase resiliency, but also by the changing utility regulatory landscape. That's driving a lot of interest in and exploration of being able to provide energy services to customers and to utilities with grid services."

The trend toward using DERs has exploded in recent years thanks to declining costs of solar PV, federal tax credits, new battery offerings and the third-party PPA and PV leasing business models.

Nesler observes that state initiatives to decentralize utility business models, especially the REV proceedings in New York,

are poised to deliver a powerful surge to this market. "In the future, as energy becomes more distributed and as buildings, institutional and other, no longer just consume energy but also produce it, there will be a lot of opportunity to monetize additional capabilities," said Nesler.

Nesler even predicts that K-12 school districts will someday start coordinating the control of their loads and aggregating the impact to provide ancillary services like frequency regulation and spinning reserves to regional grid operators and utilities. "These institutions can then be compensated for the value they bring to the grid, in addition to receiving the benefits from greater resilience and energy efficiency."

"Some of the district energy customers we work with are already providing grid regulation services to PJM," said Nesler. "They use ice storage or chilled water and have the ability to ramp up and down the variable speed drives on their pumps to provide frequency regulation. … There's a lot of opportunity to use infrastructure and installations that are primarily there to provide energy efficiency to also provide services to the grid."

"We're aligning our business around not just energy efficiency, greenhouse gas mitigation, and sustainability, but also addressing customers who are increasingly interested in distributed energy resources," said Nesler.

"I don't have exact numbers, but anecdotally we see that about 30 percent of our performance contract projects across the country include a renewable or distributed energy resource component. I'm not surprised at all by that."

DERs growing in JCI's business

Indeed, on its website, Johnson Controls highlights Distributed Energy Storage alongside Buildings, Batteries and Automotive Seating as its most prominent business lines (Lead-acid automotive batteries is a long-standing business line for the company). In 2015, a year in which the company saw its revenues decline by 4% to $37.2 billion due to the strong dollar and weakness in its Automotive Experience business, JCI's Building Efficiency revenues gained $856 million and its Power Solutions business increased by $408 million, according to the company's 2015 annual report.

> *"We're aligning our business around not just energy efficiency, greenhouse gas mitigation, and sustainability, but also distributed energy resources"*

Sixty-five percent of Building Efficiency's sales were in HVAC products and control systems for new construction and retrofit and 35% were from "service offerings," which aren't further detailed but include JCI's ESCO performance contracting business. To capture savings and value streams in the decentralizing energy markets, Nesler emphasized the growing importance of control systems and his firm's engagement in designing energy systems.

"At one level we provide HVAC equipment, controls and components into construction and renovation projects, but increasingly we're helping our more sophisticated institutional customers do upfront design and optimization of their energy systems," said Nesler. "We're providing design optimization services where we act as consultants and advisors."

In the higher education space, one of the company's key customers is **Stanford University**, with whom it co-developed the Energy Optimization Solution (EOS), a predictive cost optimization software program that enables Stanford to leverage its new thermal energy storage resources and advanced controls to operate in California's wholesale electricity market (where it won a rare direct access status in 2010 via lottery).

"EOS is an application for central plants that makes decisions for the economically optimum dispatching resources," said Nesler. "Some of the technology we've developed for the Stanford project is exactly the kind of technology you'd extend to microgrids and other facilities that might use electricity storage in addition to thermal storage to bring on, or dispatch, distributed energy resources at the right times."

"Predicting the tariffs, weather conditions and thermal loads in buildings allows you to make these kinds of decisions," said Nesler. "Increasingly, the grid will rely on the aggregation of these kinds of capabilities."

"We're very proud of that project," said Nesler about the $485 million Stanford Energy System Innovations (SESI) project, which replaced the campus's aging gas-fired CHP plant with a new centralized heating and cooling facility—and 20 miles of new piping to convert its district energy system from steam to hot water. In addition to EOS, Johnson Controls supplied its York brand heat recovery chillers and equipment for SESI.

Stanford's model not just for rich CA schools

As discussed in the feature story on colleges and universities in this issue, campus sustainability leaders and consulting firms have differing opinions on how widely Stanford's model—also known as separate heat and power/combined heating and cooling, or SHP/CHC—can be applied to other colleges that are considering repowering older CHP systems or developing new onsite generation and district energy models.

Stanford's Joe Stagner, head of the university's Sustainability and Energy Management Department and the pri-

mary champion and designer of SESI, has become something of a missionary for SHP/CHC, saying that other institutions should consider it rather than locking themselves into consuming natural gas onsite for decades.

Stagner told CCBJ in 2014 that he'd done back-of-the-envelope calcs based on some proposed CHPs at campuses in the Midwest that showed the SHP/CHC would produce lower GHGs. But higher ed sustainability specialists and consulting engineers CCBJ has spoken with laud Stanford SESI as a great leadership project but a model that's hard to replicate because few regions have the climatic characteristics of Palo Alto, Calif. "Try keeping your buildings warm with that technology when it's minus 20," scoffed one consultant when asked.

Nesler is more optimistic about the potential for its central energy facility to spread. "Every system is going to be different, needing different amounts of heating and cooling at different times and different places on their campus depending on where they are in the country and the design and configuration of their facilities," he said.

Nesler acknowledges Stanford's large investment to make such a radical overhaul of a traditional gas CHP district heating system possible, but he points out that Stanford estimates SESI will save hundreds of millions in energy costs over its lifetime. And he expects to see other campuses adopt it.

"We're getting a lot of interest in central heating and cooling systems by large institutions including universities," he said. "We're helping them go through the process of evaluating the benefits of these systems to their organization. This is an area where we're using our design optimization skills to understand their loads, their utilities tariffs and to come up with optimal designs that can meet both their environmental and financial criteria."

"I can say that many of these are not in the temperate climate of the San Francisco Bay Area," he said. "I would not view the Stanford type of system as being limited to a given climate region."

Importance of water savings growing

A significant additional benefit for Stanford in switching from CHP to SHP/CHC was the drastic drop in its water consumption. While the primary motivation for SESI was energy savings, it has also had significant water savings impacts as the evaporative cooling requirements of their old plant were greatly reduced.

Johnson Controls also offers a dry cooling technology known as a Thermosyphon Cooler that draws on its industrial refrigeration technology to cool thermoelectric power plants without water. "It's dry cooling done in a very efficient way," said Nesler. Subject of a demo project with the Electric Power Research Institute, the Thermosyphon Cooler should see more demand with increasing water stress in many regions of the world and new federal and state water quality regulations that prohibit once-through cooling of power plants.

Geothermal in the Midwest

Some of Johnson Controls' most ambitious energy projects with campuses have used geothermal heat pumps, which use heat pump technology and the relatively consistent subsurface temperatures of the earth to increase heating and cooling efficiency. "A great example in the Midwest is **Ball State University**, which is one of the largest geothermal heat pump projects in the world," said Nesler.

Located in Indiana which experiences both extremely cold winters and hot, humid summers, the system uses 4,100 boreholes 400' deep to draw on the earth's heat in winter and use the ground as a heat sink in summer when operating in cooling mode.

Johnson Controls' own headquarters in Milwaukee recovers heat from exhaust air and uses geothermal heat pumps supplied with heating and cooling from 272 geothermal wells, as well as solar thermal for pre-heating water and about 400 kW of solar PV. This energy system contributed to the firm's unique distinction of having four LEED Platinum certified buildings on one corporate campus.

Growth in China

A highly international company, Johnson Controls saw 54.7% of its 2015 sales occur outside the United States in 2015, with $10.7 billion in sales in Germany ($3.4 billion) and other European countries ($7.3 billion). Sales in China aren't broken out separately but reported in the firm's "other foreign" segment, which came to $7.7 billion. Nesler expects the Chinese energy management and ESCO business to grow dramatically over the next few years driven primarily by the country's climate change commitments.

"I've read a number of the INDCs [Intended Nationally Determined Contributions for GHG reduction] and China has one of the most detailed INDCs of any country," he said. "It specifically mentions that 50 percent of all new buildings in urban areas will be certified green buildings."

As discussed in CCBJ's Q1 2016 issue on post-Paris market drivers, China's national leaders have pledged to alter the country's pattern of single-use, car-dependent housing developments—an endeavor critically important to global climate change mitigation as hundreds of millions of Chinese are expected to move to cities by 2030.

"China is building the equivalent square footage of Canada every year," said Nesler. "They have lots of buildings that aren't very efficient and are ripe for upgrading as well."

Nesler says the ESCO market in China, which is served by about 5,000 ESCOs, will shift from a focus mainly on industrial manufacturing buildings—source of 80% of the ESCO market now —to include more commercial and institutional buildings.

"Currently, ESCOs in China tend to provide a single technology," said Nesler. "A customer will bring in one ESCO for their lighting retrofit, another to do heat recovery, another to do compressed air optimization. They don't tend to have ESCOs that integrate technology solutions like we do in the U.S.

To advance China's energy services market—and to enable its own greater participation in that market—Johnson Controls supports the US-China Energy Performance Contracting (EPC) working group. "The US-China EPC working group, which is led by the US State Department, US Department of Energy and China's NDRC, works to develop and demonstrate innovative market approaches where we can combine the best of the U.S. and Chinese ESCO business models.

More than "low-hanging fruit"

While the Chinese ESCO model may be quite different than the U.S. approach, there are critics of ESCOs who say that U.S. firms offer a relatively narrow value proposition, focusing on fast-payback "low-hanging fruit"—like swapping in LEDs for older lighting technology—and in the case of ESCOs tied to a manufacturer like Johnson Controls, Schneider, Honeywell and others, championing their own products.

On the last point, Johnson Controls certainly sells a lot of equipment as part of performance contracts, but Nesler says they also work with legacy equipment and control systems. "We're not only a competitor of other HVAC and controls equipment manufacturers, we're also a large customer for their equipment when we retrofit or expand a campus or other institutional facility which uses their technology."

"What is surprising to many people is that the percentage of materials such as chillers and controls on a major retrofit is often quite small," said Nesler, citing one of his firm's iconic energy retrofits, the 2010 Empire State Building retrofit, a model of integrated design and advanced smart-building energy management features. "We didn't replace the chillers, we upgraded them. We didn't install additional chillers, we upgraded windows, added insulation and helped tenants improve their lighting which reduced cooling requirements"

As for the low-hanging fruit critique, Nesler cites the average length of terms in its performance contractors: over 10 years. "If we were only interested in the low-hanging fruit our projects would have payback terms of three to five years." While commercial building developers and owners focused on real estate transactions typically look for paybacks of five years or less, Nesler says public and institutional clients are comfortable with deeper retrofits and longer term contracts. "The federal government can enter into performance contracts for 25 years. Many of our state contracts are in the 15 to 20 year range."

In a recent project for the **Hawaii Department of Transportation**, Johnson Controls has inked a $518 million, 20-year contract that will upgrade all the islands' major airports as part of its ambitious goals to cut energy from fossil fuels 70% by 2025.

"We're doing HVAC upgrades, control system upgrades," said Nesler. "The project will include 75,000 high-efficiency lighting fixtures and 9,100 solar PV panels, all of which are being financed through the energy savings over time." "If that is picking the low-hanging fruit, then we have a different definition of what that means." ☼

Highlights from Johnson Controls' 2016 Energy Efficiency Indicator Study

(More than 1200 respondents from United States, Brazil, China, Germany and India.)

- 76% of institutional organizations globally plan to increase investment in energy efficiency or renewable energy next year.
- 65% of institutional organizations globally said that increasing resilience has an extremely or very significant influence on energy investment decisions.
- 62% of all organizations globally expect to have one or more facilities able to operate off the grid in the next ten years?
- 36% of all organizations globally plan to invest in on-site renewable energy next year
- 22% of all organizations globally plan to invest in non-renewable distributed energy generation next year

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Woodard & Curran Takes on GHGs, Resilience for Campuses

Environmental consulting and operations firm **Woodard & Curran** has carved out a significant business serving institutions, particularly colleges and universities, with climate change and energy consulting, planning and engineering services.

"We've authored climate action plans for colleges and universities that have committed to net zero emissions," said Mary House, senior principal. "We've worked on implementing strategies to help colleges and universities achieve these goals through such measures as energy procurement, developing renewable energy projects, strategies involving operational controls and behavioral change."

For **University of Massachusetts Lowell**, the firm has helped advise and implement the campus's ambitious $27 million energy efficiency and renewable energy program, which is being funded by the state's Accelerated Energy Program. While **Constellation NewEnergy** is the primary vendor for renewable energy and energy conservation measures (see sidebar chart), Woodard & Curran wrote the university's climate action plan, designed and is implementing a solar canopy project and provided on-call energy consulting

In 2014, Woodard & Curran compiled and organized the data for the campus's first Sustainability Tracking, Assessment & Rating System (STARS) application and its submission to the **Princeton Review** for status as a Green Campus. And last year, House was seconded to the university for a year as its first director of a new Office of Sustainability.

In addition to projects that lower greenhouse gases (GHGs), engagements focused on resilience and adaptation have become larger parts of the firm's higher education business over the last several years, with major projects for the University of Massachusetts campuses and Connecticut State Colleges & Universities.

Woodard & Curran, which has about 900 employees and reported gross revenue of $162 million in 2015, brings a broad range of expertise in water, environmental management, energy, civil engineering and O&M to its higher ed clients. And it provides assistance with project funding, too.

Finding the money

"We have a team of people that track and monitor funding programs and inform our clients and project managers about funding opportunities," said Mary McCrann, senior planner. While much of this funding work is done on behalf of local governments, university systems have won grants with Woodard & Curran's help.

It's not uncommon for environmental consulting and engineering firms to help public sector clients with project funding efforts. As reported in CCBJ's Q1 2015 climate change consulting issue, **E2 ManageTech** has helped clients such as ports and cities raise over $10 million from EPA and other sources for clean energy and clean transport projects.

What is distinctive about Woodard & Curran's funding efforts is their expertise with colleges and universities—a class of entities for which the pool of prospective funders is smaller than it is for local governments. At **FEMA**, for example, only one of the agency's hazard mitigation funding programs, the Hazard Mitigation Grant Program (HMGP) accepts proposals from colleges and universities, according to McCrann. "Colleges and universities aren't eligible for assistance from other FEMA programs such as Pre-Disaster Mitigation and Flood Mitigation Assistance," she explained.

But McCrann and her colleagues advise colleges and universities to work with local communities on joint resilience funding strategies. "It's very wise of colleges and universities to participate when their local community is doing a hazard mitigation plan, to become a strong partner and advocate for their projects to be incorporated in the plan," she said. "Should the plan get approved by FEMA, then the municipality could apply for project funding on the institution's behalf if it meets specific benefit cost requirements."

The goal of Woodard & Curran's funding team is to have a broad perspective and cast a wide net. "We familiarize ourselves with the programs and seek to become experts in them," she said. "That's an ongoing job because funding programs periodically change their criteria and eligibility requirements. "

In terms of scope, a contract to help a higher ed or local government client with project funding can run from the initial discussions with clients about their want list of projects and how these might match potential funding, all the way through completing and submitting applications and in some cases doing the work once it is funded. Or it can be for the project funding side only, with Woodard & Curran then bidding on the funded project against other firms.

Woodard & Curran helped **Connecticut State Colleges & Universities**, apply for and obtain a FEMA HMGP grant of approximately $900,000," she said. "We partnered with them, completed the application, and are currently working on the plan development."

Resilience work gains traction

Like other consultants interviewed for this issue, House charts a trend toward investing in resilience and hazard mitigation by colleges and universities. Over the last several years, Woodard & Curran has done large multi-campus hazard mitigation plans for the University of Massachusetts (all campuses except for Amherst) and all 17 schools in the Connecticut State Colleges & Universities system.

UMass Lowell $27 Million Accelerated Energy Program

- Replacement of 26 boilers with state-of-the-art gas heating equipment;
- Lighting upgrades and retrofits;
- Campus-wide upgrades to energy-management, occupancy and comfort controls;
- More than 630 low-flow faucets, showerheads and toilets;
- Replacement or retrofit of approximately 20 chillers and air-handling units;
- 200 kW solar PV carport with electric vehicle charging stations;
- Solar thermal systems at conference center and boathouse.

Source: UMass Lowell news release

House says the firm's technical expertise in hazard mitigation dovetails nicely with its domain expertise in higher education. "We have a college and university practice working with schools every day," said House. "We understand how they're organized, what priorities they have, their capital constraints and budgeting challenges." She estimates the firm has worked for about 300 colleges and universities.

"We also have a broad perspective on hazard mitigation," she said. "Having worked closely with many municipalities, we can bring a regional perspective to a campus's broader community."

Where resilience investments complement energy and GHG goals—such as in microgrids that integrate solar PV and battery storage—House says she can draw on in-house energy experts. "We have an energy group within Woodard & Curran that I rely on. That's a differentiator for us, having all these skills under one umbrella, from the grant experts at the front end, to the planning which follows, to the engineering and implemention of strategies." ☼

Prison Greening Slowly Takes Shape

When Paul Sheldon, an author and consultant on sustainability-oriented management first started talking to prison administrators about reducing their greenhouse gases, back around 2009, he quickly learned three lessons. "If you're going to work with prisons and jails, do not mention climate change, greenhouse gases or global warming."

"What you talk about is saving money," said Sheldon, who is also a senior development consultant for **GreenPrisons.org**, an organization that works with prisons on sustainability, resource efficiency, and environmental/energy management. "Public safety and institutional security are still the number one priority. For anything else, the tail that wags the dog in all correctional institutions now is budget."

"If you look at the standard GreenPrisons.org helped write for the **American Correctional Association**, which their auditors now use to assess institutions' progress toward environmental responsibility and sustainably oriented practices, it never mentions greenhouse gases or global warming," said Sheldon.

"The only prisons or jails that do anything explicitly about greenhouse gases are those under some kind of mandate," said Sheldon. The Federal Bureau of Prisons, which incarcerates 196,000 of the nation's 1.5 million inmates, operates under the federal executive orders, which mandate GHG reductions. California, Oregon, Washington, Ohio, and other states have GHG mandates for state buildings. "Some counties have greenhouse gas mandates, including Boulder County in Colorado, and that applies to their jail."

The potential for saving money with energy efficiency, renewable energy, water efficiency, recycling and other measures has excited prison staff and leaders even in many conservative states, says Sheldon. "In Indiana, which is not known as a hotbed of environmental activism, a line officer at **Putnamville Correctional Facility** got interested in recycling. When he went to the warden, he was told, 'OK, as long as it doesn't cost anything.'"

Within a year, the facility's waste bill dropped by $140,000. With the warden's support, the same officer found online resources that helped him train inmates to sort recylables for sale. "In their second year, they generated $120,000 in income," said Sheldon. Soon the institution was putting up a wind turbine and replacing its oil-fired boiler with one that uses wood chips recycled from an onsite pallet remanufacturing operation.

Recycling earned $435k in 2015 for Ohio

As mentioned by Sheldon, Ohio is one of the U.S. states with policy direction around climate change, and this is reflected in the **Ohio Department of Rehabilitation and Corrections**' June 2012 statement announcing its sustainability goals: "There are many concerns nationwide regarding air quality, water shortages, gasoline usage, climate change, and waste management; as an agency of 49,853 offenders and 11,983 staff, this plan will not only save taxpayers' dollars, but also ensure we are doing our part to protect the environment in our surrounding communities and around the world."

Leah Morgan, head of energy conservation and sustainability for the ODRC, told CCBJ that energy efficiency, recycling, composting and other sustainability initiatives have saved the 27-prison state system more money than anything that didn't involve cutting staff.

In its 2015 annual report, ODRC credited its energy and sustainability programs with saving 6,900 MWh of electricity, 350,000 mcf of natural gas and 12 million gallons of water. "Recycling programs earned $436,272 in revenue

in FY15, which is reinvested to support other conservation programs. For example, Recycling and Conservation Funds purchased six Big Hannas: in-vessel composting systems—which, combined with food pulping technologies installed in FY14—are capable of processing and diverting over 3,200 tons of food waste from the landfill per year."

In "culture shift" inmates become trainers

In addition to saving money, the programs engage inmates in training and productive work that makes their time behind bars less tedious and sometimes leads to job opportunities after prison. "We have long-term offenders that have been trained and certified to facilitate this program," said Morgan, crediting the nonprofit **Roots of Success** outfit for providing the training and curriculum.

Two inmates have been certified as Master Trainers for Roots of Success and have even been tapped by other institutions in the state prison system to train male and female inmates and staff. "That is a new shift culturally, to have staff and inmate students sit together, learning from an inmate," said Morgan. By the end of 2015, Roots of Success training was being offered in 22 of ODRC's 27 facilities, up from 14 in 2014, according to the annual report.

In 2014, ODRC completed a $1.7 million solar space heat and hot water project at its **Ross Correctional Institution** south of Columbus. Inmates were trained to help install the system, and one, a 29-year-old serving time for attempted robbery, was offered a job by the project contractor, **PH Construction Development**.

The panels were provided by **Solar America Solutions**, and according to an AP story, the company specializes in correctional facilities and offers training to inmates based on a plumbers' apprenticeship program. Charlie Slavik, the company's marketing and sales vice president, told the AP that making "a difference in somebody's life," was an intangible reward of serving this class of customers. "There are guys that have been pounding the pavement here, who have been incarcerated for several years, who are going to have a shot at a better life when they get out," Slavik said.

Creativity in resource recovery

"We pay a lot of attention to our waste management practices," said Morgan. "We're expanding our windrow and in-vessel composting to divert waste and create compost for farmland and the institutions' garden beds. One institution was able to get rid of an entire dumpster thanks to composting and recycling, saving $35,000 a year."

According to Sheldon, some prisons get very creative with their recycling and resource recovery efforts. "In Washington State, the Department of Corrections took all its paper waste and asked a paper mill to make toilet paper from it." The use of 100% recycled material yielded paper that was more brown than white, but there was no need to meet consumer expectations in correctional facilities. "The department saves $257,000 a year which they now use to fund the Sustainability in Prisons Project, in collaboration with the Evergreen State University" said Sheldon.

Morgan reported that ODRC partnered with **Ohio State University**—which was aiming for zero waste status at its large football stadium. "Their pre-consumer food waste goes to a composting facility, but all their post-consumer recyclable materials come to one of our institutions where it's hand-sorted, bailed and sold, with the revenue coming back to our Roots of Success programs and other sustainability initiatives."

Sheldon reports that Ohio, Oregon, Washington, Indiana and other states have started requiring that energy project vendors include inmate training in their projects. "Smart institutions are including in their RFPs that there has to be an inmate training component as part of the engineering, installation and maintenance."

Still a tough sell

While Morgan reports that the sustainability programs in Ohio are strongly supported by her department's leadership, she and Sheldon are part of a small but growing cohort of people outside and within corrections systems that champion green and sustainable measures. Sheldon is quick to acknowledge they have a long way to go in making energy efficiency and sustainability important to most prison managers and staff.

> *"Our demand response participation earned us over $1 million last year."*
> *- Leah Morgan, ODRC*

"Very, very, very few people in corrections care about climate change or sustainability," said Sheldon. "Many of them don't know what climate change is and think Al Gore should be deported."

"Their primary mission is to protect public safety and institutional security," said Sheldon. "It's hard to get them interested in solar panels or wind turbines when they're constantly concerned that a riot or escape attempt is going to jump off."

"Cellphones are becoming a bigger security issue," he said. "If one gets into a prison, it can be used to order a retaliatory attack on a correctional officer. There's all kinds of really dangerous stuff going on in these institutions."

Still, successful examples are winning new converts. Sheldon recalls one southern jail manager, who learned about the money saved at Indiana's Putnamville and the Ohio institutions with recycling,

then brought the practice to his institution. "After he saw the solar project in Ohio, he put together a financing package to put solar water heating on his buildings, saving 85% of his heating bills and getting simple payback in 18 months," said Sheldon.

The **National Institute of Justice** and **National Institute of Corrections** have provided guidance, some of it written in part by Sheldon and Green Prisons. Sheldon is particularly happy with a 2011 Greening Corrections Technology Guidebook for NIJ which lays out seven steps to sustainability in corrections.

"Corrections Departments around the country are getting interested in energy efficiency because of the cost savings," said Morgan. "At the American Correctional Association conferences, there are more and more workshops about energy efficiency and sustainability."

"Every time we present, at least one person comes up to us after and says, 'I just got this sustainability thing tagged on to the end of my job title. I don't know what it is. Can you help me get started.' I'll flood their inboxes with things we've done, the policies and plans we've developed, the low-hanging fruit projects we started with," said Morgan.

Smart prisons align incentives

According to Sheldon, state budgeting practices have proven a disincentive to investment in solar thermal, other renewable energy technologies and even energy efficiency. "When a prison saves energy, the savings by default go into the general fund, so they don't have much incentive," said Sheldon.

"Fortunately, smart correctional managers in Colorado, Ohio, Oregon, Washington, New Mexico and elsewhere are setting aside one-third or one-half of the money saved on resource efficiency projects and giving it back to the institutions."

ESCO business is large, complex

Prisons are a major customer class for energy service companies (ESCOs). Sheldon highlighted Johnson Controls, Noresco and Energy Systems Group (which acquired Chevron Energy Solutions in 2014) as being active in the corrections space, among many others. "The projects can be very large, from $5 million to $25 million," he said. "Some are in solar water heating, some are in more traditional energy efficiency and computerized energy management systems. A few places like Massachusetts and Indiana are doing biomass boilers, but most of those projects have been sidelined in recent years by cheap natural gas."

"The Feds have installed quite a bit of geothermal [well fields for HVAC systems] at Leavenworth and other places, but it didn't go as well as they'd hoped," said Sheldon. "A number of Federal institutions that put in geothermal systems said the payback wasn't as fast as they wanted."

Ohio's Morgan reported in May 2016 that her agency had two major energy service performance contracts (ESPCs) underway and was finalizing a third for a facility with its own well water and wastewater treatment system. "The Ohio Facilities Construction Commission manages large capital projects over $1.5 million," she explained. "That agency also has the legislative authority to take on the performance contracting debt."

One ESPC achieved "tremendous" water savings after the ESCO contractor, **Brewer-Garrett**, identified leaking water lines as the culprit in overuse of water. "The savings from that alone were so great it allowed them to offset the costs of other components of the project," said Morgan.

ESCOs and ODRC have looked at combined heat and power projects, but so far, none have been in the money, according to Morgan. "We've looked at CHP a couple times in proposals for performance contracts, but so far it hasn't been able to meet our 10-year payback period."

EE Assessments ID smaller opportunities

While the largest projects need ESCO financing and implementation, there are plenty of energy efficiency projects that an institution can do on its own. "We need performance contracts for the largest projects, but they take a long time to get up and running," said Morgan. "In the meantime we push other energy efficiency opportunities."

Most of the retrofit opportunities are identified by institutional staff. "A maintenance superintendent will say, 'We need to upgrade this section to LEDs.'"

"We also do energy efficiency assessments as part of our annual sustainability audits," said Morgan. "They're not super sophisticated but they require us to identify whether we've done LED upgrades everywhere, what the facility's annual electricity, natural gas and water usage is, what we've done in the last year, what we expect to do next year."

"We'll look at those from our central office and identify projects. Then we'll put out an RFP for the supplies or projects." Lighting upgrades are the largest category of retrofits. "We've also had some really good returns on boiler replacements," said Morgan, adding that budget constraints require that boilers only be upgraded when they're approaching the end of their useful life.

ODRC uses discretionary loads to participate in regional demand response programs, working through **KOREnergy** for most of its facilities and with **EnerNOC** for one. "Our demand response participation earned us over $1 million last year." ☼

Nitsch Engineering Tackles Stormwater, Flooding for Insitutional Clients

For the Boston-based consulting engineering firm **Nitsch Engineering**, resilience to climate change has grown from being a fringe issue to a core concern for its public and institutional clients. "Four or five years ago, this topic came up once a week," said Scott Turner, director of planning. "Now it comes up multiple times a day and has become more and more a part of our business model, more and more relevant in our markets."

And for the climate change adaptation and resilience market, it's relevant to note that this 100-person firm has no climate change scientists on staff, relying on engineers and planners with strong expertise in sustainable design. "We rely on **FEMA**, we rely on **NOAA** and we keep current with the growing number of studies that are published," said Turner.

Sustainable stormwater management is one of the firm's top specialties, and it has been designing green infrastructure—approaches that use natural features like permeable pavements, green roofs and bioswales to allow stormwater infiltration onsite—for colleges and universities for about 20 years.

Interest by local governments in green infrastructure for stormwater management is growing, too, driven in many cases by water quality problems caused by combined sewer overflows. Many governments have amended or are amending stormwater regulations to require new developments to manage more stormwater onsite; and they're integrating green infrastructure in public spaces.

But as covered in CCBJ's Q4 2015 local government issue, most property owners have little incentive to build new green infrastructure, and stormwater credit programs like those in Philadelphia and DC have performed poorly due to low stormwater rates.

Colleges and universities are often ahead of local governments in implementing green infrastructure because "they have stronger mandates for sustainability than cities and towns do," said Turner. "That's driven by the fact that their clients, the students, want their campuses to be more sustainable."

Colleges can lead communities on green infrastructure

And this often makes them leaders by example in their communities, according to Turner's colleague Nicole Holmes, a project manager specializing in green infrastructure planning. "They're more willing to do these pilot and demonstration projects that make the municipalities happy but also help them meet the demands of their students and donors," said Holmes. "Their campuses become more beautiful and the projects serve to educate students and the community about how this approach can work."

Nitsch has worked on some iconic projects in higher ed, including **Harvard**'s new Science and Engineering Complex, which is being designed to withstand 100-year floods from the Charles River (see **van Zelm Engineers** profile in this issue) and innovative stormwater work with the **University of Virginia**, **Yale** and **Princeton**.

At Princeton, which famously went through Hurricane Sandy with only a 20-minute outage thanks to its gas turbined powered microgrid (and thanks to PSE&G, which restored power long enough for Princeton to start its turbine, according to the university), Nitsch is part of a team working on broader resilience considerations.

"Princeton wants to think about flooding in the adjacent lake and river systems," said Holmes. "All the roads to the campus go through low ground, so part of managing their vulnerability to flooding is making sure they can safely evacuate the campus if they need to." The team for Princeton 2026 is headed by Toronto-based urban design and planning consultancy **Urban Strategies**.

Nitsch frequently participates in sustainability and resilience design competitions and charrettes organized by trade associations and groups like the **Urban Land Institute**.

For ULI's Urban Implications of Living with Water charrettes, Nitsch's work with **Perkins+Will** received an honorable mention for a design for the rehabilitation of Boston's Fort Point.

"We looked at an historic building and neighborhood from an infrastructure basis to come up with ideas for the Boston coastline to be reimagined in a way that accepts the rising tide," said Holmes. Among the ideas explored were "ways to allow public transportation to function amidst the rising sea levels. We even imagined a transit bus that floats through a channel."

For DC Water's Green Infrastructure Challenge, Nitsch won the streetscape category for its design for retrofitting a mixed-use urban street to incorporate green infrastructure. "It was selected for demonstrating innovative, cost-effective, constructible, and replicable solutions to alleviate stormwater discharges to combined sewers," states Nitsch's website.

Turner, Holmes and their colleagues frequently advocate for innovation and investment in resilient and sustainable features for clients—and sometimes the client's goals align with the resources available to create truly cutting edge projects. For the Pittsburgh Park Conservancy's Frick Park Environmental Center in Pittsburgh, Nitsch developed the design concepts for the water management strategy that includes permeable paving, harvesting rooftop run-off and creating an "ecological zone" to retain water onsite

and provide from baseflow/overflow connections to an existing stream. The lead designer was **Bohlin Cywinski Jackson**.

At CCBJ's deadline, the firm was working with Frick on a "planning level study to validate whether or not a Living Building Challenge certification would be possible for the center to achieve," said Turner. The Living Building Challenge is one of the most stringent green building certifications in the world, exceeding LEED Platinum in some requirements. Run by the **International Living Future Institute** and the **Cascadia Green Building Council**, LBC had certified only 11 projects as living buildings by June 2016; 10 had achieved LBC's lesser Petals ranking.

But not every institutional client has the resources of the Frick Center, which is supported by a private foundation, the **Pittsburgh Parks Conservancy**, which raised $9.3 million in 2013 (the latest year for which it reports income). And without clear guidance or design standards for climate change projections, Nitsch and its clients must perform a balancing act in designing for anticipated impacts.

"There haven't been a lot of standards developed for engineering solutions for climate change resilience," said Turner. "Clients want to spend the appropriate amount of resources," and avoid over-engineering.

For the **University of Massachusetts at Boston**, which is located directly adjacent to Massachusetts Bay, Nitsch designed stormwater systems as part of a major renovation. "We sized the drainage system to accommodate future sea level rise, instead of just high tide," said Turner. "We included what we thought would be the most appropriate adjustment to allow water to flow in and out of the piping accordingly. It was two feet, a very significant increase." This adjustment was based on anticipated sea level rise in 2050 at the time the design was completed in 2011, according to Turner.

Difficult conversation: what SLR threshold to use

Arriving at that threshold required some difficult conversations with the client about how to balance capital costs against the probabilities that sea level rise would exceed two feet over the next 40 years, especially given the uncertainty around climate change scenarios as they relate to future GHG emissions scenarios. "You really have to carefully consider how much investment you're going to make," said Turner.

And as noted in prior issues of CCBJ, the level of investment in assessing and planning for climate risks depends not entirely on how vulnerable a client's project or community may be but also on how much the project sponsors or state regulators accept climate science.

"How we help a client deal with it depends on the client, how sophisticated they are and how seriously they're taking climate change and resiliency and adaptation," said Turner. "There are some clients who are very concerned and are investing staff and resources into trying to develop plans to deal with this issue, whereas others are simply kind of acknowledging it, and others are not acknowledging it at all."

Public and institutional clients in the Boston area in particular are increasingly likely to be in the first group, driven in part by the experience of Sandy and in part by leadership from state and local governments. While Sandy was a "near miss" for Boston—designers, engineers and policymakers are aware that if it had hit several hours earlier at high tide, the city would have experienced a 100-year flood event with significant inundation.

"The City of Boston has developed a climate change questionnaire," for project proponents, said Turner. "It asks a series of broad questions about how your project is going to deal with climate change.

"There's a growing body of research done about the Boston area," affirmed Holmes. "At first these were done independently, but lately they've been starting to build on each other." She also noted that the City of Boston is working on an update to its Climate Action Plan and the City of Cambridge is putting together its resilience plan now.

Turner also sees Portsmouth, NH, which developed a Climate Change Vulnerability Assessment and Adaptation Plan in 2013, taking leadership. "We're working on a comprehensive plan for Portsmouth along with NBBJ," he said. "The City has taken climate change and sea level rise seriously and are continuing to work on green infrastructure strategies to help mitigate those impacts." ☼

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