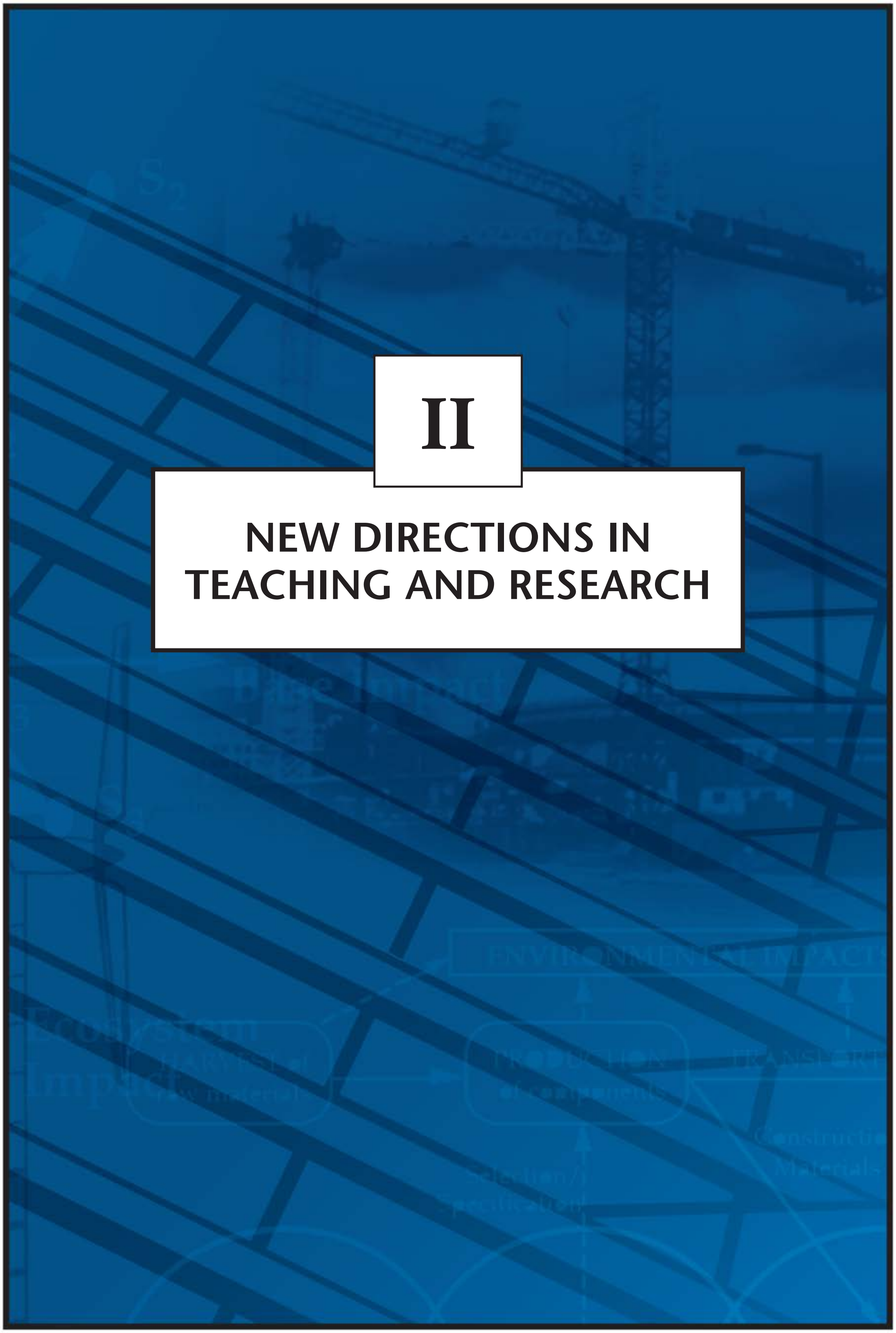

II

NEW DIRECTIONS IN TEACHING AND RESEARCH

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THE R.W. KERN CENTER AS A LIVING LABORATORY: CONNECTING CAMPUS SUSTAINABILITY GOALS WITH THE EDUCATIONAL MISSION AT HAMPSHIRE COLLEGE, AMHERST, MA

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1. INTRODUCTION

The R. W. Kern Center

In 2016 the R.W. Kern Center became Hampshire College's first new building in 40 years (Figure 1). Located at the heart of the Hampshire College campus, the R.W. Kern Center is a multi-purpose facility intended to embody a high threshold of forward-thinking sustainable design: generating its own energy; capturing and treating its own water; and processing and recycling its waste. Its design also embodies a broader definition of "green" building, prioritizing non-toxic materials, local and ethical products, and principals of biophilia and natural beauty. The new building, which includes classrooms, offices, and a community café and gallery, serves as a primary entry point to the campus and was designed to engage prospective students as well as provide community space. In the spring of 2018, the Kern Center became the 17th building to be certified and meet the Living Building Challenge (LBC) (International Living Future Institute, 2018a) after a year of post-occupancy performance verification. At 17,000 square feet, it is the largest Living Building on a higher education campus and considering the relatively small size of the college (~1300 students) it showcases Hampshire College's substantial commitment to sustainable design and development.

The Living Building Challenge

A program of the International Living Future Institute, the Living Building Challenge is a building certification system and sustainable design framework for creating built environments that have a positive impact on people and the environment (International Living Future Institute, 2018a). The Challenge is organized into seven performance areas covering different aspects of holistic sustainable design: place, water, energy, health + happiness, materials, equity, and beauty. In order to achieve "Living" status, projects must fulfill all imperatives in each of these categories.

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Hampshire College

Hampshire College is an innovative private college in Amherst, Massachusetts. The academic program is highly dynamic and interdisciplinary, emphasizing an inquiry-based and learner-centered liberal arts education. Students are empowered to think, discover, advocate, and build essential skills through an individualized divisional system utilizing portfolios, narrative evaluations, and self-reflection. The College's motto, *Non Satis Scire* (To Know is Not Enough), is a call to action for students, as well as the institution. It is not enough for colleges and universities to merely educate students on issues of sustainability or environmental and social justice; Hampshire College has the added responsibility of applying this knowledge in all of its operations. The R.W. Kern Center embodies the commitment to environmental sustainability at Hampshire and is a powerful example of the dynamic role sustainable design can play in educating the next generation of sustainability leaders.

KEYWORDS

sustainability, higher education, Living Building Challenge, regenerative design, Net Zero, innovative curriculum development

2. SUSTAINABILITY AT HAMPSHIRE COLLEGE

Since its inception, Hampshire College has been a leader in sustainability studies and environmental stewardship. Hampshire practices an ongoing commitment to integrating environmental, economic, and social justice into both academics and operations, and has received international attention and recognition for its sustainability achievements. In 2011, the college

FIGURE 1. The R.W. Kern Center at Hampshire College.

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was widely credited as the first college to divest from fossil fuels. In 2016, even before the completion of the R.W. Kern Center, Hampshire was ranked in Sierra magazine's America's Greenest Colleges at #17 amongst the nation's liberal arts colleges (Sierra Club, 2016). In 2017, the Kern Center was a recipient of the COTE Top Ten Award, the architecture industry's premier program celebrating sustainable design excellence (AIA, 2018). Finally, this year the Association for the Advancement of Sustainability in Higher Education awarded the college a Gold rating in its STARS program (AASHE, 2018).

Hampshire College is a signatory of the American College and University Presidents' Climate Leadership Commitment (Second Nature, 2018) and has a comprehensive Climate Action Plan with three main goals: 1) to provide each student with an education that nurtures sustainable values and develops skills to be leaders in sustainable societies; 2) to become climate neutral by 2022, with the exception of non-fleet transportation (i.e. air travel, commuter); and 3) to eliminate or offset the remaining air transportation and commuter emissions by 2032. The College is on track to meet these aggressive goals joining other college campuses in efforts to demonstrate the impact higher education can have in addressing climate change (*for example see* Perdue & Stoker, 2013).

Among the main tactics for achieving carbon neutrality is a commitment to meeting rigorous energy reduction targets for the construction of all new buildings as well as building renovations and retrofits. The Kern Center is one aspect of this commitment but Hampshire also plans to renovate existing buildings at the rate of at least one building every four years, with the goals of improving functionality of the buildings and significantly reducing both energy and water use. In addition, the College will pursue energy efficiency opportunities in buildings that are not slated for major renovations within the next 15 years. The combined effort is expected to reduce energy consumption by 40% in existing buildings.

In 2018, the construction of two ground-mounted solar fields covering approximately 19 acres on campus was completed. This system is on track to supply one hundred percent of the College's annual electricity demand, and is expected to avoid emissions of approximately 3,190 metric tons of carbon dioxide annually. This is the largest on-campus solar power system among colleges and universities in New England and one of the largest in the eastern US.

Hampshire is also committed to supporting local and sustainable food production. A rural campus, Hampshire College takes advantage of its large land holdings as living-laboratories to demonstrate a variety of sustainable agriculture and land management practices. The campus Farm Center is one of the oldest farms at a liberal arts college and its Community Supported Agriculture (CSA) program provides 200 shares for Hampshire College community members as well 75,000 pounds of produce for the dining commons. Hampshire College partners with over 15 local farmers with the goal of providing 100% of the food served on campus from local sources. The College also recently began returning previously mowed lawns to natural meadows. This measure reduces carbon emissions, increases carbon sequestration, and supports biodiversity of indigenous plants, animals, and insects.

3. THE R.W. KERN CENTER

Design Process

The Kern Center is the result of an inclusive and integrated design process in which owner, design team, and contactor were all profoundly invested in the project's mission. The architect led numerous charrettes and visioning sessions to ensure that all members of the college

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community could contribute. Together, the college and design team outlined project goals, including:

- The building should be a comfortable and engaging place that encourages community, collaboration and conversation.
- The LBC project should underscore Hampshire's core commitment to the environment.
- The building should convey Hampshire College's values and help tell the story of a unique, progressive, & experimenting intellectual community.
- The architecture of the building should relate to its context and reflect its natural setting. It should be striking and new; impressive, but not pretentious; vibrant; and connected to the outdoors.
- The design of the building should be accessible, flexible, and adaptable.
- The design and construction processes should be a learning opportunity for the entire community. All should understand how and why the building signals "a new age of design," and be inspired to apply what they've learned.

The project team engaged with the college community throughout design and construction by assisting in coordination of initial curriculum development; providing comprehensive tours for faculty, staff and students throughout the construction process; supporting student research projects with project data, drawings and design detailing; and providing guest lectures for classes, tours, and workshops.

Design Overview

The major challenges posed by the Kern Center project—designing a net-zero energy building in a cold climate; developing a rainwater-fed public water supply and a pilot project for greywater treatment; and using only local, sustainable, and non-toxic materials—also offered opportunities to create a unique building. Strategic use of window openings and curtainwalls take advantage of energy-saving daylight harvesting and frame signature views of the nearby Holyoke Mountain Range (Figure 2). Water collection, treatment, and discharge are showcased in design features that teach: exposed cisterns, indoor greywater planters, and a landscaped raingarden. The on-site

FIGURE 2. Interior spaces and views connect the occupants with the surrounding landscape.

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landscape surrounding the Kern Center includes native and naturalized species that emulate the indigenous ecosystem. The Kern Center's aesthetic language features local stone and timber, connecting it to its dramatic mountain surroundings while also simplifying the materials palette to eliminate troublesome finishes and plastics.

At the heart of the Kern Center is a two-story commons (Figure 3), the meeting point of the building's two intersecting wings. In contrast with the more enclosed spaces of the office and classroom wings, the center common is open and energetic, with expansive views out to the campus and landscape. The building's more private program elements branch off from it, transitioning to smaller scale and a more enclosed feel. As the gateway into campus from the north, the Kern Center also acts as a focal point for campus circulation. Several paths intersect at the building, and the transition from the outer campus into the quad is facilitated by views through the central glazed portion.

The relationship between inside and outside spaces at the Kern Center is one of both connection and differentiation. At the center common space, opposite entrances and two open expanses of glass create a visual and actual connection through the building. In this way, the building acts as a filter to nature, but not a barrier. Inside, the edges of the central seating areas abut indoor planters where the glazed wall meets the ground, creating a surprising hint of nature indoors, especially during the winter months (Figure 4).

FIGURE 3. Two-story commons in the central atrium of the building.

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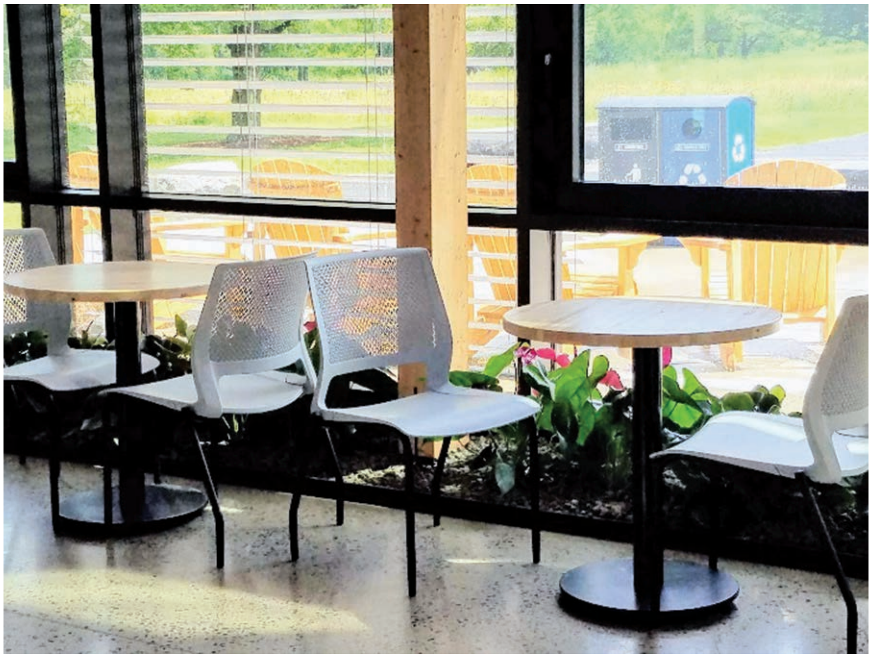
FIGURE 4. Connection with the outdoors. Plants next to seating are part of the greywater treatment system.



Site

The Kern Center project initiated a bold and transformational change in campus circulation that prioritizes pedestrians over cars. The main campus ring road was re-routed to remove vehicle traffic from the center of campus, better accommodate public bus traffic through campus, and relocate parking for easier access to buildings on the quad. The old drive was replaced by pedestrian-and-bike-friendly paths that lead people through the expanded quad and new meadow areas (Figure 5).

Energy

The net-zero energy strategy for the Kern Center sought to balance annual energy supply and demand to enable a rooftop solar array to provide for 100% of the building's energy needs (Figure 6).

The Kern Center's sustainable design begins with strategies appropriate for a cold climate: optimized building orientation for solar access, robust insulation, an air-tight envelope, exterior shades, and triple glazed windows help mitigate against large swings in temperature and humidity typical of the New England climate. The Kern Center's envelope maximizes thermal efficiency, incorporating both low-embodied energy and LBC-compliant materials. The double-stud cavity wall and roof are filled with cellulose to achieve R values of R-40 and R-60, respectively. Tall, triple-glazed operable windows help fully daylight the building with a window to wall ratio of 28%. Daylighting is supplemented by LED light fixtures equipped with both occupancy and photoelectric sensors to avoid wasting energy on over-lit spaces.

Temperature in the Kern Center is controlled with a heat-pump system that uses exterior condensers and interior exchangers. This system provides heat during the winter and cooling

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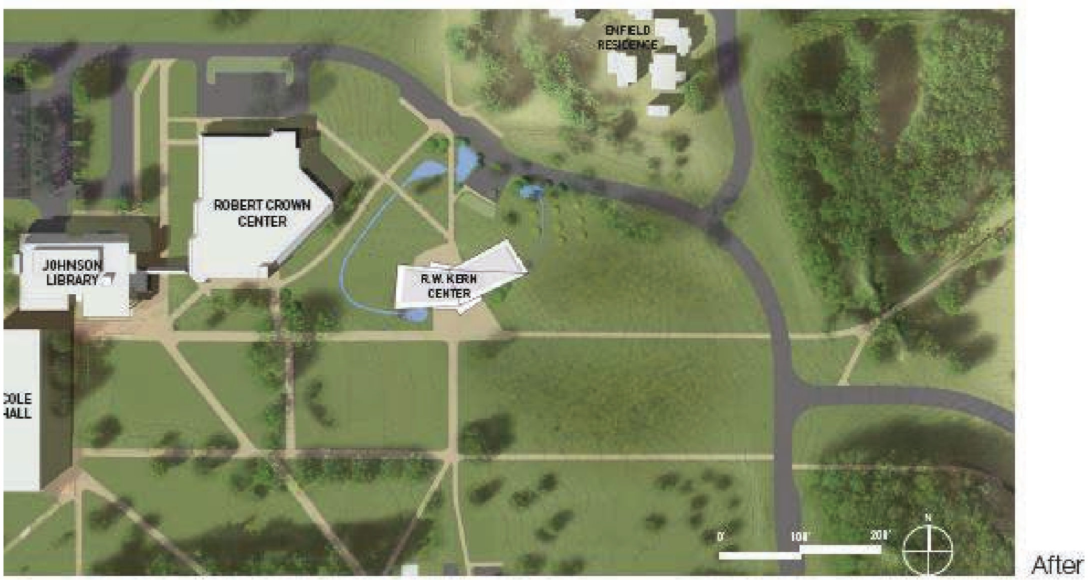
FIGURE 5. Campus transformation before and after removing the traffic circle in the center of campus.



Credit: Bruner/Cott

in summer, separate from the heat recovery ventilation system. The building's Energy Recovery Ventilation system is activated according to CO_2 sensors in each space and/or a ventilation schedule. The Kern Center is also designed to take advantage of natural ventilation when possible to minimize the use of mechanical cooling.

Plug and equipment loads make up the rest of the building's energy demand. The café equipment and refrigerators throughout the building were selected for energy efficiency. The design team, college, and food service vendor worked together to minimize the amount of equipment needed.

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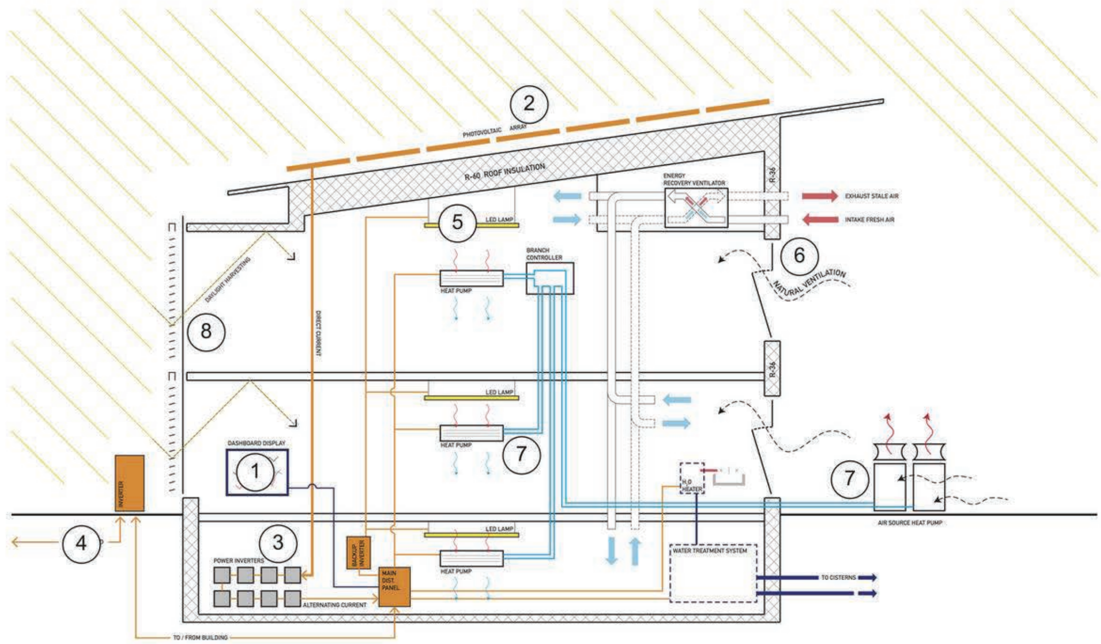
FIGURE 6. Energy system for the Kern Center.



Credit: Bruner/Cott

The Kern Center was designed to have an energy use intensity (EUI) of 23 kBtu/sf/yr, an 86% reduction from the average campus building; the building achieved an actual EUI of 23.4 kBtu/sf/yr during the LBC performance period.

Monitoring

The Kern Center includes metering and submetering by plug, lighting, fan, heating & cooling, elevator, pumps, and domestic hot water. Plug and lighting loads are also sub-metered by department (i.e. Admissions, Financial Aid, classroom, and public spaces) and the plug loads for the café can be isolated. This allows the design and facilities team to gather actual energy use, and helped with commissioning the building.

The design team took advantage of the public nature of the welcome center by making the building an educational statement. The exposed electrical conduit, ductwork, and piping express the active and passive systems that combine to create a net zero energy building. In addition to the digital dashboard prominently displayed in the central commons and café space, information on the building's systems and performance is available to campus visitors via website and an on-site brochure.

Energy Production

Annually, one hundred percent of the Kern Center's energy is generated on-site by the 118 kWh rooftop photovoltaic (PV) array. The Kern Center's rooftop PV system is connected to the local campus power loop, and benefits from the storage and delivery capacities of both (Figure 7).

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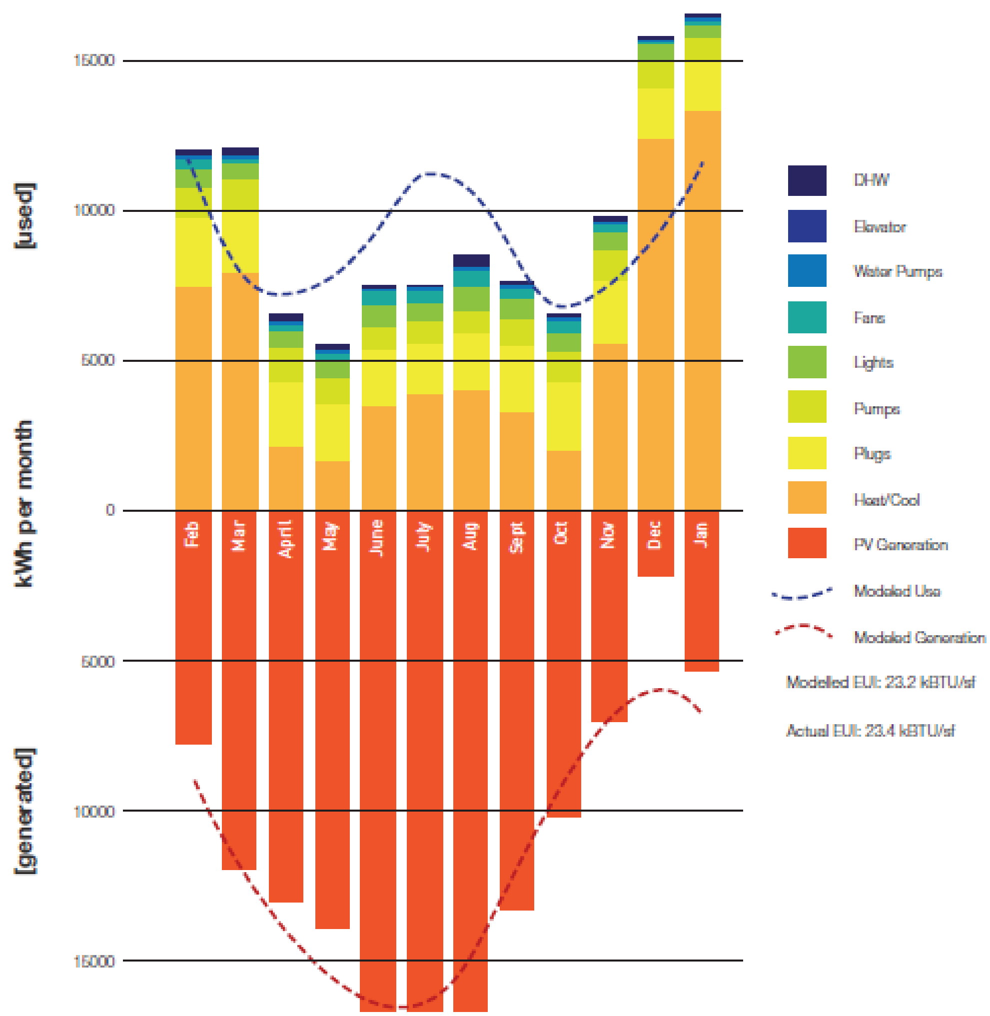
FIGURE 7. Energy production and demand summary for the first year of operation.



Credit: Bruner/Cott

Water

The water petal of the Living Building Challenge requires buildings to be Net Zero water. The objective of this requirement is to meet all water demands within the carrying capacity of the site and mimic natural hydrological conditions. The Kern Center meets this requirement by supplying one hundred percent of its potable water demand through rainwater harvesting. Additionally, all greywater and stormwater are required to be treated on-site in a closed loop system (Figure 8).

Potable Water

The Kern Center features a rainwater harvest system, designed to supply one hundred percent of domestic water (potable and non-potable) demand for the project. Rainwater is captured from the 9,300 square foot primary roof; a single gutter along the southern edge captures runoff and directs it to two downspouts, located at the southwest and southeast corners of the building.

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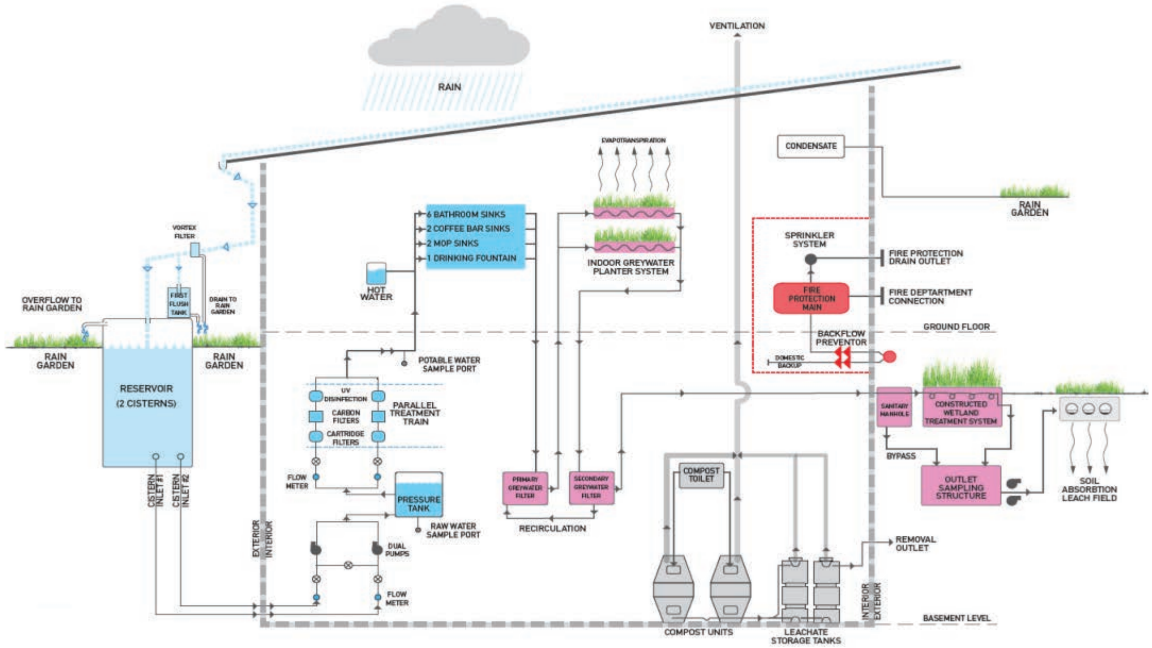
FIGURE 8. Water supply and treatment system for the Kern Center. This includes rainwater harvest for potable use, greywater treatment in indoor and outdoor constructed wetlands, and stormwater capture in rain gardens.



Credit: Bruner/Cott

The downspouts are routed through a vortex-style debris screen, followed by a "first flush" tank, designed to capture and dispose of water with the highest concentration of particulate and organic matter. The first flush tank includes a slow-release fitting, which is sized to drain the tank over 24-hours in order to reset for the next rainfall. Each cistern holds approximately 5,500 gallons, for a total storage capacity of 11,000 gallons. Water is pumped to the treatment room by a pair of ¾ horsepower shallow jet well pumps located in the water treatment room in the basement (Figure 9).

Water filtration is provided by a 1-micron (absolute) cartridge filter, followed by 5-micron (nominal) activated carbon filters; disinfection is achieved through UV treatment, validated to USEPA standards for 4-log removal of viruses. Chlorine is not used for disinfection but is used for maintenance purposes, in accordance with standard plumbing disinfection procedures. Potable water is routed through a pressure tank for distribution to the building.

The fire protection system connects to municipal water, as required by local authorities. To avoid the possibility of cross contamination, the fire service room is isolated on the first floor, away from the basement water systems. A temporary connection allows the building to use municipal water in cases of emergency or regulatory requirement; otherwise, an air gap between the two systems is maintained at all times.

The fixtures in the Kern Center are designed to minimize water use. Crucially, Kern's composting toilets use no water, reducing the overall water consumption of the building to just 150 gallons per day. Two Clivus composting units located in the basement collect waste from the toilets and process it into rich compost (Figure 10). The building has no municipal sewer connection.

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FIGURE 9. Rainwater harvesting collection cistern.

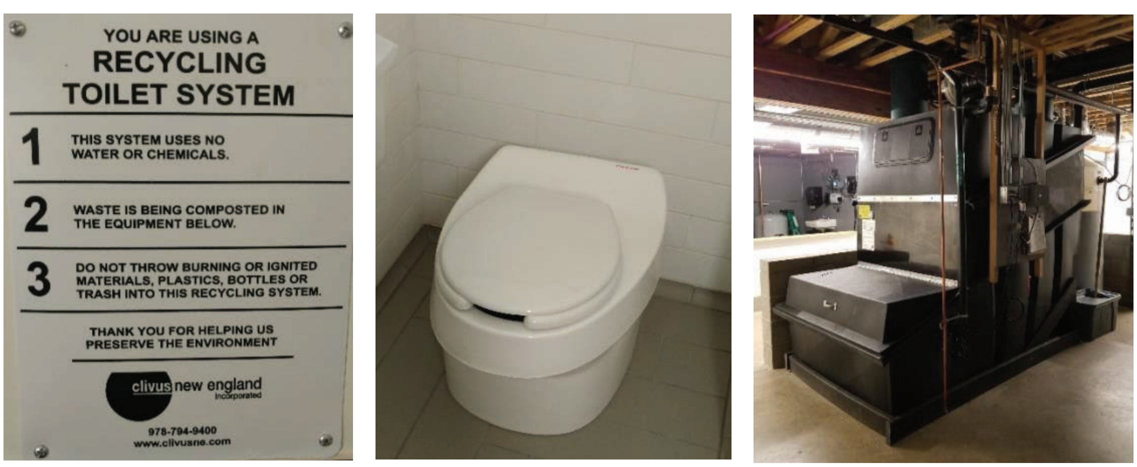
Measured Performance

Actual water use has tracked very closely with the use estimated in design. The actual water use during the first year of use was less than 1% greater than the volume estimated in design. Estimated use was 28,674 gallons per year; actual use was 28,831 gallons, a difference of just 157 gallons.

Greywater

Greywater from the Kern Center is collected, treated, and disposed of by an on-site treatment system. The building sanitary drains collect greywater from the café, bathroom sinks, water

FIGURE 10. The Kern Center uses composting toilets with two Clivus composters located in the basement.



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fountains, and custodian mop sinks and discharge it to the greywater treatment wetlands via two collection tanks located in the basement. Greywater is pumped to indoor vertical flow constructed wetlands (VFCW) in the central atrium and then to an outdoor horizontal subsurface flow constructed wetland (HSSF CW). Effluent is ultimately discharged to an on-site leach field (Figure 11).

The greywater system is permitted as a site specific pilot program under the Massachusetts Department of Environmental Protection (DEP, 2018). The permit includes specific water quality goals/limits for three standard water quality measures: 5-day biochemical oxygen demand (BOD_5; <30mg/l), total suspended solids (TSS; <30mg/l), and total nitrogen (TN; <10mg/l). These limits for the effluent to the leach field are designed to protect the surrounding environment from impacts due to discharge of excessive solids and eutrophication.

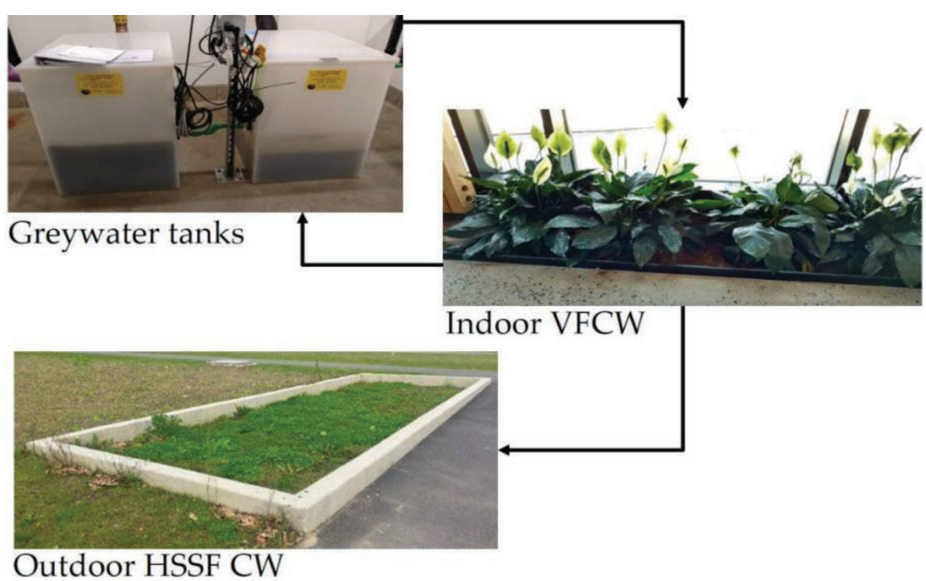
Stormwater

Stormwater from the Kern Center site is managed by utilizing meadow vegetation to minimize runoff, diverting a portion of roof runoff for use as a water source for the building, and by capturing nearly all site runoff in a series of rain gardens that allow for infiltration to groundwater.

Materials

Materials for the Kern Center were selected to meet the intersecting imperatives for local sourcing, responsible industrial practices, and avoidance of substances which have adverse effects on human health and the environment (International Living Future, 2018b). The design team chose carbon-sequestering wood as the major structural material. Minimal use of energy-intensive steel and concrete, and use of local and salvaged materials, reduced the project's carbon footprint dramatically. The palette of wood, concrete, and stone is durable, beautiful, and practical. The building features schist cladding from a nearby quarry, a polished concrete slab with local aggregate, salvaged oak planks, and tables made from campus trees. These materials offer an innate

FIGURE 11. The Kern Center's greywater treatment system.



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visual connection to the surrounding landscape and to the local stone and timber vernacular (Figure 12). All other wood products incorporated into the project are Forest Stewardship Council (FSC) certified; in 2016 the Kern Center was awarded the FSC Leadership Award. Other components, like the triple-glazed windows and high-efficiency mechanical systems, were selected primarily for their superior performance and quality.

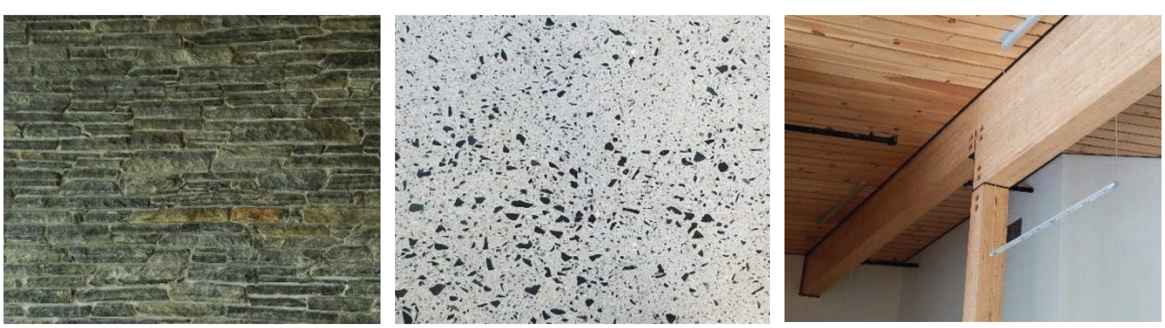
4. INCORPORATING THE KERN CENTER INTO THE ACADEMIC PROGRAM

Hampshire College Academic Program

Non Satis Scire serves as the guiding principle for the Hampshire College academic program, including the interdisciplinary curriculum and student and faculty research. Hampshire's approach to interdisciplinary and innovative education has a foundation in social justice and sustainability, with a mission to develop in students a passion for lifelong learning. Hampshire College graduates change makers—students who are entrepreneurial and creative thinkers and are dedicated to improving the world around them.

Inquiry drives a Hampshire education. During the first-year program (Division I), students learn how to ask questions and engage deeply in each of five general fields: Arts, Humanities, Cognition, Natural Science, and Social Justice. Rather than having general introduction courses in these areas, the first-year courses are seminar style where students engage deeply in narrow topics. For example, first-year courses in Natural Science have included *Molecules of Farm and Forest*, *The Science of Space and Time*, and *Water in a Changing Climate*. All first-year science courses facilitate learning how to ask questions, accessing and understanding primary research literature, interpreting quantitative data, and engaging in a project. During Division II (second and third years), each student designs a concentration with a faculty advisory committee. These concentrations are frequently interdisciplinary and may combine general areas such as `Human Biology and American History' or have a more specific focus such as `The Nexus of Civil Liberties and Technology.' In their final year (Division III), each Hampshire student designs and completes an advanced independent capstone project addressing a sophisticated and complex set of questions, concepts, and skills related to their concentration. The process and the project are all advised and assessed by a faculty committee recruited by the student.

FIGURE 12. Regional materials used in the Kern Center: Ashfield schist for the interior and exterior façade (left) and also featured in the polished concrete floor (center) and laminated Nordic Lam timber framing (right).



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Living Buildings as Inquiry Drivers

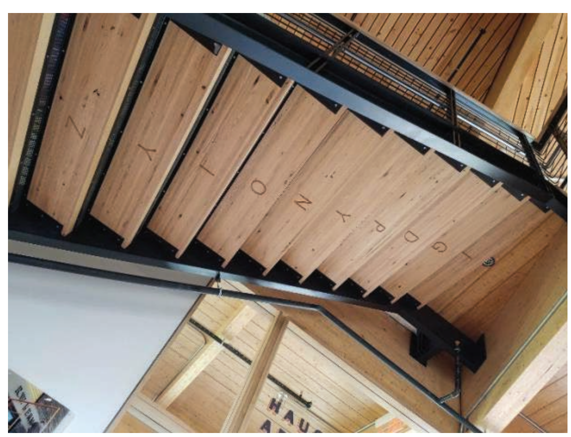
The mission of the International Living Future Institute (ILFI), "… to lead the transformation toward a civilization that is socially just, culturally rich, and ecologically restorative," (International Living Future, 2018c) mirrors the mission of Hampshire College. Building the Kern Center and subsequent work with ILFI have created multiple opportunities for curriculum development and student/faculty research.

As a Living Building, the Kern Center is a natural extension of the Hampshire College curriculum. The building systems are deliberately revealed to engage occupants in the environment around them (Figure 13). These features invite students and other visitors and occupants to be curious and ask questions, leading to a deeper understanding of the connections between the natural and the built environments. Even before construction began on the building, the Kern Center served as a living lab motivating collaborative, interdisciplinary teaching and research for students, faculty, and staff. Faculty have designed new courses centered on the Kern Center and student questions about the building have been used to motivate the design of Division II concentrations and Division III and independent research projects. *[For examples of how living buildings are being used as living labs and for education at other higher education institutions please see Hellmuth et al. (2009) and Elbaum (2010)]*

Systems Thinking and Multiple Lenses

A comprehensive understanding of the Kern Center and other Living Buildings requires developing an understanding of how the building systems work together to achieve broader sustainability goals. This necessitates using systems thinking and provides multiple lenses through which to examine issues in many different fields including urban planning, architecture, art, photography, engineering, ecology, mathematics, materials science, economics, and social justice. For example, students engaged in scientific research on the building must also explore the relationships with fields such as art, economics, and social justice. Such a systems thinking approach requires students to make connections among different disciplines and interact with a wide variety of faculty, staff, students, and industry professionals—the essence of a true liberal arts education.

FIGURE 13. Exposed systems of the Kern Center (left) and puzzles (right) located throughout the building invite occupants and visitors to engage with the built environment and ask questions about their surroundings.



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Developing Community

Making connections requires a willing and available network of collaborators. From its inception, the Kern Center project has cultivated a community of students, staff, faculty, and industry professionals. The entire design and building team embraced the educational mission of the Kern Center. Architects met with campus members during the original design process. From the moment ground was broken students were on site learning about construction materials and building techniques from the design engineers and builders. Campus facilities staff routinely gave students tours of the building throughout all phases of construction. Professionals were invited to classes to discuss the challenges and benefits of building to the LBC standard. Their generous support and time helped cultivate true partnerships among segments of campus that do not often interact. This network has given students the opportunity to see how the concepts they learn in the classroom are applied in the real world and to learn directly from leading practitioners in the field. Students and faculty are contributors to this community as well—the data they have collected has informed the understanding of the functioning of the energy and water systems and has aided in the management of the systems.

Integrated Sciences First-Year Program

One of the most successful curricular outcomes of the Kern Center project is the building's use in Hampshire's Integrated Sciences First-Year Program (ISFP). ISFP provides students with an authentic introduction to the nature and process of science from the moment they set foot on campus. Students learn the scientific mode of inquiry, understand science as a collaborative and interdisciplinary endeavor, develop mentor networks, and build intellectual community. This program brings together both students satisfying their science distribution requirement as well as students interested in pursuing science as a concentration. The design of the ISFP program coincided with the early construction phases of the Kern Center and faculty recognized the excellent opportunity the Kern Center provided to tie the academic program with the built environment. Since its inception in 2015, the ISFP has used the building and the Living Building Challenge framework as the system of study for courses, laboratory projects, student projects, and student and faculty collaborative research.

The program for first-year students consists of three main parts: 1) ISFP I—fall semester collaborative courses; 2) ISFP II—spring semester design projects; and 3) ISFP III—a summer research experience. In ISFP I, students take one of three linked courses all exploring systems of the Kern Center from different disciplinary lenses. During the fall of 2017 the following courses comprised ISFP I: *NS132 Sustainable Water Use/Reuse* (water resources/hydrology), *NS140 Modeling Systems* (applied mathematics), and *NS156 Microbes in a Living Building* (microbiology). Each course met twice a week to learn background and foundations in the individual disciplines, and once a week, students from all three classes met together to form collaborative teams and complete inquiry-based laboratory experiments.

In the fall of 2017, students explored nitrogen cycling within the greywater treatment constructed wetlands of the Kern Center. They visited the Kern Center systems and then constructed laboratory-scale wetland mesocosms to mimic the function of the *in situ* systems (Figure 14). They completed laboratory experiments to test the ability of the mesocosms to transform nitrogen from greywater under both aerobic (simulating the indoor wetlands of the Kern Center) and anaerobic (simulating the outdoor wetland) conditions. An understanding of the system required students to bring knowledge and skills from all three disciplines. They measured water quality and tested for the presence of nitrifying and denitrifying microbes. They

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FIGURE 14. Students taking a tour of the Kern Center during construction (left) and working in the laboratory on wetland mesocosms (right).

also constructed conceptual and computational models of the system using Stella dynamical systems software. For their final project, the teams were given real-time data from the greywater constructed wetlands in the Kern Center. They were tasked with using what they had learned from their mesocosms to explain the functioning of the *in situ* greywater treatment system and present their work in a public poster symposium. Students were highly successful in this process and demonstrated a strong understanding of ways in which the Kern Center both produces and processes greywater.

In ISFP II, students can choose to continue working on the Kern Center systems as part of directed, collaborative, independent projects. Students complete literature reviews, design research proposals, complete a peer-review process, engage in research, and present their work. ISFP II provides students with the opportunity to deepen their understanding of the systems by engaging them in the process of inquiry guided by their own questions rather than those identified by faculty. These projects require a more significant engagement with the building, faculty, and community of professionals and often help direct the students' academic program moving forward. In the past three years of the ISFP program, students have completed projects covering a broad range of questions/topics including:

- Measuring the Structural Behavior of the Nordic Lam Beams in the R.W. Kern Center Compared to Traditional Timber Framing and Steel
- Using Plants that are Attractive to Insect Pollinators to Filter Stormwater in Rain Gardens
- Material Sourcing: Supplier Sustainability Practices
- Modeling Water Flow of Wetland Planters
- Effects of Rainfall Intensity on the Quality of Harvested Rainwater

In ISFP III, students complete an intensive four-week summer research program. They may continue research projects started during the academic year or explore a new topic focused on the Kern Center systems. Students work closely with faculty and peer mentors, meet industry professionals for lunch seminars, and take academic workshops in a range of fields related to their research. Students also travel to the American Ecological Engineering Society annual conference to present their work to the broader scientific community—an opportunity not often available to students in their first or second years of college (Figure 15).

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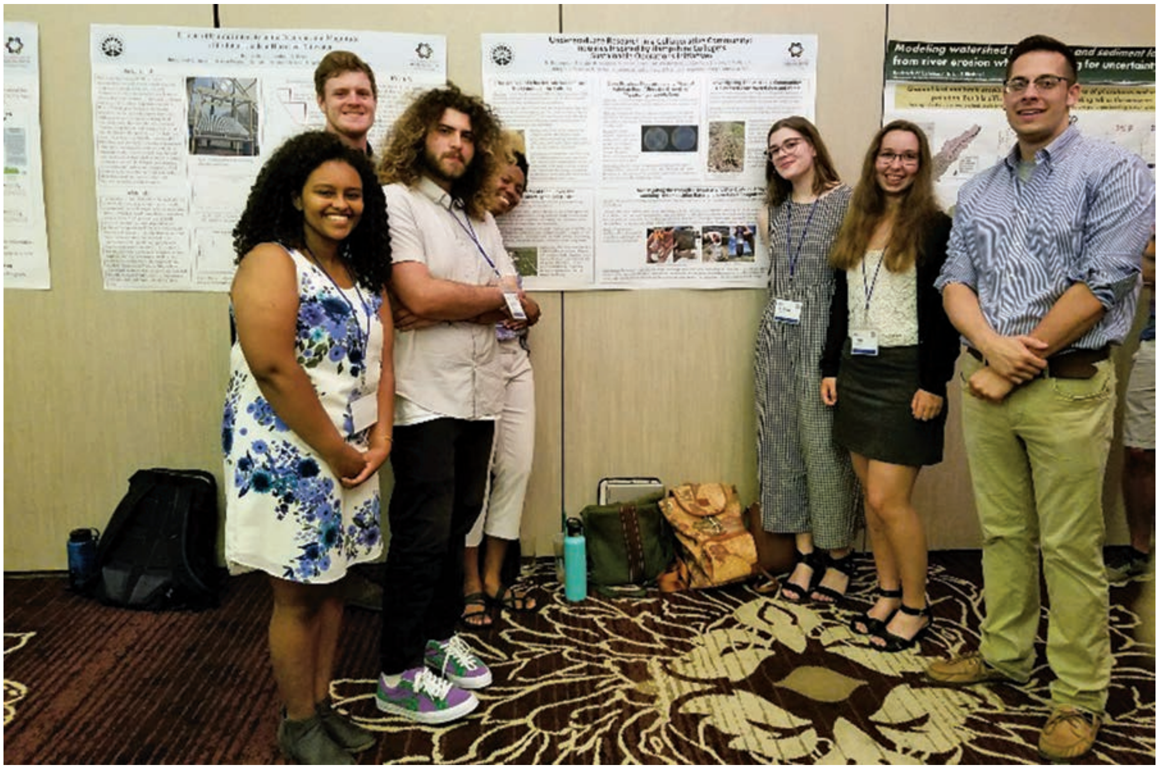
FIGURE 15. Students present their summer research work at the 2018 American Ecological Engineering Society annual conference in Houston, TX.



This program has been highly successful in introducing students to the process of science, sustainable design, the Living Building Challenge, and the Kern Center. As a result of their experience in the program, many students have become formal or informal tour guides for the building sharing their expertise with visitors and prospective students. Students from the program are routinely asked to give presentations about their work and showcase their projects to both on-campus and off-campus visitors.

For some students, completing this program in their first year has shaped their academic path and opened new avenues of study. For example, two students, one studying energy and one studying water resources, have continued their work with the Kern Center and building design throughout their time at Hampshire.

Student Research

Energy

A building science and systems analysis student became interested in how the adoption of alternative systems (i.e. greywater treatment indoor wetlands) in the Kern Center might have unaccounted for effects on traditional building components. The student began research to understand these interactions during the ISFP courses and continued his research through the summer, funded through the Four College Bio-Math Consortium. The ISFP classes, designed

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to facilitate understanding of the building from multiple perspectives, motivated investigation that connected seemingly dissimilar ideas, concepts, and systems.

The student used a systems thinking approach to create an energy model of the Kern Center that incorporated the indoor greywater treatment wetlands and assessed whether increased humidity levels in the building due to the plants would increase the loads on the HVAC (Raymond et al., 2018). The energy analysis tool eQUEST (Energy Design Resources, CA) was used to simulate the changes in energy usage under different scenarios. The eQUEST model does not allow for the addition of "plants" so the student developed a method by which to use humans as surrogates to increase the humidity levels to assess the impacts of the indoor wetlands. He found no measurable increase in the energy demand due to the greywater treatment system (Raymond et al., 2018).

The student first became inspired by the Kern Center through its alternative resource management systems and the ISFP courses. From this starting point, he developed his own independent research, worked as a student mentor, and presented work at conferences (Figure 16). From these experiences he defined a concentration and worked for the University of Massachusetts Clean Energy Extension advising towns on municipal and building energy reduction strategies. His work, centered around the Kern Center, helped define his academic concentration and ultimately had a pivotal impact on his post graduate career. He currently works as a commercial building energy data analyst.

FIGURE 16. Presenting the results of the energy model.

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Water

Observing the Kern Center come to life during the fall of 2015 while participating in ISFP's pilot year led another student to design her concentration around the building's greywater treatment system, seeking to understand the ecological, hydrological, chemical, and biological treatment mechanisms. Because this system is innovative and experimental, the mechanisms by which greywater is treated are not fully understood. Although the Massachusetts DEP requires quarterly monitoring of BOD_5, TSS, and TN to ensure the treated greywater maintains adequate quality, this data does not provide insight into *how* the constructed wetlands in this system function to treat the water. This ambiguity provides an intriguing access point for undergraduates to conduct their own research.

This student's current capstone project involves monitoring greywater quality throughout the filtration system—before filtration, after filtration by the indoor vertical flow constructed wetlands, and after filtration by the outdoor horizontal flow constructed wetland (Figure 17). Similar to Jokerst et al. (2011), the goals of this project are to analyze greywater quality by season, model nitrogen cycling throughout the system, and create a comprehensive water budget in order to quantify the building's water footprint.

FIGURE 17. Sampling greywater after it has been filtered by the indoor and outdoor constructed wetlands.

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Two factors—climate and building occupancy—are hypothesized to impact the effectiveness of the Kern Center's greywater treatment system at improving greywater quality. Because this system uses indoor and outdoor constructed wetlands, climate has the potential to disrupt the natural filtration processes. In addition, the Kern Center's role as the admissions office and an on-campus hub means that it experiences a wide range of visitor and occupant loads. Two distinct occupancy patterns exist: high-occupancy, which occurs during the semester when students are allowed in on-campus residences; and low occupancy, which occurs during winter and summer breaks when a limited number of students are allowed in on-campus residences.

A novel application of this research is the potential for greywater treated in decentralized systems with natural processes to recharge groundwater reservoirs, specifically in arid regions, regions with limited water availability, or areas facing drought. Furthermore, the results of this project will inform future research on the environmental impacts of the Kern Center and other green and Living Buildings, as well as the applications of constructed wetlands in meeting net-zero water goals and in treating nitrogen. By measuring patterns that may be caused by changes in climate or building occupancy, sustainable designs may be developed or revised based on building needs and location. Understanding how each component of the system works in different seasonal conditions may be useful information for the global community when exploring and designing sustainable water treatment options.

5. CONCLUSION

The R.W. Kern Center is an active reflection of Hampshire's educational mission and social and environmental values. The project has served as a catalyst for thinking about regenerative design practices in fields beyond building and architecture. From the inclusive design process, to the selection of materials and the construction process, to the connection with academic programs, the Kern Center project has demonstrated what is possible for community-supported sustainable buildings. It provides a multitude of systems for students and faculty to study and provides physical examples of how complex challenges require interdisciplinary and collaborative thinking. The relationships initiated through the building project among faculty, staff, students, and industry professionals from both on and off campus continue to open new lines of inquiry. The Kern Center project is a powerful example of how colleges can leverage buildings and operations to support their overall mission and goals.

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