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Cover: *Kenilworth Castle Ruins, England: Great Arched Passage leading to the Great Hall (Photographs by Rumiko Handa).* *(See p. 33)*

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Over-the-Rhine is Cincinnati's largest historic district and has contained its greatest concentration of poverty. The Over-the-Rhine Foundation sought to study preservation-oriented redevelopment in Over-the-Rhine. Attacking the problem with an interdisciplinary team of experts (the Integrated Design Team, or IDT), the foundation sponsored an intensive all-day colloquium in spring 2008 that brought to light a myriad of structural and customary impediments to sustainable rehabilitation. The foundation then sponsored an undergraduate design studio at the University of Cincinnati to explore historic sustainable design. Several buildings used as representative case studies allowed students to test new methodologies for greening historic structures. The IDT joined with the students to apply real-world costs, a LEED rating system, historic district design guidelines, and the Secretary of the Interior standards to the student design solutions. Students taking a follow-up graduate seminar explored conflicts between the historic and sustainable objectives and explored design and technological solutions that could achieve both goals. The IDT concluded that sustainable historic preservation design is achievable if a team of consultants familiar with both issues is formed early in the project and if impediments to common-sense sustainable strategies are removed. Energy modeling found that a balanced approach could improve a historic building's energy performance to basic LEED standards. Existing building condition, planned adaptive use, market factors, and costs are closely interlinked; all must be considered when developing an effective strategy for the green rehabilitation of a historic building.

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Sustainability in the Adaptive Reuse Studio: A Case Study in Cincinnati's Over-the-Rhine Historic District

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Although many historic preservationists have dedicated years to preserving our shared built heritage because they prize continuity between past and present cultural and aesthetic values, others are becoming interested in historic preservation from a new perspective: they see conservation of the built environment as a key element in developing a sustainable, "green" future for our planet. Although historic preservation advocates have long held that conservation is a primary means for reducing our carbon footprint, the sustainability community is just now recognizing that "green" building starts with making the most of what we already have. In the past several years, increasing attention has been paid to urban conservation: the result is a vision of the city of tomorrow that offers continuity with our past and leaves resources for the future. We have been particularly eager to make this vision a reality in Cincinnati.[1]

Cincinnati shares many of the challenges that face the post-industrial Middle West. Its economy has shifted from manufacturing to the administrative and service sectors, and thousands of its residents have been caught in the transition. Many have left the community, and thousands more have chosen to live beyond its urban core to escape the burden of caring for those left behind. At the heart of the city lies Over-the-Rhine (OTR), the city's largest historic district, and perhaps, paradoxically, also the site of the city's greatest concentration of poverty (Fig. 1).

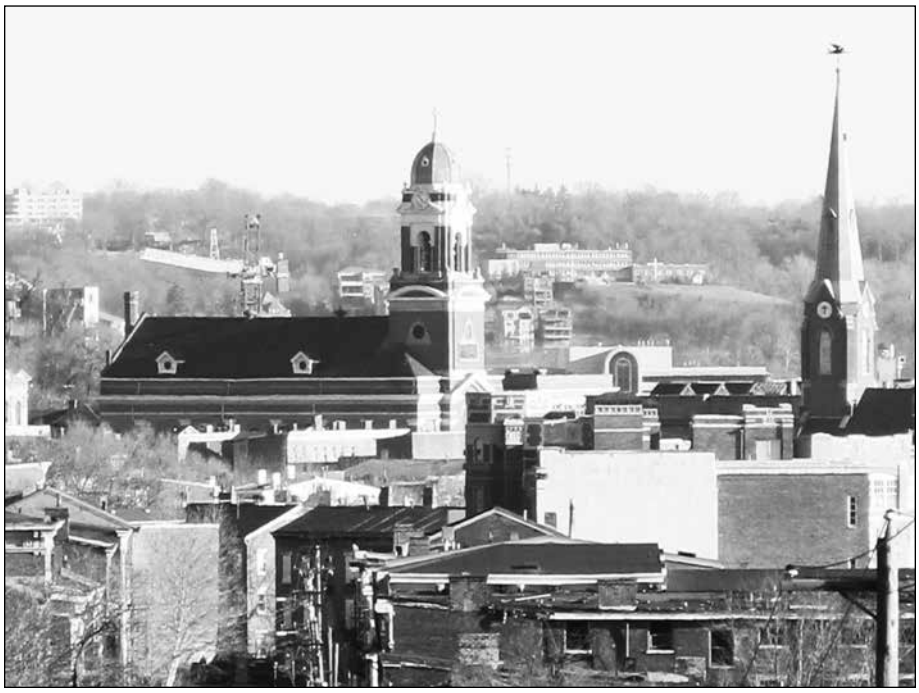

Fig. 1. Over-the-Rhine seen from West Clifton Avenue (Illustrations by author unless otherwise noted).

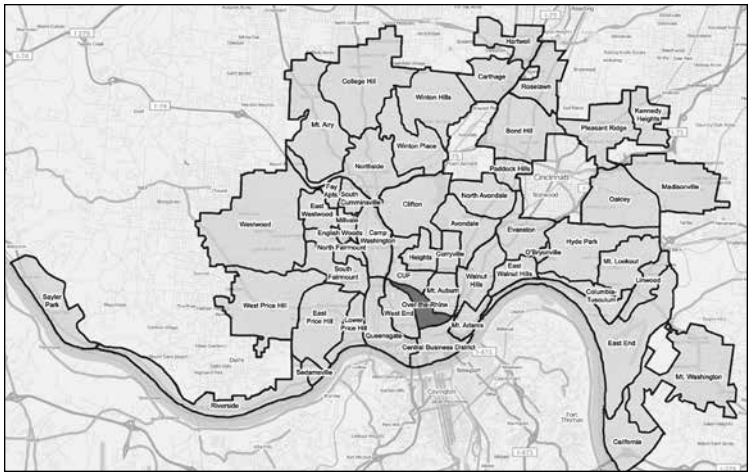

Fig. 2. Map of Cincinnati, Ohio, showing Over-the-Rhine (City of Cincinnati).

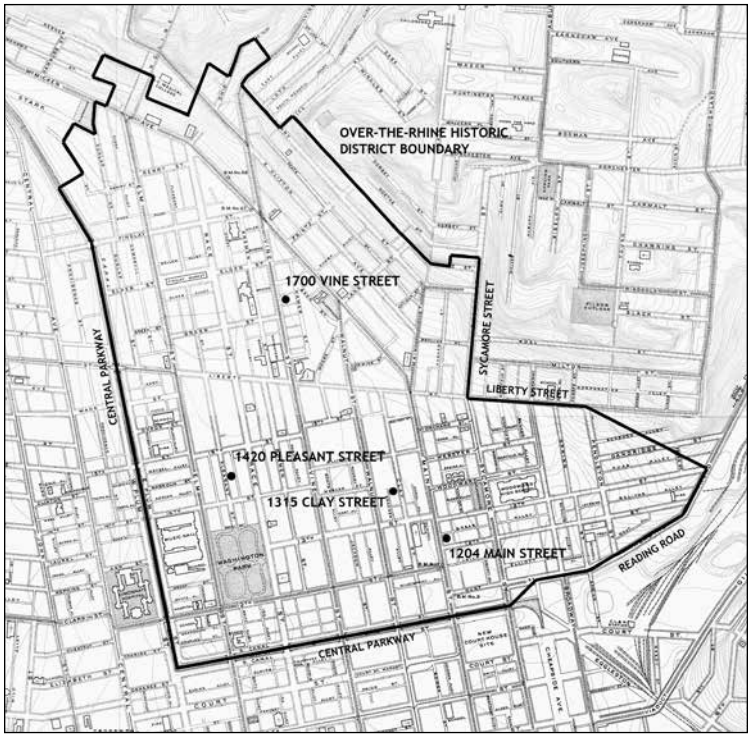

Fig. 3. Over-the-Rhine Historic District, Cincinnati, Ohio, featuring project properties.

While Over-the-Rhine boasts one of the largest collections of Italianate architecture in the United States, and the historic district comprises well over 1,500 contributing structures (Figs. 2, 3), the viability of this community as a functional, living neighborhood has been in doubt. The German-American population that constructed Over-the-Rhine moved to less dense neighborhoods on the bluffs and across the Mill Creek Valley in the 1920s.[2] New residents from Appalachia moved in and remained the dominant cultural presence through the 1970s. Since that time, African Americans displaced by expressway projects have moved into buildings vacated by residents who had moved to the inner-ring suburbs. Social-service providers have also focused their operations in the neighborhood due to its proximity to the Central Business District and transportation hubs and its abundance of underutilized commercial buildings. Today, Over-the-Rhine is highly contested space—tensions among the remaining Appalachian community, the African American majority,

arts organizations, social-service providers, and the city's business interests have until recently resulted in a paralysis in efforts to curate or redevelop the neighborhood (Miller 1998). Due to rapid population decline and massive disinvestment, more than five hundred structures, nearly all historic, now stand empty. It is for this reason that Over-the-Rhine was named to the National Trust for Historic Preservation's 11 Most Endangered Historic Places in 2006.

The City of Cincinnati has made a significant commitment to both the redevelopment of Over-the-Rhine and to sustainable building by offering tax abatements for construction that earns a Leadership in Energy and Environmental Design (LEED) rating from the United States Green Building Council (USGBC). The public-private partnership that has taken the lead in redeveloping vacant and derelict sites in Over-the-Rhine, the Cincinnati Center City Development Corporation (3CDC), has bought nearly one hundred vacant sites, abandoned buildings, and underutilized structures, and the organization is creating development opportunities that emphasize market-rate housing and medium-scale retail spaces, as these are in short supply. Although 3CDC has invested nearly $430 million since 2004, its for-profit orientation and desire to demonstrate immediate results had led it until recently to emphasize new construction and infill projects rather than historic rehabilitation of contributing structures (Cincinnati Center City Development Corporation 2011).

THE GREENING OVER-THE-RHINE PROJECT

In 2007, the Over-the-Rhine Foundation, another prominent stakeholder in the neighborhood, chose to study how Over-the-Rhine might become the greenest historic district in the United States. Partnering with the School of Architecture and Interior Design at the University of Cincinnati and with members of the Cincinnati chapter of the USGBC, the foundation sponsored an in-depth interdisciplinary examination of sustainable urban conservation in spring 2008.[3] The foundation's executive director, Michael Morgan, called on experts from architecture, landscape architecture, construction, structural and mechanical engineering, and code enforcement, who met in an intensive all-day colloquium that brought to light a myriad of structural and customary impediments to sustainable design in the Over-the-Rhine historic district. Some of these impediments could not be readily removed, such as the paltry number of points awarded an adaptive-reuse project under the LEED system, while other barriers might be eliminated with increased study and the creative adaptation of existing technologies. At the conclusion of the day, the Integrated Design Team (IDT), as the group became known, committed itself to demonstrate that Over-the-Rhine's buildings could be renovated for contemporary use while earning LEED certification and meeting the conservation goals of the historic district.[4]

The foundation sponsored an undergraduate design studio in spring 2008 to explore the possibilities of historic sustainable design. Several buildings were used as representative case studies, allowing students to test new design strategies and methodologies. The Integrated Design Team joined with the students to apply real-world costs, an appropriate LEED product, historic district design guidelines, and the Secretary of the Interior's (SOI) standards for rehabilitation to evaluate how well each solution would work (Morton, Grimmer, and Weeks 1997). Students taking a follow-up graduate seminar considered conflicts between the Secretary of the Interior's standards and LEED certification and explored design and technological solutions that could achieve both historic preservation and sustainable goals. Finally, Integrated Design Team professionals verified the students' research regarding the energy efficiency of triple-wythe brick structures.

Resources

Early on, the Integrated Design Team discovered that there were surprisingly few recently published resources on sustainable historic preservation design or policy. Several seminal reports and published texts from the 1970s and 1980s, when American architects and preservationists began to focus on the energy performance of buildings, were helpful. James Marston Fitch urged the Advisory

Council on Historic Preservation (ACHP) to adopt Richard Stein's concept of embodied energy to reinforce the idea that the nation's building stock was a valuable economic and environmental asset (Fitch 2006). In 1979, the ACHP published *Assessing the Energy Conservation Benefits of Historic Preservation: Methods and Examples* (Booz, Allen & Hamilton 1979); this text formed the basis for the more widely read publication by the National Trust for Historic Preservation, *New Energy from Old Buildings*, published two years later (Maddex 1981; Jackson 2005). It was a primary axiom of these two works that the era of "cheap energy" was over and that the scarcity of fossil fuels would mandate the conservation and rehabilitation of existing buildings and discourage new construction on greenfield sites.[5]

New Energy proved to be the starting point for sustainable historic preservation, even if some of the examples of adaptive reuse now seem heavy-handed. The subsequent refinement of the Secretary of the Interior's standards for rehabilitation discouraged preservation architects from making radical interventions in historic buildings—the sun-filled atriums carved out of historic fabric common in the 1970s were stunning (Schmertz 1982), but hardly reversible or historically responsible. Students in the Greening OTR design studio were exposed to the SOI standards in a series of lectures and case studies and were asked to become familiar with the City of Cincinnati's design guidelines for the Over-the-Rhine Historic District (City of Cincinnati Urban Conservation Board 2003).

In the energy efficiency arena, the question arose as to what standard of "energy efficient" would be most appropriate for the project. The students had particular interest in ANSI/ASHRAE/IESNA Standard 100-2006: *Energy Conservation in Existing Buildings*, but these standards do not consider historic buildings as a special class and address a selective range of building performance criteria.[6] The project team felt a broader range of sustainability criteria should be applied and decided rather quickly that the USGBC's LEED rating systems were more appropriate; the LEED rating standard also had the advantage of incorporating a number of ANSI standards (USGBC 2005, 2007, 2008).

Since its founding in 1993, the USGBC's products have emphasized new construction over reuse. However, it was obvious to the members of the Integrated Design Team that it was necessary to demonstrate that common historic residential buildings of the nineteenth century could be rehabilitated within the Secretary of the Interior's standards and also achieve LEED certification. The students scoured the USGBC website and published materials for the few case studies that highlighted historic structures. One study, published by Robert A. Young in the *Journal of Green Building* entitled "Striking Gold: Historic Preservation and LEED" (2008), described how the architectural firm of Gillies Stransky Brems Smith (GSBS) transformed the Art Deco W. P. Fuller Paint Company building in Salt Lake City into headquarters for the Big-D Construction Company. Close cooperation between the design team and the builders afforded Big-D a federal tax credit for historic preservation and gave the building a gold LEED rating.

Finally, one important book-length treatment of the intersection of historic preservation and sustainability should be mentioned, although it was published just after the close of the Over-the-Rhine project. Jean Carroon's *Sustainable Preservation: Greening Existing Buildings* (2010) offers a wide range of perspectives and case studies, many of which achieved LEED certification as high as gold while earning awards for going well beyond the Secretary of the Interior's standards for rehabilitation. One of the more well known of these case studies is the Cambridge City Hall Annex, built in 1871 as a school. A model for the students and the Integrated Design Team, the building employs load-bearing triple-wythe brick construction similar to that found in many Over-the-Rhine buildings. By replacing nearly all of the obsolete mechanical, lighting, and HVAC systems, carefully replicating the window glazing with contemporary low-e glass, and introducing roof-mounted photovoltaics and ground-source heat pumps, HKT Architects, their consultants, and the City of Cambridge, Massachusetts, were able to achieve a gold LEED rating and win a bevy of awards for the sensitive rehabilitation of the building's public spaces (Carroon 2010, 190-194).

The Undergraduate Studio

The students tested new strategies for addressing the greening of historic structures on several representative buildings. Led by University of Cincinnati associate professor Virginia Russell and the author, the student teams spent eight weeks of the spring 2008 term analyzing their building, determining a program in conjunction with the owners, and designing several architectural solutions.[7] After consultation with the Integrated Design Team, they presented a consensus solution that identified the project's potential LEED rating and its conformance with the Secretary of the Interior's standards. These projects were academically oriented and were not likely to be built. Therefore, they were not rated by either USGBC or the Ohio State Historic Preservation Office for conformance to LEED or SOI standards. Instead, the Integrated Design Team followed up with an independent assessment of each design, which was then used as the basis for a report to the sponsors and the State Historic Preservation Office (Morgan and Matts 2009).[8]

Over-the-Rhine has some inherent advantages when it comes to green design. The neighborhood is a tight-knit, mixed-use, walkable community—it is precisely the kind of ideal site described by the site selection criteria for LEED certification. All of the project buildings were adjacent to bus lines and in proximity to a gamut of site amenities. Simply reusing these buildings on their sites yielded nearly two dozen LEED points.[9] Although the students initially employed the LEED-NC v. 2.2 rating system, they and the IDT felt that the then relatively new LEED for Homes rating system best fit these strictly residential projects. The LEED for Homes point schedule in place in 2008 required at least forty-five points for certification, at least sixty points for silver, seventy-five points for gold, and ninety points or higher for platinum. Thus, the students were challenged to achieve silver or gold LEED status rather than mere certification.

The building at 1700 Vine Street is representative of the Italianate structures along Main, Vine, and Race streets, with two three-room flats over a retail space (Fig. 4). Several additions had been made, extending the structure through the entire depth of the block. A young couple had just bought the property and the lot immediately to the north, intending to convert the upper floors into a single-family residence. The students designed a multiphase renovation of the property that allowed the couple to rehabilitate the main building first, then expand into the outbuilding and the adjacent lot as their family grew. Landscape features, such as the garden walls and the patio paving, were planned to make use of brick salvaged from the demolition of the derelict addition behind the main building (Figs. 5, 6).

Sustainable features were easily incorporated into the design scheme; the greater challenge was in the historic preservation. The preservationists on the Integrated Design Team were concerned that the students' proposal for a new garage door opening and new dormers in the existing outbuilding would compromise its historic integrity and violate the Over-the-Rhine Historic District design guidelines. They also argued persuasively that the introduction of the interior stair shown in the section of the outbuilding would also violate SOI standards, because it would make the historic exterior stair obsolete and require the complete rebuilding of the interior floors. The students reworked their design to better incorporate the daylighting shafts in the main building and to tie the outbuilding and the existing stairs to the rest of the project. The innovative use of green technologies and the huge amount of recycling and reuse of materials in this project earned it a tentative LEED for Homes score of 77.5 points, for a gold rating (Morgan and Matts 2009, 72).[10]

The building at 1315 Clay Street was in some ways the most challenging to reconcile historic with green (Fig. 7). Constructed in 1884 and extensively remodeled in 1904 and again in 1930, the building served as a livery stable for the French Bauer dairy; the milk wagons were stored on the lowest floor, the horses were stabled on the second floor, and feed was kept on the third floor. Some evidence of this equine habitation remains in the cleated ramp that led the horses to the upper floors of the building and in hoof marks gouged into the soft brick of the south wall. While the building was heavily altered

Fig. 4. View of 1700 Vine Street, Cincinnati, Ohio.

Fig. 5. Rendering of 1700 Vine Street by student design team members John Hoebbel, Sean Lyons, Elizabeth Schultz, and Sarah White, showing the landscape and terrace additions to the north lot and the proposed restoration of the existing Vine Street storefront.

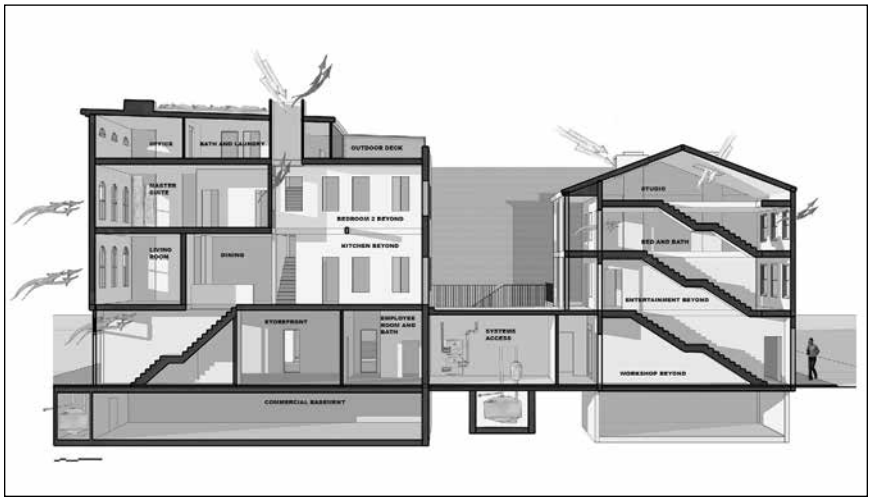

Fig. 6. Section of 1700 Vine Street by student design team members John Hoebbel, Sean Lyons, Elizabeth Schultz, and Sarah White, showing the exploitation of the building's existing ventilation and skylighting shafts and the problematic interior stair proposed for the rear outbuilding.

in 1930 to accommodate an automobile garage, and the upper floors were essentially gutted of their interior partitions, the surviving evidence of the building's use as a stable was deemed to be absolutely essential to the historical interpretation of the building. Thus, the exposed south wall of the building could not be insulated from either the interior or the exterior side. This left the triple-wythe brick wall with a very low R-rating. The students learned to accept this limitation and designed a three-unit residential building that reserved the lowest floor for parking and storage. This design contained a pair of two-bedroom units on the second floor and a large two-bedroom unit for the

owner on the top floor (Fig. 8). The project included a green roof and terrace, extensive daylighting in the living units, a solar-panel system for hot water, and an inventive ventilation chimney within the building that exploited existing gaps in the floor systems (Fig. 9).

Some of the student design interventions were quite contemporary in detail, such as a set of vertical strip windows for the south facade and the glass stair pavilion on the roof. The historic architects on the IDT reminded the students that the Over-the-Rhine Historic District design guidelines demanded a more conservative approach to anything visible from the street. In the final designs, the students eliminated the glass pavilion and restored the windows to their c. 1900 configuration. The Clay Street building represented the most difficult scenario, a building whose few remaining historic and character-defining features limited the strategies available for improving its rather poor energy performance. Under the LEED for Homes rating system, the project as designed would be certified at 52 points, not quite at the silver level (Morgan and Matts 2009, 31).[11] The Integrated Design Team examined the issues raised by the Clay Street project later in the study.

Fig. 7. View of 1315 Clay Street, Cincinnati, Ohio.

Fig. 8. Interior rendering of lounge, 1315 Clay Street, by student design team members Zach Fein, Kaitlyn Ferncez, David Hoffman, Eric Lindsay, and Peter Schultz.

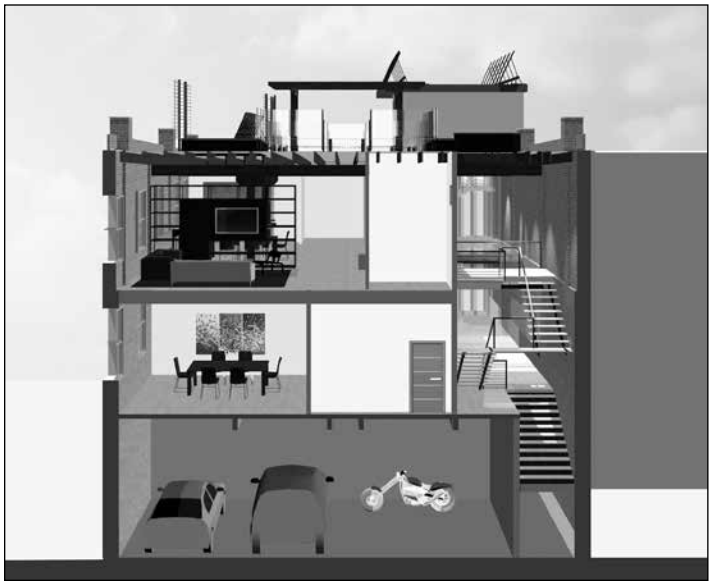

Fig. 9. Transverse section of 1315 Clay Street by student design team members Zach Fein, Kaitlyn Ferncez, David Hoffman, Eric Lindsay, and Peter Schultz.

The building at 1420 Pleasant Street is part of a group of adjacent parcels owned by Over-the-Rhine Community Housing, a not-for-profit low-income housing and land-banking group. The building is a classic example of a very common type—the three-story walk-up tenement (Figs. 10, 11). As was typical in these residential buildings in Cincinnati, the primary entrance was through an areaway to the side, and the plan is bisected by the stair—each of the five upper-floor apartments was entered from the landings. The student team chose to add a small glazed passageway around the stair hall on the second and third floors to allow each of three newly configured units to expand into both halves of the building (Figs. 12, 13). What is unusual is that the building retained a high degree of integrity in its interior finishes on the first and second floors. For this reason, the student team had to maintain as much of the interior configuration as possible in the front half of the building. This compromised energy performance and so the new plans for 1420 Pleasant Street would qualify for certification under LEED for Homes with 59.5 points, one-half point shy of silver certification (Morgan and Matts 2009, 72).[12]

The Greening Over-the-Rhine studio expanded the objectives of the typical adaptive reuse studio in ways the faculty did not originally anticipate. It was expected that the students would learn that designing within the constraints of an existing structure can be far more challenging than designing *ex novo* and that preservation-minded design requires consideration of all scales of design, from the larger neighborhood to the building detail. But the students also seemed genuinely pleased to learn just how sustainable the communities of the nineteenth century were and to find out just how many "new" passive design strategies were commonplace in working-class structures built before the Second World War. In this way, the studio experience sensitized the students to the less technologically focused aspects of sustainable design. The Greening Over-the-Rhine studio delivered a balanced message—that sustainable design was essential one-hundred-fifty years ago, and it is achievable today with a minimum of technological gadgetry, if one adapts the environmental control features already present in the historic building.

The merger of the "green" agenda with the "historic" agenda allowed students to view their real-world project from more than one perspective. This multiplicity of viewpoints had a collateral benefit: ecologically minded students joined forces with history buffs and community activists in a common cause in which each learned skills from the other. Whether the participating students ever engage in a historic preservation project again or not, they developed an appreciation for existing building stock and for the conservation and continued occupation of that heritage.

Fig. 10. View of 1420 Pleasant Street, Cincinnati, Ohio.

Fig. 11. Oblique view of 1420 Pleasant Street, Cincinnati, Ohio, showing south elevation windows and grocer's alley.

Fig. 12. Floor plans of 1420 Pleasant Street by student design team members Maria Bergh, Wade Hart, Lauren Karsten, James Kehl, and Joseph McGovern.

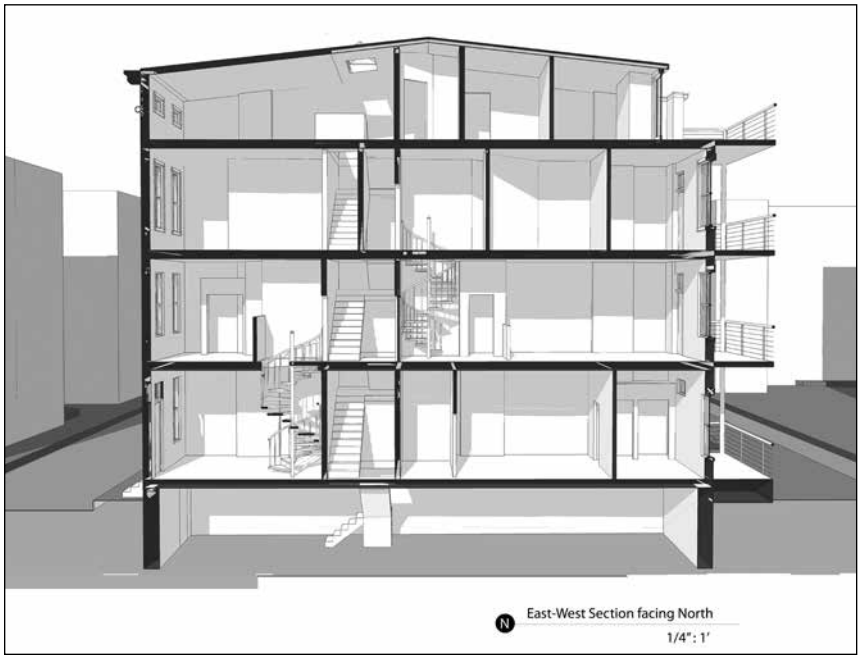

Fig. 13. Longitudinal section of 1420 Pleasant Street by student design team members Maria Bergh, Wade Hart, Lauren Karsten, James Kehl, and Joseph McGovern.

The Graduate Seminar

Although the undergraduate design studio ended in June 2008, student research continued into the summer term. Virginia Russell taught seven students in a graduate seminar that further developed themes and issues arising from the undergraduate design process.[13] These areas of inquiry included a preliminary historic character assessment of the studio project buildings; an energy analysis of the OTR building stock; research into the building envelope and its impact on energy performance; a look at how interior finishes contributed to energy performance; a master plan for the creation of infrastructure parks; and a study of the impediments to historic sustainable design established in the undergraduate studio.

The historic character assessment was equivalent to the first draft of a historic structures report. Students formalized the research done by the undergraduates and thoroughly documented each building with a set of measured drawings and a large number of photographs. Their reports documented each building's construction history, its architectural significance and character-defining features, and its current condition. Each report concluded with a set of conservation recommendations consistent with the SOI standards. The students' study of existing building energy analysis protocols had two parts: the first was a survey of more than twenty-five energy modeling and sustainable building design tools, from Green Building Advisor to Ecotect to the GreenSave calculator. Students then applied the most promising of these tools to one of the projects studied in the studio; the results formed the basis for the last three sections of the research study—those dealing with the building envelope, interior finishes, and infrastructure.

The building envelope study made conservation recommendations for the principal elements of the building envelope, including the exterior cladding, the internal insulation, the windows, and the roof. The interior finishes discussion did the same for a wide variety of interior materials, including flooring, plasters, paints, and carpeting. The discussion of each recommended material or assembly included detailed drawings, an evaluation of its positive and negative characteristics, a list of sources for procurement and installation/operation expertise, and a bibliography for further research. The students considered heat, air, and moisture transmission through the walls, seeking to protect the historic fabric while increasing thermal performance.

The infrastructure study posited that a number of green design strategies would work best if they were employed on a block-by-block basis. Storm water management and geothermal energy systems work better in "infrastructure parks," where the open space required could be created by pooling the setback areas of many lots into a more usable commons. The students found that the densities in Over-the-Rhine made completely off-the-grid "infrastructure parks" feasible only if they occurred very frequently and occupied about 50 percent of the developed land area. Eventually, the Integrated Design Team's desire to make the study as economically realistic as possible prevailed, and the students found that infrastructure parks were not feasible without a considerable subsidy.

The Impediment Study

The graduate students thoroughly researched the impediments to sustainable historic conservation, which had originally been developed in the undergraduate studio, and alternative strategies were developed for each. The students found that conserving the energy embodied in extant buildings is a lesser-known aspect of sustainable design and is consistent with historic preservation principles. They believed that tying the preservation movement to the green movement helps to make preservation projects more marketable to both the consumer and to the design and development communities.

It was clear to the students that the passive strategies built into pre-WWII buildings are often misunderstood; frequently, these features were disabled or removed during postwar "modernizations." The students recommended keeping passive features as functional as possible. For example, where transoms are not allowed to be operable due to code, one should consider adding electronic controls that close the transoms in the event of a fire or employ a ventilation

system that can pressurize the stairs or other common spaces. Contemporary users know very little about how to operate the buildings they inhabit; all would benefit from some building-systems education. The LEED commissioning process should be extended to include the maintenance and operation of a building's character-defining historical elements, such as its awnings and shutters, as well as its active systems. Permanently affixed educational material is desirable to ensure appropriate maintenance and service of the building over time.

The student research team identified a number of architectural elements designed to modulate light, temperature, and humidity. Dormers, light scoops, and skylights are excellent ways to light interior spaces without affecting the character of the building when seen from the street. Unfortunately, new insertions of these older technologies are often prohibited by historic preservation design guidelines. The graduate students argued for the alteration of these restrictive guidelines to permit these elements on non-contributing facades, as long as the designer makes it clear that the new elements are not historic, but complementary. Nineteenth-century structures often contain a great deal of plenum space within their walls; originally, these were intended for gravity-driven heating and ventilation systems. These spaces can be exploited for plumbing chases or for high-velocity forced-air and energy-capture systems. Because the installation of active sustainable systems can compromise the historic fabric of the building, it is important that experts in green systems and historic preservation work together to identify the challenges the new systems will present to the historic fabric.

Some challenges with greening older structures are inherent in their design. The addition of sustainable features such as solar arrays may require structural reinforcement of the building. In Cincinnati, local code requires that an extensive structural investigation be undertaken whenever there is a net increase in dead load of 5 percent or more. This greatly discourages green roofs, as the additional engineering work is often perceived as leading to the reconstruction of the roof itself. These fears can be allayed by point loading the additional weight of photovoltaic panels or vegetated roofs, which can limit the extent of new structural reinforcing. It may also be possible to make some material substitutions where the original roofing material is no longer serviceable or is considered hazardous; these substitutions could help to reduce the structural loads on existing buildings.

Windows are often a flash point between historical values and energy conservation. All too often, the original windows in a structure are sacrificed in the name of energy efficiency. The students' research suggests that if the original wood sash is salvageable, one should reglaze the window with double-paned or low-E glass. When paired with storm sash, these repaired windows perform nearly as well as new double-paned windows. Given the number of windows in Over-the-Rhine requiring restoration or replacement, existing building trades job-training programs could stay busy for years refurbishing the neighborhood's historic windows while putting money back into the local at-risk economy.

Perhaps the most difficult issue to reconcile between historic preservation values and rating systems like LEED is that of the energy performance of the building's exterior envelope. These standards require that exterior solid masonry walls be insulated, but in situations where both the exterior and interior surfaces of the wall are historic, it is impossible to add insulation without compromising historic integrity. In Over-the-Rhine, the three-wythe masonry wall—R-value of 1.32—is the typical condition. There are also many buildings whose party walls were designed to be thermally protected by a neighboring building but now stand open to the elements because of an adjacent demolition. The Integrated Design Team recommended that newly exposed party walls be furred out with battens, insulated with rigid insulation, and parged—this can be detailed to ensure that the work is reversible. In other cases, the exterior wall is historic and must be left exposed, although it should be painted to protect the surface of the brick (Morgan and Matts 2009, 43). The common impulse in these situations is to insulate the interior of the wall and lay drywall over the insulation. In windowless party walls, this approach often works well, with minimal loss of historic fabric. But often both the interior and exterior surfaces are historic, as with

the Clay Street building. In these cases, the student research found that it may be better to tighten up the windows and insulate the floors and attics rather than to insulate the walls. This finding was surprising to the Integrated Design Team, and so the Over-the-Rhine Foundation hired architect Sanyog Rathod, AIA, LEED AP, to create energy models of the Clay Street building and the Belmain building, an Over-the-Rhine apartment house (Fig. 14), to determine whether those buildings could meet LEED standards without compromising the historic walls.

Rathod's research showed that selective improvement of the building's envelope can bring it up to the minimum standard without sacrificing the exterior walls or most interior surfaces. Rathod and his modeler, Chris Dwyer, created three energy models for each building—the first assumed no changes to the uninsulated walls and single-paned windows. The second model presumed that storm windows were affixed to the windows and that two inches of rigid insulation and drywall were built out into the interior. The third model assumed the most energy efficient windows available and 3.5 inches of insulation under drywall. Rathod ran performance simulations to develop an efficiency rating called a Home Energy Rating Score (HERS).[14] With the Belmain building, Rathod established that storm windows and a mere 1.5 inches of rigid insulation were enough to improve the building's HERS score from 102 to a LEED-acceptable 84. Rathod found "that 7/8" to 1.5" furring, use of a rigid or foam insulation layer, and surface drywall will permit a property to reach minimal standards of energy performance for LEED certification with minimal impact on historic character" (Morgan and Matts 2009, 77). If a more historically accurate interior finish is to be maintained and plastering needs to be reconstructed or repaired, the addition of a vapor retardant film along with increased airspace between the masonry and lath also raises the R-value significantly and will improve the building's performance.

Where furring out the walls is impossible, as at the Clay Street building, other improvements can be made that can bring a building into compliance with LEED. Using the same three scenarios as with the Belmain building, Rathod found that the Clay Street building earns a HERS score of 159 in its current, raw state and that minimal furring of the walls and the addition of storm windows could bring that score down to 84, exactly that of the Belmain building. However, if one wished to leave the bare brick walls intact, Rathod found that by installing very high efficiency HVAC equipment (16 SEER, 92 percent efficiency), high-end replacement windows (U=0.19), and greater-than-typical insulation to the ground floor and attic (R25 insulation to the basement ceiling and R49 insulation in the attic), the Clay Street building could achieve a HERS score of 85, the minimum required by LEED at the time of the study (Rathod 2008). Rathod's analysis supports the prevailing ethic of the entire research enterprise: existing, sound historical finishes can and should be retained wherever possible to reduce the embodied energy of the project by eliminating the use of new materials. Where sustainable materials and finishes are introduced into a historic building, they must be sensitively employed. This means that

Fig. 14. Belmain building, 1204 Main Street, Cincinnati, Ohio.

they should not replace historic fabric or mimic the historic appearance of the original materials. Instead, contemporary additions to a building should frankly read as such, be fully reversible, and contribute to, but not obliterate, the history.

LESSONS LEARNED

The specific buildings examined in this study were not rehabilitated as anticipated in early 2008. As in much of the rest of the nation, funding for real-estate development in Cincinnati dried up in mid-2008, just as the study was concluding. The buildings on Clay Street and Vine Street remain as they were in 2008—both have been stabilized, and their owners are committed to their eventual rehabilitation. Construction did begin on the rowhouse development on Pleasant Street during the undergraduate studio; these units were successfully marketed in 2009 and 2010. The building at 1420 Pleasant Street was remodeled into condominiums with little regard for the remaining historic fabric, and some of these units remain unsold as of this writing.

In the months that followed the student investigations, the professional members of the Integrated Design Team wrote their own report, which evaluated the studio work and offered both improvements to the designs and strategies for further improving the energy performance and feasibility of the projects (Morgan and Matts 2009). The report, coordinated and prepared by Michael Morgan and Michael Matts of Gray & Pape, a Cincinnati-based cultural resources management firm, came to several general conclusions.

The first was that all the projects could meet both basic LEED certification and the Secretary of the Interior's standards while remaining within acceptable cost structures for the Cincinnati area. While the students' appraisal of the LEED points earned by their interventions were in some cases overly ambitious, there was no question that all the projects would be LEED-certified if rehabilitated as designed. The historic preservation goals were less likely to be realized, as they are privately owned residential projects, and it is unlikely that the Secretary of the Interior's standards would be rigorously applied to them. The historic preservation experts were also concerned that many of the innovative design ideas proposed by the students, such as the roof terrace at the Clay Street property, would likely be denied a certificate of appropriateness by the City of Cincinnati's Historic Conservation Board under a strict interpretation of the OTR Historic District design guidelines.

The Integrated Design Team report also determined that existing building condition, historic use, planned adaptive use, market factors, and costs are closely linked with historic tax credit certification, green design, and code compliance. Design decisions that have a positive benefit on one side of the ledger, say for energy efficiency, may very well have a negative consequence for historic integrity. A balance among the various competing interests must be achieved to ensure a successful outcome. For this reason, the report also stressed that an interdisciplinary team that works well together is essential to making "green" historic preservation a success. The team must be assembled early in the project, work closely with local code officials and SHPO personnel, and remain in place through construction in order to meet the documentation requirements of both LEED and the U.S. federal historic preservation tax credit. The interaction among the members of the Integrated Design Team was the most rewarding aspect of the project. Each person made a contribution to the whole, and each design choice could be examined from several points of view simultaneously. Therefore, the Integrated Design Team model can serve as a model for any project that attempts to coordinate the interests of sustainability and historic preservation.

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Associate professor Jeff Tilman researches and writes on the history of American architecture between the Civil War and World War II, focusing on the first decades of the twentieth century. A registered architect, Tilman's interest in historic preservation stems from a conviction that preservation is a part of architectural practice and that no work of architecture is fully successful unless it addresses

its pre-existing social, political, physical, and historical context. Professor Tilman has taught at the University of Cincinnati since 2000, delivering course work in architectural history, preservation theory, and building conservation. He has also led a number of graduate and undergraduate design studios in adaptive reuse, urbanism, and traditional architectural composition.

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ENDNOTES

1. For example, under the direction of Mayor Mark Mallory and with the support of the city council, the City of Cincinnati Office of Environmental Quality issued in June 2008 the fourth update of the "Green Cincinnati Plan," which set ambitious goals for the city with regard to sustainable redevelopment. The plan clusters 82 specific goals into six main categories: Transportation, Energy, Waste, Land Use, Food, and Water. The most far-reaching goal statement requires the city to reduce its greenhouse gas emissions by 2 percent per year for 42 years (City of Cincinnati Office of Environmental Quality 2008). The city has also become a "Climate Showcase Community," winning an Environmental Protection Agency grant for an innovative sustainability messaging initiative called "What's Your Green Umbrella?," which encourages citizens to learn of sustainable strategies and the work of Green Umbrella, the Cincinnati Regional sustainability consortium (City of Cincinnati, Office of the Mayor 2011). Just this past spring, in April 2012, Cincinnati became the first major American city to offer 100% "green electricity" to its households, reducing the city's dependence on coal-fired electricity generators (City of Cincinnati, Office of the City Manager 2012).
2. Over-the-Rhine was named for the German-American community that settled north of the Miami-Erie Canal, nicknamed the "Rhine" for its seeming resemblance to the German frontier.
3. The Greening Over-the-Rhine project was made possible by funding from the Ohio State Historic Preservation Office's grants program for certified local governments.
4. The Integrated Design Team was assembled by Michael Morgan, executive director of the Over-the-Rhine Foundation. Members of the IDT included: Greg Badger of Urban Sites, Inc, Developers; Chad Edwards, LEED AP, of Emerson Design, Architects; John Faneslow of Third Sun Solar & Wind, HVAC consultant; Amit Gosh, building inspector with the City of Cincinnati; Steve Hampton of Hampton & Associates, Architects; Ralph Jacob of Jacob Bros. Heat & Cooling, HVAC engineer; Ken Jones of Ken Jones & Associates, architect; Michael Matts, Gray & Pape, cultural resource manager; Dean Niemeyer, urban planner for the County of Hamilton; Sanyog Rathod of SOL Developments, architect; and Margo Warminski, architectural historian for the Cincinnati Preservation Association.
5. Neal R. Peirce (1981) went so far as to proclaim the energy crisis of the late 1970s "Preservation's Windfall." Ironically, the Glencoe Place project on Mount Auburn in Cincinnati (immediately north of Over-the-Rhine), used to illustrate Peirce's study, is no longer the vibrant community-funded rehabilitation project that the trust celebrated in 1980. Today, the rows of late nineteenth-century townhouses sit foreclosed upon and abandoned as repeated attempts to rehabilitate them to contemporary expectations have failed.
6. ANSA/ASHRAE/IENSA 2006; 2007. This standard was employed as a part of the LEED evaluation, even though the projects for which it was employed were in the end designed to be entirely residential in program. A further complication in the application of these standards was that they are comparative in nature—this was extremely difficult in this study because the buildings had not been occupied for many years, in some cases decades, and thus there were no energy performance histories available.
7. The students participating in the spring 2008 studio were: Maria Bergh, Zach Fein, Kaitlyn Ferncez, Wade Hart, John Hoebbel, David Hoffman, Lauren Karsten, James Kehl, Eric Lindsay, Sean Lyons, Joseph McGovern, Kendra Pochadt, Elizabeth Schultz, Peter Schultz, and Sarah White.
8. In evaluating the studio designs for LEED compliance, the students initially employed the LEED-NC 2.2 rating system, but as their designs developed, they chose to apply the then-fledgling LEED for Homes rating system and the pilot version of LEED for Neighborhood Development. The final LEED score sheets (much too lengthy to be published here) and the SOI assessments can be found in the published report of the Over-the-Rhine Foundation (Morgan and Matts 2009).
9. All the project buildings earned at least 10 of 14 Sustainable Sites points and 12 of 13 Materials & Resources points on the LEED-NC v. 2.2 point schedule.
10. The LEED for Homes point totals for the Vine Street project were: 7 points for Innovation and Design Process; 10 points for Location and Linkages; 20 points for Sustainable Sites; 9 points for Water Efficiency; 4 points for Energy and Atmosphere; 6.5 points for Materials and Resources; 20 points for Environmental Air Quality; and 1 point for Awareness and Education (Morgan 2009, Appendix B).
11. The LEED for Homes point totals for the Clay Street project were: 6 points for Innovation and Design Process; 10 points for Location and Linkages; 17 points for Sustainable Sites; 3 points for Water Efficiency; 4 points for Energy and Atmosphere; 4 points for Materials and Resources; 6 points for Environmental Air Quality; and 2 points for Awareness and Education (Morgan 2009, Appendix A).
12. The LEED for Homes point totals for the Pleasant Street project were: 6 points for Innovation and Design Process; 10 points for Location and Linkages; 19 points for Sustainable

Sites; 4 points for Water Efficiency; 4 points for Energy and Atmosphere; 2.5 points for Materials and Resources; 13 points for Environmental Air Quality; and 1 point for Awareness and Education (Morgan 2009, Appendix D). Although the project did meet Energy Star requirements, and thus certification, it earned no exceptional performance points because the interior walls were to remain uninsulated. Sanyog Rathod's analysis (discussed later in this article) suggests that high-efficiency HVAC equipment, quality windows (no historic windows remained), and solid floor and attic insulation could earn the project the exceptional performance points needed to achieve silver certification.

13. The students who participated in the summer 2008 seminar were: Peter Ekama, Nikki Fannin, Janice Fredwest, Chantel Hall, Chris Jolley, Mike Kocher, and Laura Mosca.
14. This score is expressed as a ratio of energy consumed by the building divided by the energy consumed by a reference standard created in 2004, multiplied by 100; thus, a home that consumed twice as much energy as the reference standard would have a HERS score of 200, while one that consumed only 50% of the reference would earn a HERS score of 50.

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