

# ACHIEVING DEEP ENERGY RETROFITS IN HISTORIC AND MODERN-ERA BUILDINGS



Wooster Hall, looking north as sunlight strikes the steps of the atrium, marking solar noon.

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## LEARNING OBJECTIVES

After reading this article, you should be able to:

- + **ASSESS** the sustainable potentials and limitations of an existing building of historic/cultural significance.
- + **PRIORITIZE** the overall active and passive design strategies within the physical limitations and the historic/community values of a given setting.
- + **DISCUSS** a daylighting strategy that combines the use of direct and diffuse daylight and thermal loading attuned to functional need.
- + **ANTICIPATE** the future life of the building in transition to sustainability and generate an “anticipatory” design to support the implementation of that vision.

**T**he high-performance retrofit of an existing building is more difficult than building new because the structural system, orientation, and massing—the first tools in the architect’s kit—have already been used. Moreover, the deep affection often associated with existing structures that possess cultural and historic significance presents even more resistance to high-performance design—the fear that the process will require massive modification of “untouchable” community assets. Yet this critical segment of the built environment represents a vast reservoir of sustainable potential and carries with it our society’s multi-generational heritage.

Saving an existing structure avoids the embodied



energy required to harvest, fabricate, transport, and erect the materials for the new building, but we often forget that existing structures are also served by an extant network of walkways, roadways, and utility infrastructure that can be saved or even optimized in an informed process of reuse. Historic structures are often located in downtown or “old town” areas, making them candidates of the first order for higher urban density and the avoidance of suburban sprawl.

Our firm recently executed two quite different projects—Iredale Mineral Cosmetics International Headquarters, a reimagining of an abandoned 130-year-old school in Great Barrington, Mass.; and Wooster Hall at SUNY New Paltz, the transformation of an outdated Brutalist science building—in an effort to untie this apparent Gordian knot of high-performance objectives in historic/cultural contexts.

Success in projects like these requires an entirely different mindset than in new construction. The design team must gain a deep understanding of the building’s historic/cultural value as well as how the existing built and natural systems are uniquely juxtaposed and interacting on the site. Only then can the team achieve the highest and best performance outcome: a deep energy retrofit that delivers the greatest net value within what already exists.

#### These projects raise three questions of interest:

- 1 | What is the order of the design priorities in undertaking a deep energy retrofit of a building of historic/cultural merit?
- 2 | Where do such projects fit within the larger societal goals of sustainability, net-zero carbon (NZC), and net-zero energy (NZE)?
- 3 | What performance potentials are achievable as a result?

#### MAKING USE OF THE GIFTS OF NATURE

Although LEED and the Living Building Challenge present guidance in the realm of opportunities on site, neither framework fully addresses all the unique natural systems potentials that can be achieved in the redesign of an existing structure and its site. We can harvest sunlight to heat water and generate electricity via photovoltaics, but the most efficient use of solar is in the displacement of electric lighting with daylight. Currently, the reach of daylight is calculated as penetrating twice the head height of the window into the floor area in calculations by LEED, or 15 feet, 0 inches by most building codes. This is a vast area of unrealized potential.

In both case studies, all regularly occupied

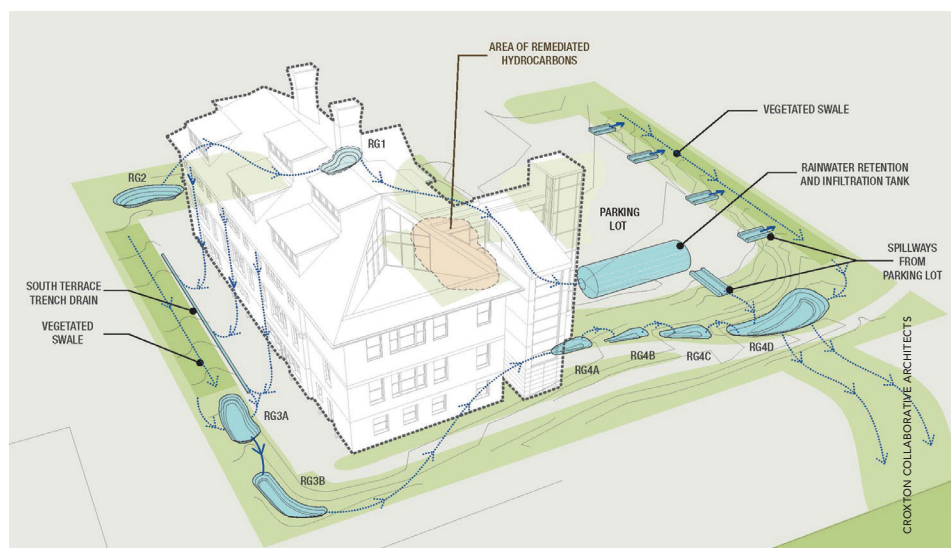


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spaces (as well as corridors and stairways) receive natural light, even if they don’t meet the light level threshold to qualify as being “daylit” under LEED (25 footcandles at 30 inches above finished floor). This flows from a rigorous incorporation of all “free” passive assets on site before tapping into high-technology systems. In such cases, we also take advantage of the sun’s derivative characteristics of thermal loading and offloading via materials on and around the existing building in the night/day (diurnal) and seasonal cycle. Exterior walls and



**Bryant School’s exemplification of the Arts and Crafts style prompted the design team’s creation of a free-standing glass elevator/stair tower bridging over to a minimally impacted exterior of boulders and wood shingles. Below: The site has been reshaped to achieve universal access, rain gardens, and visually shielded building equipment.**



roofs are advanced beyond code to near-passive house levels: R-35 for the walls, R-50 for the roofs. In this sense, you could say that the first design problem is to accomplish, through ceiling geometrics, material selection and juxtaposition, interior open space, and transparencies (skylights and clerestories), a Mesa Verde or Canyon de Chelly for the 21st century.

This approach—“passive before active”—has particular applicability in retrofits where you can prepare the building shell 100% for a sustainable future pathway, knowing that the active energy systems incorporated today have a relatively short life span and can viably transition to renewable fuels in three to five years or be changed out for fully sustainable systems within the next 20–30 years. Recasting the entire building envelope at a later

date is far more difficult, and the lack of resilience in the short run undermines the fundamental viability of the building.

**HUMANISTIC AND RESILIENT**

There is a deep biological value when daylight is expressed in its variability over the course of the day and from season to season. Floor-to-ceiling windows cannot achieve this combination of passive wall performance and deep daylight without generating heat and glare. Both of our case studies use shaped ceilings and multiple re-reflective surfaces to eliminate glare and achieve deep daylighting and connectivity to the passing of the day within occupied spaces. This capture of daylight to offset or supplement electric light also introduces the variability of a natural source, such as clouds

passing in front of the sun and variations in the color and angle of light, recreating a dynamic quality within which we as humans thrive. In this sense, a day in the building is a day in nature.

The failure of building codes and LEED to recognize the value of low levels of daylight within buildings—even a couple of footcandles—goes against the reality that the human eye can perceive the smallest unit of light (1 photon) and detect the light of a candle 1.6 miles away. The resilience and inherent safety of a building that provides low daylight levels throughout, even though it may be less than the IECC minimum of 5 footcandles, is vastly more resilient than a building interior that goes black in a crisis, when battery storage and emergency lighting may be dead.

Both examples incorporate south-facing terraces (outdoor rooms) whose paving and adjoining masonry walls passively absorb and re-radiate heat, extending their comfortable use into the spring and fall. In both cases, a row of deciduous trees provides shading during the summer.

**PRESERVING MEMORY, SETTING LIMITS**

The first step in projects like these

**TABLE 1. CONSTRAINTS AND OPPORTUNITIES IN TWO CONTRASTING PROJECTS**

	<b>BRYANT SCHOOL</b> (Iredale Mineral Cosmetics International Headquarters)	<b>SUNY New Paltz Wooster Hall</b>
<b>Regional sustainability</b>	Significant potential for intensification of use within Bryant’s existing footprint/volume (basement/attic).	Significant areas for intensification and expanded function were available on the long north and south faces looking out to the Old Main and Sciences Quads.
<b>Urban design</b>	Three exposed elevations with views from the street led the design team to concentrate new construction/interventions on the east end of building (interior to the site).	Open/safe exterior connectivity to the ground level of Wooster’s west end via the new stairway was established to lead up to the Sciences Quad. Two new urban-scale entries now mark the access through a skylit atrium to connect the Old Main and Sciences Quads via the “sun calendar” stairway.
<b>Site potential</b>	Significant flexibility in regrading for Sustainable Sites objectives and flood risk mitigation (the site abuts the Housatonic River) provided the opportunity to visually mask the high-tech components (condensers, emergency generator, transformer, etc.).	Extension of the Sciences Quad elevation at grade directly into the second floor of Wooster was achieved. The integration of landscaped/terraced planting and seating at the new grand exterior stairway and rainwater irrigation feeding down from the roof complete the interconnectivity of site to building. The south soffit/shading was extended along the entire south elevation, creating a shaded “porch” looking out on the Sciences Quad.
<b>Solar/thermal signature</b>	Unobstructed south exposure drove the interior organization of all large spaces and outdoor rooms.	The north elevation (low thermal/soft light) is home to the building’s large labs and office space for Student Services. A three-story exterior “prow” provides a north-facing overlook and connection to nature from all levels to Old Main Quad.
<b>Exterior shell and identity</b>	Critical to maintain. Only minimal interventions necessary for viable reuse were permitted.	Wooster’s footprint and massing were retained as important urban design elements. Because the Brutalist façade was in an on-going state of failure, there was little support within the SUNY New Paltz community to undertake the extensive modifications necessary for a full restoration to meet current building and energy codes. This scenario created an extraordinary opportunity to retain about 96% of the concrete thermal mass within a new high-performance thermal envelope/rainscreen exterior wall.





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is to establish the inherent value of the building as a historic/cultural asset and thereby determine the degree to which preserving its existing features will inform the design process. This discipline sets the boundaries within which all new technologies and passive design modifications can operate. The key is to harness all remaining strategies within these limits to achieve the high-performance objectives—for example, modifying the surrounding grades for site work or making use of underutilized volumes within the structure (attics, high roof volumes, basements, etc.)

The goal is to exhaust all remaining options that may introduce daylight; to increase density and use the available volume within the building; and, wherever possible, to incorporate all viable high-performance technologies that can fit within the established limits of visual disturbance.

The two examples closely bracket the range of interventions from minimum to maximum that one might anticipate in a deep retrofit project. See Table 1, page 52.

### IREDALE MINERAL COSMETICS INTERNATIONAL HEADQUARTERS

The former William Cullen Bryant School (1889) had significant historic/cultural standing with the community of Great Barrington, the Great Barrington Historical Society, and the Massachusetts Historical Commission, which named it a Massachusetts Cultural Resource. Located on

a downtown corner lot, the 21,000-sf structure presented its north, south, and west elevations to the surrounding community and displayed the distinctive signature of the Arts and Crafts movement: a first-floor exterior wall comprised of local boulders forming the dramatic base of the building.

### SUNY NEW PALTZ WOOSTER HALL

The former Wooster Science Building (1967), an outmoded Brutalist-style building, was slated to be converted into a multiuse academic building housing two academic departments, Student Dining and Lounge, and the offices of Student Financial Services. The SUNY New Paltz community was originally divided regarding interventions on the building. Some called for its demolition; others wanted to preserve this early exemplar of Brutalism.

A range of performance and code issues came to the fore as the building's fate was being decided:

- Large areas of the exterior were poured-in-place concrete that was continuously connected to the interior beams and concrete floor, forming a giant thermal bridge.
- The exposed concrete was deteriorating due to moisture infiltration and the effects of freeze/thaw.
- Multiple level changes and stairways throughout the interior were not compliant with ADA or building codes.
- Rooms were isolated into separate concrete “pods,” which severely reduced the flexibility for

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**Three newly expressed building blocks anchor Wooster Hall to the site in this view of the southwest boundary. Cascading stairs, seating, and landscape connect to the upper Science Quad at right. The south-facing glass bar above provides a seasonally shaded porch along the south elevation. The three-story glass tower marks the east/west daylight atrium cutting 236 feet through the interior. The tower incorporates overlooks at levels 2 and 3 and marks the entry to the Dining Hall at level 1.**

changes in future planning and interior layouts.

- Wayfinding was poor—a common complaint in Brutalist structures.

The original plan and massing of the building formed the southern boundary of the Old Main Quad (directly accessible at the ground-floor level) and the northern end of the Sciences Quad (directly accessible at the second-floor level). No public space or stairway connected the quads through the building. The lone exterior stairway connecting from the west end of the building up to the Sciences Quad had a “blind” sequence that prevented students from seeing a threat or obstruction at the intermediate landing—which today we recognize as an unsafe pathway.

The first exercise in developing a passively smart and resilient building is to map the solar dynamic on each of its four elevations. Both case study buildings are rectilinear in plan with their long axes running east-west. Each elevation—the short east and west and the long north and south—receive direct sun for a specific duration during the year coming from a continuously variable direction in plan and a continuously variable vertical angle in section.

This awareness of the unique “signature” loading of each face, of the variable duration across the seasons of the year, framed within the local climate is the wisdom that informed all architecture prior to the modern era. This is the wisdom we must reacquire if we are to achieve sustainable—and therefore resilient—architecture today.

The following five performance objectives have been addressed in very different ways, given the unique constraints and opportunities of the Bryant vs. Wooster Science buildings:

### 1 | Perimeter/Boundary Conditions

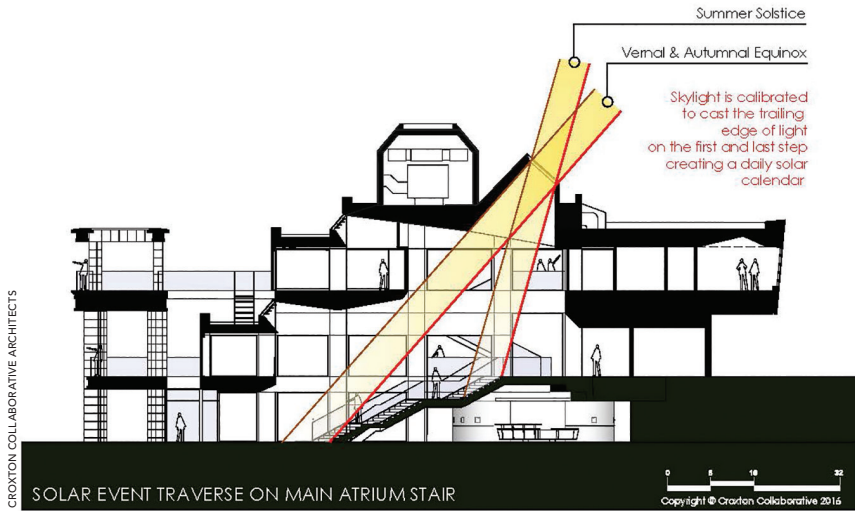
**BRYANT SCHOOL:** Excavation along the south perimeter brought daylight into new functional spaces (IT, lunchroom, pantry) on the basement level adjoining a new full-length terrace with stone pavers opposite the stone boulder south wall. This strategy extends the warmth and comfort of this “outdoor room” into the spring and fall.

**WOOSTER SCIENCE:** With greater flexibility for change, the cantilevered portion of the third floor was extended the full length of the south elevation, creating space for new faculty offices as well as a summer-shaded, winter-warmed solar exposure at ground level.

### 2 | Thermal Envelope

**BRYANT SCHOOL:** A high-performance insulating layer was applied on the inside face of the exterior walls and roof. Existing windows were retrofitted with high-performance glazing. The existence of the wood exterior/interior structural system meant that there was no thermal bridging to contend with.

**WOOSTER SCIENCE:** The greater flexibility for the exterior envelope led to what envelope expert Joseph Lstiburek has referred to as the “perfect wall”: a membrane applied directly to the concrete exterior wall; then, insulation; finally, a terra cotta rainscreen system. The concrete thermal mass becomes a building-within-a-building that stabilizes temperature swings and preserves and extends comfort conditions for a day or two in the event of a power failure.



CROXTON COLLABORATIVE ARCHITECTS

SOLAR EVENT TRAVERSE ON MAIN ATRIUM STAIR

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Section looking east through the main atrium. The direct beam of light creates the solar noon event, followed by the skylight (with parallel fins) acting as a gigantic indirect solar light fixture, shielding glare at the source but maximizing re-reflection to create diffuse, no-glare light.

The large concrete thermal mass of Wooster now serves the retention of energy and stabilization of comfort conditions within the building should there be a loss of power. Existing built-in daylight overhead clerestory slots from west to east have been carefully refitted to provide full solar traverse in the labs and dining spaces. A solar calendar calibration skylight marks solar noon, the equinoxes, and summer solstice at the atrium stair.

### ACHIEVING PERFORMANCE OBJECTIVES

While the high-performance natural gas mechanical systems employed in both projects have much in common and serve as stepping stones to a future NZ carbon transition, it is the much more permanent design envelope, the apertures, and the resulting pathways of light and thermal exchange in the two buildings that are the solid foundations on which future sustainability success can be built.



### 3 | Deep, Diffuse Daylight

**BRYANT SCHOOL:** Existing windows were upgraded. The interior ceiling geometries were significantly reshaped to re-reflect the diffused sunlight passing through translucent/solar shades along the south office perimeter. This created the opportunity to gain effective ambient light for the work environment without introducing direct beam light.

**WOOSTER SCIENCE:** A new east-west daylighting spine—three stories deep for most of its length—created the central pedestrian pathway. A calibrated solar skylight marks the summer solstice and the vernal and autumnal equinoxes by registration on the main atrium stairway. Through the use of wavelength-selective glass, horizontal louvers, light shelves, and ceilings that slope downward from the clerestory tops on the north wall exterior, the individual labs can achieve fully day lit academic spaces. Lowering the north lab window scrims dims the light level to 12 footcandles for note taking during A/V presentations. (Note: While selective solar beam light is allowed to traverse and animate the public circulation and dining areas, only diffuse light penetrates the learning spaces.)

### 4 | Daylight and the Interior Plan

**BRYANT SCHOOL:** The interior spaces look to the south. The largest, most open areas are organized with the ceilings sloping up to the south with the low point of the north-south ceiling intersection shifted to the north. In the original 1886 layout, the classrooms were on the south, with the massive brick chimneys shifted to the north.

The one option we could exploit for daylight within the massive volume beneath the steeply pitched roof was the original dormer windows. In opening up this previously unoccupied space, we gained approval for multiple additional dormers, primarily oriented south, with a single, modern, window/terrace/conference room facing east (not visible from the surrounding north/west/south view shed). While we used only diffuse light on the lower office/studio spaces, we introduced direct beam light and light shelves into the upper reaches of the high attic-ceiling.

**WOOSTER SCIENCE:** All sloping ceilings and major spaces look to the north. Original clerestory windows on the north side of the second and third floor run the entire 251-foot length of the building. We tapped into them in unique designs for labs, the main atrium, the dining area, and a third-floor conference room. The result provides a great insight into the underrated power of north

light and its friendly applicability (if properly tamed) to learning environments.

In studying Wooster's structural bones, we discovered a three-story slot that could easily be exploited to create a similar building-length necklace of skylights receiving south light (direct beam) that would traverse a three-story wall aligned with the back wall of the labs. This completed the full distribution of daylight through Wooster.

### 5 | Photovoltaics, NZ Carbon, and NZ Energy

**BRYANT SCHOOL,** with a base case energy consumption of 144.2 kBtu/sf/yr, is projected to achieve 77.3 kBtu/sf/yr, a 46.4% improvement over ASHRAE 90.1-2007. Due to historic restraints, Bryant will only be able to achieve net-zero carbon by incorporating remote dedicated PVs. Bryant increased its net usable square footage by 75%, from 12,000 sf to >21,000 sf.

**WOOSTER SCIENCE,** with a base case energy consumption of 96.3 kBtu/sf/yr, is projected to achieve 61.1 kBtu/sf/yr, a 36.6% improvement compared to ASHRAE 90.1-2007. The project added 3,500 sf of usable space.

Wooster has a future pathway to advance toward NZ carbon. Under such a transition, the current campus-wide heating contribution (district heat) of 12.6 kBtu/sf/yr would be accounted for by an on-campus photovoltaic array. Our design for Wooster can then incorporate a 435 kW photovoltaic array with tailored openings to preserve daylighting performance. This combination would bring the building to 81% of the net-carbon-neutral target.

Bryant has been awarded LEED Gold. Wooster is in review for LEED Gold. Both have qualified for the AIA 2030 program via the Code Equivalency method. Neither project can achieve net-zero energy as currently defined.

An underlying theme runs through the design of these two retrofits. While they have not yet earned an NZ energy or NZ carbon designation, they demonstrate that, operating within current benchmarks for cost/sf, a foundation of solid passive design can often be achieved, even in historic building retrofits.

In the longer term, with the next change-out of their systems, they are positioned to advance to even higher levels of sustainability and resilience.



BOTTOM: CCA1 TOP: © 2016 TIM HURSFLEY



The original lab spaces (above) followed the 1960s notion that learning spaces should have no views to the outside. New labs (top) incorporate horizontal louvers and a light shelf to redirect light upward. All daylight-sensing fixtures run parallel to the outside wall and reinforce the natural priority of a lighted canopy overhead.

#### + EDITOR'S NOTE

This completes the reading. To earn 1.0 AIA CES HSW learning units, study the article and take the exam posted at [www.BDCnetwork.com/DeepEnergyRetro](http://www.BDCnetwork.com/DeepEnergyRetro)