BROWN UNIVERSITY

Successfully Linking Brown's Past to a Green Future

PROJECT SNAPSHOT

PROJECTS
Renovation of the GeoChem building and construction of MacMillan Hall

TECHNOLOGY
Comprehensive resource efficiency in new and existing buildings

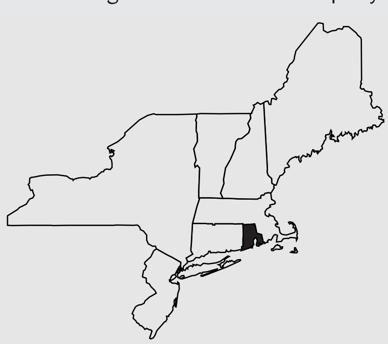
CO_2 EMISSION REDUCTIONS
Approximately 1,611 tons per year

INVESTMENT
$30 million for MacMillan Hall; additional investments in the existing GeoChem building

LESSONS LEARNED

- Inclusive, patient planning is key.
- Too much emphasis on up-front savings can raise long-term costs and produce a building that is less user-friendly.
- Including students in construction and maintenance decisions can create excellent teaching opportunities.

FUNDING SOURCES
A major gift from W. Duncan MacMillan, funding from the university's endowment and financial incentives from Narragansett Electric Company



INTRODUCTION

The planning and construction of a new building at a university – especially when resource efficiency is a key goal – presents myriad challenges. When that new building will house science laboratories, and has to be connected to an older, less efficient structure, those challenges multiply considerably. Safe chemistry labs, for example, require carefully designed indoor airflow. Hoods must be placed over student workstations to expel fumes from the building. Yet this safety requirement reduces the opportunity to recycle indoor air – while increasing air conditioning demand.

How, then, did Brown construct MacMillan Hall, a new, 75,000-square-foot lab and classroom building, attach it to the GeoChem building next door, and in the process save more than two million kilowatt hours (kWh) each year – enough to power about 560 average homes? The answer has a lot to do with learning, which is appropriate to an institution like Brown University.

THE PROJECTS

Brown's 125,000-square-foot Geologic Sciences and Chemistry Building was built in the early 1980's. As soon as GeoChem went into operation, facilities managers knew they had a problem on their hands. The building instantly became one of the largest energy users on campus, accounting for roughly eight percent of consumption. Students, faculty and maintenance staff consistently encountered problems in the use and maintenance of the building.

Today, the consensus is that the problems stemmed from a hurried and poorly-coordinated planning and construction process. First, high inflation in the early 1980's forced things onto a very fast track; indeed, planning and construction were undertaken almost simultaneously. Second, the process was driven by a need to minimize up-front costs. Finally, plans were drawn up without significant input from the faculty, staff and students who would use building, or from the facilities managers who would operate and maintain it. The result: more than a decade's work trying to address high levels of energy and resource usage at GeoChem.

Now flash forward. In 1992, Brown began planning for a new science building to be constructed adjacent to GeoChem. The lessons accruing from that earlier project covered a wide expanse, from the technical and engineering to the administrative. The latter, for example, focused on how a diverse group of interested parties within the university community could better contribute to a more coordinated planning process.

Initial planning discussions brought to the table maintenance personnel, university faculty and staff, and representatives from Rhode Island's main electric utility, Narragansett Electric Company. Narragansett Electric offered incentives to customers like Brown who built energy efficiency into new construction. In this way the electric company could purchase a resource, energy efficiency, that in many cases was far less expensive than building new power plants or even operating the ones it owned. As planning proceeded, Brown students, particularly those from its growing Center for Environmental Studies, got involved.

From the outset, MacMillan Hall was to be a showcase of environmental responsibility – from basic design features like ventilation and window placement, to new technologies like highly efficient lighting. A strong connection was made to the University's primary mission, education. Students worked with Narragansett Electric and outside consultants to examine energy savings and payback periods for a range of different design and technology scenarios. Measures were chosen based primarily on energy savings and payback. They included high-efficiency fluorescent lighting systems with daylight sensors; variable speed drives in nearly all motors; and heating, ventilation and cooling systems incorporating a number of energy-saving technologies. Taking into account incentives provided by Narragansett

Electric, most measures paid for themselves within five years. Perhaps the most elegant design decision was connecting MacMillan Hall's chilling system to the existing system in GeoChem. Initially, the plan was to install two 450-ton high-efficiency centrifugal chillers in the new building. However, after analyzing the collective needs of both buildings, two 725-ton chillers were installed in MacMillan, and the two buildings' systems were connected. In addition to serving GeoChem, the chillers in MacMillan are large enough to serve adjacent university buildings when the underground piping system is expanded. This will further increase system efficiency.

THE RESULTS

Brown has kept detailed records of the investments made in the GeoChem building and MacMillan Hall, as well as estimated cost savings. These data are available on the Brown Is Green website listed below. The following table summarizes the energy, cost and CO_2 savings from energy efficiency investments made in the GeoChem building during 1990s. University staff emphasize the importance of the financial incentives provided by Narragansett Electric in creating the attractive payback periods of many of these measures.

The University started to collect data on MacMillan hall as soon as it opened, and compared it to planning projections. One study found that some systems were over-performing slightly while others were under-performing. On the whole, it was estimated that the building was saving 1,059,300 kWhs per year, or 97 percent of the energy it was projected to save, using standard building practices and technologies as a baseline. The study also explored possible reasons for each deviation from predicted performance, thus providing input for future construction planning.

Taken together, the changes to the GeoChem building and the efficient design of MacMillan Hall are eliminating an estimated 1,611 tons of CO_2 emissions a year, as well as 6.6 tons of SO_2 and 2.2 tons of NO_x.[3] In CO_2 equivalents, this amounts to avoiding the combustion of nearly 2,950 barrels of oil or taking 227 typical passenger cars off the road. The upgrade also helps save the earth's ozone layer. It employs R-134A refrigerant – which has minimal ozone depletion potential – in the MacMillan chillers. All of these benefits will grow when the piping system is extended to other buildings.

By insisting on a cohesive and integrated planning process that included students, faculty, architects and facilities maintenance staff, the project delivered two other benefits as well. It produced an extraordinarily efficient and safe set of science labs, and it has created a living laboratory – encompassing the entire structure – for the hands-on study of energy-efficient building design and resource conservation.

Table 1. Energy Savings from Retrofits in Brown's GeoChem Building[1]

Measure	kWh Savings	Annual Electricity Cost Savings	Net Simple Payback Period[2]	Annual CO_2 Reductions (tons)
Motion Sensors on Fume Hoods	124,867	$9,365	1.5 years	95
Variable Speed Drives on HV-1	142,253	$10,669	1.5 years	108
Lighting Occupancy Sensors	26,201	$1,965	1.5 years	20
Variable Speed Drives on Fume Hoods	319,019	$23,926	2.5 years	242
High Efficiency Motors	50,946	$3,821	3.2 years	39
Free Cooling Heat Exchanger	397,682	$29,826	1.5 years	302
Total	1,060,967	$79,573	---	806

LESSONS LEARNED

Hundreds of meetings went into planning MacMillan Hall. They included not only architects, designers, administration and faculty, but also students and – importantly – the custodians, plumbers and electricians who would maintain the building. "We were being asked questions about the details of what would go on in our labs," recalls Chemistry professor Ronald Lawler. "That never happened during [the planning of] GeoChem." In the end, the following were among the key elements that led to success:

- Inclusive, patient and coordinated planning, especially involving those who ultimately would use, operate and maintain the building.

- Willingness to look closely at the experience with the existing GeoChem building, and act on the lessons learned.

- Availability of funds (most notably Mr. MacMillan's gift) to support the higher up-front costs of the efficient systems.

- Technical support and financial incentives provided by Narragansett Electric Co.

FUTURE COMMITMENTS

Brown University is a signatory to The Talloires Declaration, an international voluntary agreement between university leaders and their stakeholders, as well as all signatory institutions of the Association of University Leaders for a Sustainable Future. The Declaration calls for restructuring higher education to ensure that all graduates are environmentally literate and thus able to participate in the process of thinking about and bringing about sustainable development. By December 2000, 279 individuals and institutions from around the world had signed the Talloires Declaration. The Brown Is Green ("BIG") program, described below, has committed most of its resources to reducing emissions associated with electrical generation. In the future, it also will focus on waste reduction efforts at new construction and renovation sites, and increase the visibility of the University's recycling programs.

THE INSTITUTION

Brown University is a private university of some 7,000 undergraduate and graduate students in Providence, RI. The school is funded by tuition, as well as by donations and bequests from alumni, and grants. During the 1980's and 1990's, interest in environmental stewardship grew significantly at Brown, as did the University's multidisciplinary Environmental Studies Program. In 1990, the school established Brown Is Green (BIG), an educational and advocacy program that links student research to all departments and administrative offices. The goal of BIG is to reduce the negative environmental impacts of the University's operations, while employing them as educational opportunities. Students, faculty and university staff work together in such areas as recycling, employee trip reduction (reducing vehicle-miles-traveled by employees), campus energy efficiency and the planning of new facilities. BIG also is active in the Campus Environmental Stewardship course, in which students work with the local community on urban environmental issues like lead exposure, urban planning and environmental justice. The course is team taught by the Environmental Studies faculty.

CONTACTS

Kurt Teichert
Director, Brown Is Green:
kurt.teichert@brown.edu

The "Brown Is Green" website:
www.brown.edu/Departments/Brown_Is_Green

[1] These estimated CO_2 savings are slightly different from those shown on the Brown Is Green website due to the use of different CO_2 emission factors.

[2] Net simple payback: "Net" means net of the utility rebate, and "simple" indicates use of constant (i.e., today's) dollars, which does not consider the time value of money.

[3] All emission reductions cited here are calculated based on New England regional marginal emission rates, provided by ISO New England. See Appendix A for a discussion of these calculations.

CLEAN AIR-COOL PLANET CASE STUDY RATING

This case study reduces CO_2 emissions equivalent to the following:

Avoiding the consumption of 8 barrels of oil per day.

OR Taking 227 vehicles off the road per year. (1 car = 20 vehicles)

Assumptions: 1,093 lbs of CO_2 per barrel of oil. Vehicles are average passenger cars (approximately 20 lbs CO_2 per gallon of gasoline – 22.5 miles per gallon, averaging 16,000 miles per year)