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Program Evaluation

198-2

Northland College's Environmental Living and Learning Center

September 2000

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Northland College's Environmental Living and Learning Center

A Process Evaluation of a Green Building

September 2000

Prepared by

Ingo Bensch

Prepared for

ENERGY CENTER
OF WISCONSIN

We show you how

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Abstract

This report presents findings of a process evaluation of Northland College's green dormitory – the Wendy & Malcolm McLean Environmental Living and Learning Center. As part of the evaluation, we interviewed college staff, consultants, and students familiar with the building and reviewed published reports about the building, including the results of the Energy Center's year-long monitoring of the building's energy performance. The building appears to be serving Northland College well, both as a student residence and a symbol of the college's environmental mission. The building encompasses an energy-efficient design, renewable energy systems, and the use of materials that are considered to be environmentally friendly. The energy performance of the building is due mostly to design, equipment, and materials choices that reduced the amount of energy required to heat the building. The building's renewable systems contribute only modestly to its energy performance, but they provide a visible icon of the building's green design. Experience with sustainable design by some of the project consultants and the college's commitment to a green design contributed to the successful construction of a green building. However, lack of experience with sustainable projects by other project team members, some communication problems, immature markets for green materials, and weaknesses in the commissioning effort provided challenges and, perhaps, some missed opportunities. The project has also resulted in public relations benefits for Northland College and its consultants and the prospect for the inclusion of sustainable elements in subsequent building projects by both Northland College and its consultants.

Report Summary

Northland College built a new dormitory on its campus in Ashland, Wisconsin, that has been cited frequently as an example of environmentally friendly, or "green," design. The Wendy & Malcolm McLean Environmental Living and Learning Center was completed in 1998 and features living space for up to 114 students within 40,000 square feet of gross floor area. Green features include the use of renewable energy systems and various design and material choices intended to reduce the energy consumption and environmental impact of the building.

The Energy Center of Wisconsin evaluated the building's design and construction process, as well as its performance. Results are presented in this report. Energy performance is also described in more detail in a separate report titled "Performance Monitoring of a Green Commercial Building at Northland College."

Building Performance

Overall, the Environmental Living and Learning Center appears to be performing its function well, both as a student residence and a demonstration project.

College staff are pleased with the building as a residence hall, giving it an overall grade of B. Students reported that it is a desirable place to live, largely because of its newness and amenities. The building has also served Northland College well as a demonstration project that highlights the college's environmental mission to potential students, donors, and the general public. As a demonstration project, the building has yielded favorable press for the college in trade and regional publications and at conferences.

The building has been incorporated into some aspects of the college's educational goals. Past residents reported that the building's green features have not been consistently communicated to its residents or integrated into life in the dormitory, however. Several educational ideas have not yet been implemented due to lack of time and cyclical student interest.

The building's energy performance appears to have exceeded the design team's expectations. The design team established an energy performance goal of 65,000 BTU per square foot for a somewhat smaller design of the building, which is 40 percent lower than the energy consumption of the same building modeled to meet Wisconsin's energy code. Actual energy consumption of the building during a one-year monitoring period that ended in March 2000 was 51,500 BTU per square foot at an occupancy rate of 75 percent. Adjustments to the ventilation system during the monitoring period should allow for even lower energy consumption in the future.

Design, equipment, and materials choices affecting the building's space heating accounted for a large part of the efficiency gains of the building. These include high insulation levels for walls, ceilings, and windows; heat recovery; and an efficient boiler. Other significant efficiency measures included efficient water heating equipment, efficient lighting, and occupancy controls.

The renewable energy systems contribute only modestly to the energy performance of the building. The building's wind generator and solar photovoltaic system provided approximately six percent of the building's energy needs during the monitoring period, and its solar water heating system reduced the water heating load of the building somewhat. The renewable systems performed poorly when evaluated solely based on financial

savings from energy generation or savings. However, their visibility and popularity among Northland College's constituency make them an effective icon of the building's green design and the college's commitment to environmental education. As such, they have provided public relations benefits to the college.

Although the environmental performance of the building has not been formally evaluated, an informal review by project participants suggests that the building would qualify as a bronze level building under the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) standard. This level suggests that the building carries a lighter environmental footprint than the average conventional building.

Green Building Design & Construction Process

Overall, the design and construction process for the ELLC resembled those for many conventional buildings, and the problems encountered by the project team tended not to be related to the building's green features. For example, poor communication between some project team members led to some design problems that needed to be rectified later, and a rush to finish the project before students moved in resulted in numerous "punch list" items that needed fixing during early building occupation.

Green building elements were not immune to problems, however. The wind power system's inverter failed during the first year of service, an experimental resin used on countertops weakened when it got wet, and compact fluorescent bulbs have been burning out faster than expected.

The building design process appears to have resulted in a green design and building, as defined by the U.S. Green Building Council's LEED standard. Several project team members we interviewed complimented the contributions of two design professionals on the team with prior experience in green and energy efficient design. Despite the use of some experienced green designers, however, the effort did require additional research and design time.

Project team members noted that earlier involvement by various players would have been helpful and might have improved the design further. For example, one project team member joined the process in mid-design when his suggestion concerning a revised orientation for the building to maximize passive solar gain could only be incorporated partially. Involvement of more project team members in the design process could also have brought other benefits, such as better communication among team members and a better common understanding of project goals within a team that included professionals with and without prior green experience.

The construction process itself did not differ much from that of conventional buildings, but three aspects of the construction phase offered some challenges related to the ELLC's green aspects:

- The general contractor reported that procurement of some specified materials was more difficult than for comparable conventional materials because they are more difficult to find and tend to involve greater mark-ups.
- Recycling of construction materials was at times difficult to implement because it was new to the construction crews and teams on site changed over time.

- Expectations concerning attention to detail and general construction practices differed between project design professionals and some members of the construction team, which may suggest that green construction requires higher levels of quality than sometimes found in conventional construction.

Commissioning of the building did not appear to live up to its potential. The commissioning team did not find some design and construction problems that project team members thought it should have identified, while some commissioning findings were not acted upon. As a result, this project did not serve as an effective demonstration of the commissioning process. Members of the commissioning team noted that the scope of their involvement was not ideal, as they were brought into the project after the design had been completed, were given limited scope and authority, and exited the process earlier than normal commissioning process would dictate.

Building Cost

Northland College staff report that the building project cost $4.2 million, or $105 per square foot of gross floor area. Construction costs totaled approximately $3.7 million, while design and other project costs accounted for the remaining $0.5 million. Information provided by project participants suggests that the marginal cost for green design and construction was $230,000, or slightly more than five percent of total project costs. Overall, project costs appear to be within the range of normal costs for student housing.

Nevertheless, it appears that some members of the Northland College board have been left with the impression that green construction is substantially more expensive than conventional construction. This perception may be the result of the increase in construction costs from the initial budget of $1.5 million to $3.7 million (due largely to non-green changes in the project scope and initial underbudgeting, according to some members of the design team). Whatever its cause, this perception would need to be addressed if Northland College were to initiate another green building project.

Building operating costs, on the other hand, have benefited from the building's green design. Energy savings (compared to Wisconsin energy code) were approximately $18,900 during a one-year monitoring period. The long-term effect on maintenance costs is not yet known, but short-term maintenance costs have been in line with the college's expectations.

The prevailing perception among those who participated in this project is that the college did receive a good value for its money, both from the building as a functional structure and as a green showcase. The most valuable aspects of the green design appear to be the public relations value and the energy efficiency.

Broader Project Effects

The ELLC project appears to have had some effects beyond those inherent in the completion and use of the building. Northland College staff indicate that the college has taken two steps toward greener and more energy efficient projects due, in part, to their experience with the ELLC. The college's board approved a resolution that establishes a building process based on a green design guide and process, and the college intends to bring the project's energy consultant into the design process of subsequent projects. However, the college has taken only limited steps to incorporate green design into projects that are currently in progress or initial planning.

Design and construction professionals involved in the project reported that:

- the attention the building has received as a green demonstration project has provided public relations benefits to their firms;
- their involvement was financially worthwhile (all, but one respondent); and
- the project resulted in relationships that have led to additional business or other professional benefits (for two firms).

Design professionals with past green experience indicated that their experience with the ELLC has added to their base of experiences and resulted in some refocusing of subsequent green projects. Design and construction professionals with little or no past green experience reported greater awareness and some limited use of green approaches in subsequent projects.

Introduction

Northland College, an institution of higher learning with a strong environmental studies program, completed a sustainable (or "green") dormitory on its campus in Ashland, Wisconsin, in 1998. Green design is a small, but growing field in the commercial building industry that blends consideration of the environmental and human health effects of building design, construction, operation, and deconstruction into the building process. Northland College's new dormitory, known as the Wendy & Malcolm McLean Environmental Living and Learning Center (ELLC), is one of a small number of green buildings in Wisconsin and has been showcased as an example of green design and construction.

The Energy Center of Wisconsin became involved in this project in early 1997 as part of its program to research and facilitate green commercial construction in Wisconsin. Ultimately, the Energy Center's role in the project encompassed:

- partial funding of an energy consultant during the building design process;
- funding of a commissioning agent for the building construction process;
- a year-long metering effort to document the energy consumption of the building and the generation by its renewable energy systems; and
- a process evaluation to identify lessons learned and communicate them to a wider audience of actual or potential green practitioners.

This report reports the results of the process evaluation. Separate report sections address the following topics: evaluation methodology, building description, building operation and performance, design process, construction process & early occupancy, building commissioning, building costs, and broader effects of the project. Conclusions and lessons that may be transferred to other green projects are included at the end of the appropriate report sections.

Building Description

The Environmental Living and Learning Center encompasses 40,000 square feet of gross floor area on two floors and a partial basement. The building can house up to 114 students in three wings, but occupancy in 1999-2000 was only about 85 students. Northland College staff indicated that the building was completed to accommodate future growth.

The layout of the building resembles an obtuse "L" shape with a north and south wing connected by a center wing. The building features double rooms, suites, and apartments, as well as four lounges, five seminar/dining rooms, four kitchens, a laundry area, a recycling center, storage, and mechanical rooms.

The building includes design elements and material choices intended to reduce the energy consumption and environmental impact of the building. These choices include:

HVAC

- high-efficiency natural gas boiler for space heating
- passive solar design in the south wing
- heat recovery units in the building ventilation system
- high efficiency motors
- absence of air conditioning
- operable windows to allow natural ventilation

Envelope

- cellulose attic insulation (R-value of 45)
- fiberglass and foam wall insulation (R-value of 25)
- low-emissivity windows

Lighting

- high efficiency light fixtures - T-8 lamps in hallways and compact fluorescent bulbs in other common areas and student rooms
- motion sensor lighting controls for common areas

Indoor Air Quality

- low VOC carpet (limited areas)
- low VOC paint
- organic-based linoleum flooring (also an environmental feature)

Resource Minimization

- low-flow showerheads and toilet fixtures
- two waterless, composting toilets
- engineered structural lumber
- construction-site waste recycling
- recycled content toilet partitions

Renewable Energy Systems

- 20 kW wind generator on a 120-foot tower
- 3.2 kW in photovoltaic solar panels
- solar thermal water pre-heating

Other

- high efficiency appliances
- milled white cedar shingles harvested regionally
- furniture made from recycled milk jugs and recycled steel
- bio-composite material in selected countertops
- low-maintenance masonry exterior
- high-efficiency natural gas water heating (with solar pre-heating)

The initial design goal was to exceed the Wisconsin energy code requirements by 40 percent through energy efficiency measures and another 10 percent through the generation of electricity from wind and solar power, as well as solar preheating of water for domestic consumption. Actual energy and environmental performance are reported below.

Project cost totaled $4.2 million, which includes design, site preparation, construction, equipment and furniture, parking lot installation, and landscaping.

Method

The evaluation consisted primarily of face-to-face interviews with nine members of the ELLC project team and several building occupants. Interviewees included:

- two Northland College staff who were active participants in the building project – the director of student development and the facilities director;
- two other Northland College officials who are familiar with the project – the vice president for finance and administration and the director of public relations;
- the two lead project architects;
- the general contractor;
- the renewable energy contractor;
- two representatives of the commissioning team; and
- five students who have lived in the dormitory.

Interviews were conducted by Ingo Bensch in February and March 2000. Interview guides are included as the appendix.

Additional evaluation activities included a tour of the building; informal conversations with several of the project participants; and review of documented analyses of the building, such as the Energy Center's metering report, the commissioning report, and various academic papers and promotional materials about the building.

Results

Building Operation: Performance & Function

Building operation encompasses the use of the building for its intended purposes and the performance of the building's systems. We explored both of these aspects of the building.

ELLC as a Student Residence

The primary function of the Environmental Living and Learning Center is as a student residence, and it appears to be serving this function well. Northland College staff indicated they would give the building a grade of "B," indicating that the dormitory has a good reputation on campus and expressing overall satisfaction with the building's appearance and current operation. A member of the commissioning team also commented that, overall, the quality of the building was good.

Brief interviews with five past and present residents suggests that Northland College students perceive the ELLC as a desirable place to live. The dormitory has become a desired on-campus residence, largely because of its newness and the amenities included in its design, such as the public kitchen and lounge areas. Residents were generally pleased with the performance of the building, although several past residents remarked that the building was not ready for occupancy when students first moved in for the 1998-99 academic year.

Early problems with the building will be discussed in an assessment of the construction and early occupancy of the building. Most of the early problems have been resolved, leaving only a small number of lingering issues, such as:

- uncertainty whether the building meets ventilation code at night as it is operated;
- the lack of an override for a motion sensor in a meeting room;
- the rapid burnout of compact fluorescent bulbs in circuits controlled by occupancy sensors; and
- a soy resin on bathroom countertops that is not holding up satisfactorily in wet conditions. (One of the project team members indicated that the use of the resin was an experimental material choice that was chosen with the expectation that occupants would make some efforts to keep the countertop dry, but it appears that there was either insufficient communication with building residents or a lack of follow-through by the residents.)

ELLC as a Demonstration Project

The building also appears to be working well as a demonstration project by providing positive public relations to the college, although opportunities to integrate the green aspects of the building into life in the dormitory have not been fully developed. College staff indicated that the initial drive to incorporate green elements in the new dormitory came from students who argued that the college ought to "walk its talk." An institution that portrays itself as a leading environmental liberal arts college needs to demonstrate its commitment to environmental and sustainable concepts, they argued. As the building plans developed, the college also developed plans to integrate the building into its educational process.

College staff believe that the Environmental Living and Learning Center provides a visible icon that demonstrates the college's environmental mission and provides valuable public relations benefits. The college has featured the building on promotional materials sent to both potential new students and donors and has showcased the building in tours of the campus. One college staff person indicated that the wind turbine and solar installations are particularly helpful in public relations efforts because they are highly visible parts of the building, adding that first impressions are critical for prospective students, who often make up their minds about an institution within their first ten minutes on campus. The college has also received favorable press in trade and regional publications and at conferences at the initiation of other project team members, including the design firms.

The educational goals for the building have led to the development of a course on sustainability, which includes the building in parts of its curriculum, and monitoring of the building's energy performance by residents in the building's four "environmental" apartments. However, past and current residents indicated that residents of other parts of the building are not necessarily aware of most of the green features of the building, such as material choices, energy-efficient design, and environmentally sensitive construction practices. Housing staff do not generally introduce residents to these features when they first move in, and the college was slow to post information in the building about its green features. College staff indicate that there are plans to conduct more education of residents, but several educational ideas have not been implemented yet due to lack of time and cyclical student interest.

ELLC's Environmental & Energy Performance

As the construction of a green dormitory became one of the project goals, the project team made some efforts to define this goal more explicitly, documenting its intention to build a building that provides a healthy environment for its occupants, minimizes environmental impacts, and conserves energy. The design team also established quantitative energy performance goals based on a similar, hypothetical building designed to just meet Wisconsin energy code requirements. The team intended to build a building that used 40 percent less energy than this comparison code-based building (50 percent when renewable generation is included in the equation).

Environmental Performance

The environmental performance of the Environmental Living and Learning Center has not been formally evaluated, but an informal review by college staff suggests that the building would qualify as a bronze level building under the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) standard. (LEED classifies qualifying buildings into one of four levels: bronze, silver, gold, and platinum.) One member of the commissioning team who is familiar with the LEED standard corroborated that the building would probably qualify as a bronze-level green building, adding that LEED tends to set a high standard so the bronze level is an accomplishment.

Energy Performance

The Environmental Living and Learning Center's energy performance underwent close scrutiny as part of the Energy Center's involvement in the project. CDH Energy Corp. conducted comprehensive monitoring of the building's energy consumption and renewable generation during this period and found that the building consumed 186,600 kWh and 14,200 therms, or a total of 51.5 kBTU/ft2 (site energy), during a one-year period

ending in March 2000. Several adjustments to the building during the monitoring period – most notably, changes to the ventilation system – are expected to further reduce consumption by 25 percent.

As shown in the table below, the building's energy consumption compares favorably to both the design goal and a proxy of the Wisconsin code established for an early design of the building. The design team established a project goal of 64 kBTU/ft2 based on a desire to exceed Wisconsin's energy code by 40 percent and a computer model that of similar building designed to code that would have consumed 109 kBTU/ft2. Both of these standards were based on full occupancy of a smaller design of the ELLC, however, so the savings implied by this comparison may be overstated.

Table 1: Energy consumption: standards, goals, and actual (all units are kBTU / ft^2 / year.)

	Heating	Fan, pump	Water heating	Lights	Equipment	Total***
Code-based building*	57	6	15	19	12	109
Design goal*	26	6	10	11	12	64
Actual**	26	5	10	4	7	52

* Based on an earlier, smaller design of the building (no basement, 27,000 ft2)

** Measured values for the actual building (partial basement, 40,000 ft2) with an occupancy rate of approximately 75 percent; March 1999-March 2000

*** Totals may not equal the sum of the parts due to rounding

Various energy efficiency measures, especially those related to the building's heating needs, provided these energy savings. The monitoring contractor concluded that the increase of insulation levels of the wall, ceiling, and windows above those required by code provided the single largest efficiency measure. Other significant efficiency measures included the heat recovery of exhaust air, the installation of efficient boilers for space and water heating, reduced lighting power, and occupancy controls.

The renewable systems provided some additional "energy savings," although these were comparatively small, as shown in the table below. The solar water heating system reduced the amount of natural gas needed to heat water for three apartments located in the building, displacing 29 percent of the water heating need for these apartments. The wind and photovoltaic systems did not reduce energy consumption, but provided 6.0 percent (3.7 percent wind, 2.3 percent photovoltaic solar) of the electricity that would otherwise have been purchased and taken from the grid. It should be noted that wind power generation did not reach its potential during the monitoring period because of equipment problems. The annualized rate of wind power generation would have been 5.4 percent of the building's electricity consumption if the system had been fully functional during the entire period.

Table 2: Energy savings and renewable generation March 1999 – March 2000

Source	Savings*/Generation (1000's of BTU/ft^2 – site energy)	Percentage
Efficiency measures	57.0	97.4%
Wind & solar power	1.0	1.7
Solar water heating	0.5	0.9
Total	58.5	100.0%

* Savings compared to a computer model of a similar building designed to Wisconsin energy code requirements.

Payback periods for all three renewable systems were comparatively long: 55 years for the wind generator, 174 years for the photovoltaic system, and 119 years for the solar thermal system despite the use of free equipment. However, it should be noted that the renewable systems were designed not only to generate output, but also for educational purposes and to serve as a demonstration project. One project team member pointed out that output could have been maximized (and payback periods reduced) with the off-site installation of a single, larger wind turbine. However, the project team chose the existing mix of renewable systems to also provide visibility, reuse existing thermal solar panels, and better allow integration of the systems into the college's instruction.

The installation of solar water heating illustrates this balancing of multiple objectives. Northland College had access to existing solar panels at no cost, which provided an opportunity to include previously used equipment in the building. From a generation standpoint, however, the use of solar water heating in a dormitory is not optimal because the solar panels provide their greatest output during the summer while the building use is much reduced. The use of the panels, however, allows the college to reuse existing equipment and demonstrate how solar water heating systems work.

The energy monitoring results also illustrate the potential effect of occupants on a building's energy consumption. The amount of hot water used in four similar apartments differed substantially with a range from 22,700 gallons to 41,000 gallons, suggesting that energy consumed for water heating varied by the same proportions due solely to occupant behavior. However, these numbers have not been adjusted for any possible differences in official or actual occupancy rates.

More detailed results from the monitoring efforts are available in a separate performance monitoring report.

Occupant Health

The building design included several measures to ensure healthy indoor air for building occupants. Building materials, paint coverings, and adhesives were selected for their low-VOC properties, so that release of volatile organic carbons during early building operation would be minimized. Ventilation was provided both mechanically by the HVAC system and manually through the installation of operable windows.

The Energy Center's energy monitoring project included analyses of VOC and carbon dioxide concentrations in the HVAC system's exhaust air. The monitoring began too late to measure any initial release of VOC by the

building's low-VOC materials, wall coverings, and adhesives. The concentrations of carbon dioxide in the exhaust air indicate that the building was generally well-ventilated, both before and after the HVAC fan was replaced.

Conclusions and Transferable Lessons

The Environmental Living and Learning Center is performing largely within the college's and design team's expectations. The building has become a popular residence hall among students and makes a visual statement about Northland College's focus. The building's energy performance exceeded design goals, and its green design suggests that it bears a lesser environmental impact than conventional counterparts. Use of the building as an educational tool has developed more slowly than envisioned because of lack of time and cyclical student interest.

The building demonstrates that green design can bring public relations benefits to the building owner. The concept of environmentally friendly buildings appeals to the design community and the broader population, yet green buildings are still relatively uncommon. The combination of these factors provides opportunities for owners of green buildings to garner positive attention with modest efforts, possibly even at the initiation of others with a stake in the building. Such positive attention can be valuable for building owners who are trying to portray an environmental image or whose constituents value environmental ideals. Visibly green design elements and independent assessments of the building are particularly helpful for public relations efforts. Visible design elements set the building apart from conventional counterparts, while independent assessments lend credibility.

Energy efficiency measures were a substantially more effective way to increase building performance than the renewable systems. Energy-efficient design measures helped the building achieve good energy performance, which reduces operating costs and the environmental effect of the building. In comparison, the building's renewable systems provided only modest economic and environmental benefits with long payback periods that would have made them infeasible for most building owners. The visibility of the wind tower and solar cells, however, has made them effective icons that describe the nature of the building.

Decision-Making and Design Process

Design team members described the design process itself as being fairly standard, although some major changes in the project scope did affect the process and the decision-making was more complex than normal. The green nature of the project required additional research and trade-offs, but the inclusion of green elements proved to be a smaller complicating factor than some other issues that arose.

Process

The Environmental Living and Learning Center did not begin as a green building project, but evolved into one during the planning process. Early plans called for a low-cost conventional building at another location. However, during the planning process, Northland College and the design team changed the building location and made design choices that upgraded the quality of the building and added amenities. In addition, students began to speak out for the inclusion of green aspects. College officials listened to the students' call for "walking

the talk," and sifted through a student-developed "wish list" of 60 green building features with the design team. Some of these ideas were incorporated into the building.

The design team initially consisted of Hammel Green and Abrahamson, Inc., LHB Engineers & Architects, and a northern Wisconsin-based general contractor, but the shift in the building design resulted in changes in the design team. Most notably, The Weidt Group and Great Northern Solar were added for their expertise in energy analysis and modeling and renewable energy, respectively. In addition, the two primary design firms – one of which had some prior experience with green design – took some steps to familiarize themselves with green design issues. The project's commissioning agent, Dorgan Associates, Inc. – hired by the Energy Center – did not join the team until construction was already underway.

The changes in the building design also resulted in a revised estimate of construction costs of $4.2 million, which was much higher than the initial construction budget construction of $1.5 million. The cost increases – due primarily to non-green features and initial underbudgeting, according to two design team members – had several effects on the project, including:

- prompting revisions in the design to reduce the construction cost to approximately $3.7 million,
- delaying the project while the Northland College board sought additional funds from contributors, and
- opening up the selection process for the general contractor to a bid, which caused the initially selected contractor to be replaced by the Frank Tomlinson Company after design was completed.

Project Team Observations

Project team members indicated that the building design resulted in a successful building project, but the team encountered several challenges during the design process. The most serious challenges appear to be process issues that were unrelated to the green goals of the building. A number of project team members indicated that communication and coordination with some members of the design team was difficult at times, in part because of the distance of one of the design firms to the project site and the number of firms involved. Examples cited by project team members include:

- Engineering designs appeared to conflict with the project team's intent, resulting in (1) the installation of a fixed speed fan in the HVAC system that moved too much air and eventually needed to be replaced and (2) the connection of the solar water heating system to too few bathrooms.
- Landscape architects developed plans that would have interfered with utility lines for which plans had already been completed by another firm.

The green goals of the project appear to have produced a good design with only moderate effects on the design process itself. Project team members were complimentary of the energy-related design features suggested by The Weidt Group, saying the firm's expertise in this area had been very helpful, and citing the green materials choices made by LHB Architects & Engineers. Nevertheless, several project team members thought that the project design could have been improved if the full project team had been involved throughout the process. For example, one project team member was brought into the process in mid-design when his suggestion concerning a revised orientation for the building to maximize passive solar gain could only be incorporated partially.

Although one architect developed a one-page statement of project goals, members of the commissioning team felt they should have been involved during the design process in order to document the design intent more fully. These goals would then have served as criteria in the decision-making process and provided context for project

players who joined the team later. The need for well-defined project goals at the beginning of the process was echoed by one other member of the design team.

The involvement of a variety of members of the Northland College community – including student development staff, facilities staff, members of the administration, trustees, faculty, and students – received mixed reviews. On the one hand, some project team members lauded their involvement as helpful in ensuring that the building met the needs of its users. On the other hand, at least one team member felt that the large number of players complicated the decision-making process. In a related comment, some Northland College staff felt that it would have been helpful for the college to have had a dedicated representative with an explicit responsibility to oversee the design and construction process, rather than the loose assortment of staff who were involved in the actual project.

The design choices required to make this building "green" did require more research and more conscious trade-offs than for a conventional building. One of the design firms had some prior involvement in green design, but both primary architects spent some time familiarizing themselves with green design issues. Furthermore, some specific design choices required research concerning their practicality (e.g., local availability, feasibility for this project, etc.). Others involved difficult trade-offs between project goals. For example, the project team considered the use of a copper roof that would have allowed the use of locally mined material and enhanced the longevity of that building component. However, environmental concerns about the mining process and cost considerations prompted Northland College to choose asphalt shingles with some use of locally harvested cedar shingles as an accent. Decisions like these required additional time by the design team and prolonged the design process.

Other relevant comments about the design process from project team members included:

- Northland College's decision to earmark $100,000 for renewable energy systems proved to be instrumental in ensuring that renewable energy systems were included in the project despite the unexpected cost increases of the building.
- The Wisconsin building code proved to be a barrier to three green ideas that were considered: the reuse of laundry water, reliance on natural ventilation, and the replacement of bathroom stalls with composting toilets. (Composting toilets were added to the building anyway, but they could not be used in place of some of the number of toilets required by the code.)
- The presence of one or more advocates (or champions) for green construction proved to be critical to the development of a green strategy for the building and this strategy's survival through the design process.

Conclusions and Transferable Lessons

The design process for the Environmental Living and Learning Center suggests that design processes for green buildings need not be radically different from conventional approaches. However, as with other custom-designed buildings, the design of green buildings requires clarity concerning project goals and communication among project team members. An early decision and commitment to design a building in a "green" fashion can reduce the extent of design revisions needed later. Clarity concerning the project team's priorities and definition of "green" can help to reduce the complexity of subsequent design decisions.

Northland College's experience also suggests the benefit of design teams that include a certain amount of green experience and involvement by a wide range of project team members. As noted, the project team for the Environmental Living and Learning Center was rather complimentary of the input provided by the project's

experienced energy consultant and the materials choices by a project architect with prior experience in green buildings. At the same time, project team members consistently suggested that more involvement by the major players in the design process – perhaps coupled with a more focused approach by the building owner – would have led to a better project design. Involvement of more project team members in the design process could also have brought other benefits, such as better communication among team members and a better common understanding of project goals within a team that included professionals with and without prior green experience.

Building Construction and Initial Occupancy

Although the Environmental Living and Learning Center was built as a green building, the issues encountered during the construction process and early building occupancy tended not to be related to the green aspects of the building. However, differing understandings of what it means for a building to be "green" and differing levels of experience with green construction by those on the construction team became evident during this part of the project.

Building Construction

The construction phase of the project began in 1997 and involved the general contractor, the renewable energy contractor, various subcontractors to both the general and renewable energy contractors, Northland College staff, the major design professionals, and the commissioning agent. The general contractor and the commissioning agent did not join the project team until the design phase was complete and the construction phase was ready to begin.

Responsibilities for construction were divided among the general contractor and the renewable energy contractor. The renewable energy contractor was responsible for the wind and photovoltaic systems located next to the building, the solar water heating system located on part of the building, and the composting toilets in the south wing of the building. The general contractor was responsible for the building itself and all other green features, including mitigating measures to reduce the environmental impact of the construction process itself. As noted above, the renewable energy contractor was involved in the later stages of the design process, but the general contractor was not. Nevertheless, the general contractor indicated that the green goals of the project were clear from the start.

The general contractor indicated that the construction process itself did not differ much from that of a conventional building, stating that the biggest differences were the team's construction-site recycling efforts and the need to search for different materials. Admittedly, the recycling efforts were slow to begin because the construction workers were not used to recycling construction waste and were reluctant to implement the recycling program. Over time, construction-site recycling did increase, according to a construction team member, and the construction crews began to understand and embrace the concept.

Procuring the design's material specifications proved to be a challenge for the general contractor. He noted that the location and purchase of local, sustainably harvested wood, in particular, proved to be difficult, adding that a lack of vendors makes it difficult to find these materials and causes mark-ups beyond those for conventional material. Use of these materials on site, however, did not require the construction team to deviate from usual construction or installation practices.

Other project team members offered a more cautious assessment of the construction process. Several other team members questioned whether the recycling program ever became truly effective, noting that crews on site changed as the building progressed and recycling seemed to ebb and wane through these transitions. Others perceived some reluctance from the construction team in project team meetings and in the nature of the substitution requests submitted. Furthermore, the insulation subcontractor was replaced because the company's work was not of sufficient quality, thereby compromising one of the project's green goals.

Early Occupancy and Quality

The building opened its doors to residents in late August 1998, but several team members noted that the building project had fallen behind schedule and construction work continued for several weeks after occupancy. Early student residents echoed the sentiment that the building was not yet complete. We did not systematically explore the causes of the project delays, but one team member commented that the project timeline was managed more loosely than most projects of that size.

As a result of a "rush to finish the project," the building yielded a 60-80 page punch list of items that needed to be addressed subsequently. Northland College staff indicate that these items tended to be "fit and finish" issues, such as cracked walls, poorly installed carpets, and valves that were installed backwards. Mostly, they were not related to any of the green aspects of the building.

However, one of the renewable energy systems did encounter some equipment problems. The wind system's inverter failed in the fall of 1998, causing the wind system to be inoperative until mid-1999.

Most of these initial problems have been rectified, leading to a building that receives positive marks from the project participants, including the commissioning agent, and from student residents.

Conclusions and Transferable Lessons

The most problematic issue to arise in the construction process appeared to be the rush to finish the project in time for the beginning of the 1998-99 academic year, which contributed to a seemingly long punch list of items that needed to be finished or improved. Neither the delays nor the punch list items appeared to be disproportionately related to the green nature of the building, however.

The composition of the ELLC project team and lack of communication may have hampered, at least somewhat, the implementation of green design choices and construction practices. The consultants and contractors on the team came to the project with a wide range of prior green experience, as well as a range of demonstrated commitment to green practices. These differences appear to have led to differing expectations between the design team members and the construction team and to deviations from the designers' intent in the implementation of some green practices and goals. To some extent, these problems can be overcome through the selection of project team members with prior green experience and the involvement of all key project team members – especially any with little green experience – in the design phase of the project.

Commissioning Process

The Energy Center provided funding for a commissioning agent as part of its work to research, demonstrate, and provide training on building commissioning. However, the scope of the commissioning process was limited by the late addition of the commissioning agent to the project team and by budget constraints. The commissioning agent did not begin work on the project until construction had already begun, and the process was limited to:

- a retroactive review of the design process;
- limited documentation of the design intent;
- participation in construction team meetings; and
- on-site inspections of the building at various phases of the construction process.

Several project team members seemed to question the value of the commissioning process. In particular, they expressed disappointment that problems such as the initial overventilation by the HVAC system and the ongoing burning out of compact fluorescent bulbs were not identified by this process. One Northland College staff person indicated that the commissioning process also did not result in useful system documentation of the HVAC system and other building systems, which often falls within the scope of commissioning projects.

Members of the commissioning team agreed that the value of this commissioning process was limited by the reduced scope of the process and their late entry into the project. The absence of the commissioning agent from the design process appeared to be particularly detrimental to the commissioning process. The final commissioning report highlighted many instances in which the design intent was not clearly documented and not obvious to the commissioning team members, leaving them unable to determine whether the design was consistent with the project's intent. Members of the commissioning team indicated that this lack of clearly documented design intent also made it more difficult for them to identify potential problems, such as overventilation by the HVAC system. Further, this lack of documentation may also have limited the construction team members' understanding of the design intent.

The commissioning agent did identify some problems related to the building's energy performance, occupant comfort, and system documentation while the building was still under construction, but none of these findings appeared to lead directly to changes in the construction process itself. In at least one case – deficiencies with the insulation and vapor barrier – another member of the project team was already aware of installation problems. In two HVAC-related findings – exposure of HVAC equipment to dust and debris and deficiencies in system documentation – project team members either disagreed with the commissioning team's assessment or chose not to pursue the issue.

One member of the commissioning team believed that the commissioning agent lacked the authority needed for a successful process and that Northland College was not as committed to the commissioning process as a direct client would have been, noting that the college was reluctant to approve or request any changes that might affect the timeline or cost of the project. In contrast to most commissioning projects, the commissioning agent was hired by a third party with the consent of the building owner, so the owner may never have fully bought into the concept of building commissioning.

Conclusions and Transferable Lessons

The commissioning process for the Environmental Living and Learning Center provided only limited benefit to the project, in part because of limited resources and less than optimal allocation of these resources. It appears that the late beginning of the commissioning process diminished its value, as the commissioning agent was unable to influence the building design or glean clear objectives from the design documents for use in evaluating whether the building was being constructed in a way that would meet the project goals. Further, the lack of testing of building systems limited the process' effectiveness in identifying problems or suggesting improvements.

The commissioning process also did not serve as an effective demonstration of commissioning to project participants because expectations were not managed to reflect the limited nature of this commissioning process. Hence, Northland College staff expected the process to find problems that could not be identified by a commissioning process that excluded participation in the design process and testing of building systems.

The structure of the commissioning process also highlights one of the potential drawbacks of having a third party sponsor an add-on activity in a building project. As noted, time and financial constraints appeared to limit follow-through by Northland College. Nevertheless, the commissioning process was able to proceed because the process was free to the college. The value of commissioning in this project – and the likelihood of improvements to the project – might have been scrutinized more carefully if the building decision-maker also had experienced a financial stake in this part of the project.

Financial Analysis

There has been much interest in whether, and how much, the green nature of the building increased its first cost and decreased its operating costs. While there is no definitive answer to the green aspects' effect on first cost, there are some indicators and diverse opinions, which will be discussed in this section. Operating costs do appear to be lower, but the savings can only be approximated.

First Cost

Northland College staff report that the building project cost $4.2 million, or $105 per square foot of gross floor area. Construction costs totaled approximately $3.7 million, and design costs added approximately $250,000. Other miscellaneous project costs incurred by Northland College accounted for another $250,000. (In addition, the Energy Center of Wisconsin funded a limited commissioning of the building, whose $40,000 cost is not reflected above.)

Determining how the green aspects of the building affected project costs is difficult because the design team did not systematically compare and document the costs of green and alternative conventional approaches for the various building components. Members of the project team have made some attempts to analyze the marginal cost of having built a green dormitory, however.

One way to estimate the marginal cost of the building's green costs entails a component-by-component comparison of project costs to conventional alternatives and norms. As shown in Table 3, marginal costs for the green design and construction of the ELLC totaled approximately $230,000. An analysis by Northland College staff and the general contractor indicated that green choices added about $150,000 to the construction costs,

including $110,000 for the building's renewable systems. Design fees for the project were seven percent of construction costs, which is no higher than fees for conventional projects. However, the added services of the energy consultant and the commissioning agent added approximately $80,000 to the project cost.

Table 3: Project costs by type: conventional vs. green

	Construction	Design & Other	Total
Conventional cost	$3,550,000	$460,000	$4,010,000
Marginal cost for green design & components	150,000*	80,000**	230,000**
Total cost	$3,700,000	$540,000**	$4,240,000**

* Includes $110,000 for renewable systems (wind power, solar photovoltaic and thermal systems, and composting toilets) and an estimated net cost difference of $40,000 for all other building components.

** Includes $40,000 paid by the Energy Center of Wisconsin for building commissioning.

Two project team members have also compared project construction costs (excluding design and other miscellaneous project costs) to industry averages. In a project fact sheet, a lead architect compared the project's construction cost per bed of $31,578 to a median cost per bed for student housing of $30,000. Meanwhile, a college staffperson indicated that the construction costs per square foot of $92.50 fell about $10 below the national average for residence hall construction, as reported by in 1998 by American School and University in their annual residence hall construction report. These comparisons suggest that the construction costs were within the range of normal costs for student housing.

Nevertheless, some members of the Northland College board have been left with the impression that green construction is substantially more expensive than conventional construction, according to another Northland College staff person. This perception appears to be result of the increase in construction costs from the initial budget of $1.5 million to $3.7 million and the emphasis that the addition of the green goals has received. However, some project team members have indicated that these increases in costs were attributable mostly to initial underbudgeting and changes in scope and expectations for the building that were not related to the project's green goals, including the addition of a partial basement, the selection of better quality materials (such as brick and stone in place of wood or vinyl siding), and aesthetic features added to the roof.

Operating Cost

Building operating costs encompass primarily energy and maintenance. As noted, the building was designed to exceed Wisconsin's energy code and appears to be doing so by a substantial margin. The Energy Center's metering project found that the building consumed 186,600 kWh of electricity and 14,200 therms of natural gas over a one-year period ending in March 2000. Ninety-four percent of the electricity and all of the natural gas were purchased from Northern States Power Company, resulting in energy costs of approximately $15,700. We estimate that the building's energy cost would have been $34,600 if the building had been built to code with no renewable systems. Hence, energy savings were approximately $18,900 during the Energy Center's monitoring period. Future savings are likely to be higher as a result of several adjustments to building systems completed after the monitoring began. However, it should be noted that: (a) construction to code standards is a

requirement that many buildings exceed, and (b) the code-based energy consumption used in this calculation is based on an code-compliant version of a somewhat earlier design for the ELLC.

Northland College has not tracked maintenance costs for the building separately, but facilities staff indicate that maintenance costs have not stood out as being usually high or low. The only recurring deviation from expectations for maintenance staff has been the short lifespan of some compact fluorescent bulbs.

Conclusions and Transferable Lessons

The Environmental Living and Learning Center cost approximately $230,000 (or five percent of total project costs) more to design and build than a similar conventional building, according to information and estimates provided by project team members. The renewable systems accounted for $110,000 of this amount, while other design and construction costs added the remaining $120,000 (including some design/commissioning services paid by the Energy Center of Wisconsin).At the same time, Northland College representatives and others involved in the project believe that the college received a good value for the funds it spent on the building, both as a functional structure and as a green showcase. The most valuable aspects of the green design appear to be the public relations value and the energy efficiency.

Nevertheless, the perception remains among some decision makers for Northland College that the building did cost substantially more because of its green features. This perception needs to be managed and addressed in future green buildings by the college and others if green construction is going to be a sustainable approach to designing and constructing buildings. Detailed and independent cost analyses of a few green buildings would be helpful, especially buildings for which the financial implications of individual green elements were tracked during the design process.

Finally, it should be noted that the five percent cost premium for this building may be dependent on the upgrade in building quality that occurred during the design process. A low-budget building may incur higher cost premiums for green design and construction because similarly priced green alternatives may not be available for low-cost conventional materials.

Effects of the Project beyond the ELLC

The Environmental Living and Learning Center project appears to have had some effects beyond those inherent in the completion and use of the building. Project team members cited a number of benefits and changes in their practices resulting, at least in part, from their involvement with this project. These include: Effect on Northland College, business benefits to design/construction firms, and changes in approach by design/contruction firms.

Effect on Northland College

Northland College staff expect that the Environmental Living and Learning Center will have lasting effects on subsequent building projects on campus.

- The college was impressed by the work of the project's energy efficiency consultant and intends to bring this firm into the design process of subsequent projects.

- At its May 2000 meeting, the college's board approved a resolution that establishes a building process based on the Minnesota Sustainable Design Guide for future college buildings. This design guide is an instrument intended to assist in the development of environmental goals and strategies for building projects.

However, the college has taken only limited steps to incorporate green design into projects that are currently in progress or initial planning. The Science Hall currently being constructed, for example, will be highly energy efficient (a design that is 46 percent better than Wisconsin code), but will feature only limited amounts of green materials. Further, green design has not been included as a goal for a fine arts building that may be built in the next few years, in part because college board members believe that green design would cost more and not fit into the project budget.

Business Benefits to Design/Construction Firms

With one exception, the project's major contractors reported that their involvement in the project was financially worthwhile, and all felt it provided public relations benefits to their firms. The building was featured by the American Institute of Architects' Committee on the Environment as one of ten examples of "viable architectural design solutions that protect and enhance the environment" and received positive press in several publications.

Two contractors indicated they established relationships on this project that have led to additional business or other professional benefits.

Changes in Approach by Design/Construction Firms

All major project players considered their participation in this project to be a positive learning experience. Most believed that they are now better able to address green issues in any future green projects. One architect with prior green experience believes that his work on this project will save some research time on other green projects, but he would not be able to simply apply the same choices because the availability of green materials is continually changing.

To varying degrees, the project architects and the general contractor report continued and/or increased use of green techniques in subsequent projects.

- One architect indicated that he has continued to promote green design and include it in his projects wherever feasible, albeit with a revised focus. He now emphasizes energy efficiency, other green design elements with measurable advantages, and recyclable materials (over recycled materials).
- Another architect indicated that he now presents green options to clients more frequently.
- The general contractor reported a greater awareness of the environmental implications of construction practices and a heightened interest in construction-site recycling. The company's crew is recycling some materials in a current building project on Northland College's campus.

Conclusions and Transferable Lessons

The Environmental Living and Learning Center project appears to have had effects beyond those inherent in the completion and use of the building. Northland College's adoption of a green policy is a positive outcome of the project, but it is offset somewhat by the limited use of green features in current and future building plans by the college. The perception among some decision-makers that green buildings are substantially more expensive

than conventional buildings may account for the college's decision to implement only some green elements in these newer projects.

The project's major players reported some incremental change toward green design and construction in their approach. The three major players with a prior green disposition – Northland College, one of the architects, and the renewable energy contractor – have taken steps to build on their green approaches. The two major players with limited prior green disposition – one other architect and the general contractor – appear to have taken small steps toward a greener way of approaching their work.

The energy efficiency components of the Environmental Living and Learning Center appear to have had the greatest effects on future building design, in part because the energy consultant for the project was viewed by the project team as highly skilled and effective. The perceived expertise of this consultant – possibly coupled with the financial benefits of energy improvements – have motivated the college and project architects to make subsequent projects more energy efficiency.

Involvement by building professionals in this green project was generally good for business. Although one firm indicated that it lost money on the project, most of the major project players reported a profit, an expansion in their understanding of green design and construction, and positive public relations.

Policy Implications

A number of public and private organizations have promoted green design and construction practices both in Wisconsin and nationally. Northland College's experience with its Environmental Living and Learning Center holds some potential lessons for any public policies intended to promote sustainable construction and for designers and implementers of green building programs.

These potential lessons include the following:

- Green building programs should emphasize the public relations benefits of green buildings for their owners (especially those attempting to portray an environmental image) and for project team members.
- Perceptions concerning the cost of green construction present a barrier that needs to be addressed through cost analyses of additional green buildings and the communication of their findings to potential owners. Ideally, cost analyses would be integrated into the design and construction process.
- In states such as Wisconsin, where customer-sited renewable generation has limited potential to cost-effectively displace conventional generation, green building programs should emphasize efficiency measures over renewable generation as the primary strategy to reduce energy costs.
- Any third-party financial incentives for green design and construction should be structured in a way to ensure building decision-makers perceive a stake in the outcome of the design or construction element being supported by outside funds.
- The importance of clarity of goals and communication among project team members should be emphasized to building owners and design and construction professionals involved in green building projects.

- Green building program managers should promote and facilitate the inclusion of professionals with prior green experience on green building project teams and may wish to facilitate the inclusion of some without prior experience. (Experienced professionals increase the likelihood of project success, while the exposure of inexperienced professionals can serve to stimulate the incremental use of green approaches by a broader range of market players.)
- Green building programs should consider promoting the development of corporate green building standards or policies by building owners who have completed successful green projects. Such policies may serve to extend the organizational memory about a successful green project and increase the likelihood of subsequent green projects.
- The markets for green building materials are still immature, and further analyses may be needed concerning the best way to stimulate these markets.

It should be noted, however, that this evaluation and the points noted above are based on the review of only a single green building. Hence, they can contribute to the formulation of policy decisions and program measures, but should not be the sole basis for either one.

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