The Doyle Conservation Center

Headquarters for The Trustees for Reservations

Demonstrating the promise of renewable resource use and the future of land conservation.

A Case Study of Challenges, Successes, Lessons Learned

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Executive Summary

The Doyle Conservation Center, headquarters of The Trustees of Reservations, meets standards set by the US Green Building Council's Leadership in Energy and Environmental Design (LEED) program and is expected to qualify for Gold level certification. Modeling data predicts that the building will be 60 percent more energy efficient than a modern building with the same square footage.

The Doyle Conservation Center is located in Leominster, Massachusetts. Its design incorporates a host of sustainable features, including: minimal land disturbance, photovoltaic panels that provide 25 percent of the building's electricity, ground source heat pumps for heating and cooling, maximized daylighting, composting toilets and waterless urinals, ecological landscaping and green furnishings. The 22,000 square foot facility had a final cost of $236 per square foot.

Planning for this facility began in 2001 and construction was completed in 2004. The Trustees of Reservations consider themselves to be one of the pioneers in the sustainable building movement and welcome the opportunity to share their experience with others. This paper documents the challenges, lessons learned, and accomplishments of those involved in the design, construction, and commissioning of the Doyle Conservation Center to inform advocates and others who are interested in creating similar buildings or exploring green construction issues.

1 Introduction

The Trustees of Reservations (TTOR) was formed in 1891 with a mission "to preserve, for public use and enjoyment, properties of exceptional scenic, historic, and ecological value in Massachusetts." The organization currently (July 2005) protects 54,000 acres and actively manages 24,000 acres on 95 reservations in Massachusetts. TTOR has 130 full time employees, 43 part-time positions, and 229 seasonal workers.

The Trustees of Reservations is a nonprofit organization supported by 40,500 members. With an increase in employees, membership, and activities TTOR needed more office space. In 2001, an anonymous five million dollar donation was received for the construction of such a space. The Trustees of Reservations decided to create the Doyle Conservation Center (DCC), an office building for 38 employees and meeting place for up to 150 people in the central location of Leominster. The DCC houses staff that work on issues of land conservation, ecology, resource protection and planning, environmental education, and mapping. The DCC is also home to the Putnam Conservation Institute and the site of workshops and training seminars for conservationists around the state of Massachusetts. TTOR also facilitates educational programs, exhibitions, recreation, and conservation purchasing, which can be further explored on their website, www.thetrustees.org.

1.1 Site at a Glance

Table 1: Sustainable Building Features of the Doyle Conservation Center

Category	Description
Site Selection	Minimal land disturbance, use of pre-existing house
Material Selection	Portland cement with 20% fly ash, Werzalit siding, construction waste salvaged for reuse
Energy Conservation	Optimized daylighting, passive solar design
Energy Production	Photovoltaic panels, geothermal wells, heat exchanger
Stormwater Management	Detention ponds, manmade wetlands
Water Efficiency	Composting toilets, waterless urinals, ecological landscaping
Indoor Environment	Green build-out materials, including floors, carpets, desktops
Contractors	Architect: *HKT Architects* Photovoltaic Panels: *Global Resource Options* Waste Treatment: *Clivus Multrum* Geothermal: *Affiliated Mechanical* and *Water Energy Systems* Landscape Architect: *Hines and Wasser* Commissioning Agent: *Sebesta Bloomberg & Associates*

2 Site

The Doyle Conservation Center is located at 464 Abbot Avenue in Leominster, Massachusetts. It sits on the 50-acre Doyle Reservation, which is owned and administered by The Trustees of Reservations. The area is forested and has scattered wetlands. The DCC site was already partially developed and had no mature forest; choosing this site minimized the impact the on local ecosystem.

The DCC's footprint (11,560 square feet) expands a pre-existing house and garage. Total greenspace that includes the manmade wetlands, meadow, and landscaped area around the building, is 101,000 square feet. The regularly mowed backyard of the pre-existing house is approximately 33,000 square feet. Approximately 68,000 square feet of young forest were cleared for the meadow, parking, and artificial wetland areas. The cleared area had been a meadow approximately 30 years prior to re-clearing it.

Master planners (The Halverson Company) and architects (David Perry/HKT) originally suggested that the DCC be built across the street from its current location on a site that would allow for a large building and a significant landscaped area around it. Yet this site was not acceptable to TTOR for environmental and practical reasons: the original site area has a more mature and ecologically valuable forest (mostly red pine) that had been growing back from agricultural uses for over a century. Additionally, the proposed site was also on a slope and would require expensive earth-moving grading. Finally, the added cost of creating ramps and railings for handicap access due to the slope being over 5% presented unnecessary financial constraints. Upon further discussion, expanding on the pre-existing backyard of the existing "Red House" was a more environmentally friendly option. The selected site had only young trees due to its recent use as a meadow, and thus less ecological value. Of the 101,000 square feet needed for the site, 33,000 were already meadow.

2.1 Landscaping

The site where the DCC is now located has a compact footprint. The site design, according to the landscape architect Blair Hines, "has been to reestablish a natural system to allow an unfolding of a natural process." Featured in the site's landscape design is a manmade wetland that serves as a retention pond and a series interconnected swales that were created to direct and filter stormwater runoff from impervious surfaces such as the parking lot, as well as help to support wildlife. These artificial wetlands require no maintenance. Water run-off from the roof of the building and the parking lot is channeled into these wetlands and absorbed by specialized plants chosen for their ability to filter and absorb rainwater.

When water exits the site, sedimentation is stabilized and erosion is minimized, fulfilling necessary stormwater management requirements while creating a small wetland habitat. Thus when run-off is incorporated into the natural wetland to the northeast of the site, the impact is minimal. Wildlife observed in these wetlands include: cranes, wood frogs, turtles, and various birds.

The wetland plants are stoloniferous, meaning that the plants grow horizontally, creating a dense mat of roots and shoots that can adequately filter water. The native plants used to create the artificial wetlands and swales include American beauty bush, meadow sweet, silky dogwood, red dogwood, and inkberry. All of these varieties were purchased at local nurseries that carry species that are indigenous to the area. The meadow outside of the created wetlands is seeded with little bluestem, a native meadow grass that does not need irrigation. The trees included yellow birch, hophorn, sugar maples, shad bush, red oak, black and sweet gum, bluebeech (ironwood), and dogwood. The native bushes that were planted include highbush blueberry, maplewood viburnum, arrowood viburnum mountain laurel, and stanhorn sumac.

The native plants selected are hearty and drought resistant, which eliminates the need for frequent watering and the use of fertilizers and insecticides. The DCC landscaping team, led by ecological landscape designers Hines Wasser & Associates, learned that it can sometimes be difficult to obtain seed or seedlings of native species. Landscape architects are confronted with a regional trend within the nursery business of offering few native species. The limited number of nurseries that do specialize in providing a wide variety of indigenous plants are often quite expensive. Organizations, companies, and individuals that are interested in sustainable landscaping practices may need to incur higher costs when specifying for native plantings.

2.2 Reuse of Site Materials

Locally produced materials were used in the landscaping process whenever possible. Topsoil was stockpiled and covered during the construction process, and re-used for landscaping purposes. Felled trees were recycled into light poles and woodchips that are used as groundcover around plants and bushes. Old stone walls from the site (symbolizing the area's agricultural past) were re-created into new walls. Granite slab, from an antiquated weir (a dam built across a stream to raise its level or divert its flow) in another section of the reservation, was utilized to channel run-off into the artificial landscape.

2.3 Transportation and Parking

The DCC is located approximately 40 miles from Boston. Because of its remote location, the most common mode of transportation to the building is a private vehicle. The North Leominster commuter rail station is less than two miles from the DCC. Bicycle transportation is encouraged with eight outdoor spaces to lock bicycles, and a changing room and shower in the building. No local commuter busses run in the area.

Parking capacity at the facility is a maximum of 84 vehicles. Parking and driveways together comprise 36,400 square feet, with 12,000 square feet of asphalt parking lot (44 spaces), 7,000 square feet of gravel parking lot (14 spaces), and 5,000 square feet of structurally stabilized soil along the 12,500 square feet of asphalt paved driveway (26 overflow spaces). The structurally stabilized soil is made with locally excavated gravel mixed with soil. The grassy overflow parking looks similar to the surrounding meadow, but allows for cars to park without creating ruts or getting stuck in mud. Other overflow parking schemes that use buried plastic or concrete for soil stabilization were evaluated but rejected because winter freezing can cause these materials to buckle, which would create an uneven surface and difficult mowing conditions in the summer months. Large shade trees along the driveway help to keep the pavement cool, minimizing the heat island effect that typically results from paved surfaces.

Originally, the entire parking lot was designed to be gravel because it allows for the absorption of water and thus decreases the amount of stormwater. However, gravel parking lots in the northeast can cause difficulties for snow plowing in the winter. Porous paving material was not available at the time of construction. The compromise was to have a parking lot partially made of gravel and partially of asphalt. The impact of the non-porous, conventional asphalt is minimized by directing stormwater runoff into the wetland retention ponds, where it is properly filtered before returned to the surrounding ecosystem.

3 The Building

In August 2001, TTOR staff began the process of planning the new building. Designs were made from 2001-2003; construction began in May 2003 and was completed in June 2004. The Doyle Conference Center has a total of 22,000 square feet; the newly constructed facility is 18,000 square feet and two pre-existing structures (Red House and Grey Garage) were converted into office space for an additional 4,000 square feet. The three buildings are connected by walkways and form a campus like environment.

3.1 Planning Process

In 1981 Louise Doyle donated a portion of her property to The Trustees of Reservations to create the Doyle Reservation. This reservation has since grown in size as Miss Doyle has given additional parcels to TTOR. In 1999 Miss Doyle, in conjunction with TTOR staff, authorized the development of a Master Plan for the entire 50-acre reservation. In developing the Master Plan, an expansion of current TTOR office space was identified as a significant need. An assessment entitled "The Headquarters Space Needs Report" was written by David Perry Architects. New construction at the Doyle Reservation would relieve the space constraints and accommodate new organizational growth.

Once the need for a building was identified, TTOR created the Doyle Conservation Center Staff Team (Staff Team) to facilitate and guide the process of envisioning, designing, and overseeing the construction of the largest capital project the organization had ever undertaken. The Staff Team was comprised of five employees, with many other staff, board members, and members of the organization loosely affiliated. The team included Director of Planning and Stewardship Lisa Vernegaard, Regional Director (Central

Region) Dick O'Brien, Director of Land Conservation Wes Ward, Director of Structural Resources Jim Younger, and Executive Director Andy Kendall.

The selection process for consulting services to develop the Master Plan was based on cost, experience, and ability to collaborate. The team issued a Request for Proposal (RFP) to several companies TTOR had worked with in the past and selected The Halvorson Company.

Two goals guided the planning process that began in July 2000:

1. To assess the landscapes and structures of the Reservation to identify resources critical to the integrity of the whole property; and
2. To make recommendations for use and management of the Reservation that met priority needs of the Trustees and respected Miss Doyle's preferences.[1]

The planning process involved a space needs assessment, site analysis and property history, visioning, program definition and concept design, and finally the development of the Master Plan and an implementation analysis. An output of a visioning workshop that Halvorson Company conducted for senior TTOR personnel was the guiding principle that "the Reservation and all its improvements should be constructed and managed as a model of environmentally conscious, sustainable development and land management."[2]

3.2 Building Design

Because the nature of planning is complex and requires significant expertise, the Staff Team recruited four architects and a planner from its membership to create the Design Review Team (DRT). Because TTOR owns many properties, utilizing support from its membership for peer review of various organizational projects is a common practice. According to Dick O'Brien, the Central Region Director, this team was comprised of "highly experienced and knowledgeable members, and facilitated a highly creative and thorough pre-design process." O'Brien described the Design Review Team's involvement in the process as essential to keep the project in line with their vision and budget.

The Staff Team and the Design Review Team collaborated to send out an RFP to various architectural firms. The group decided that the DCC would strive for LEED (Leadership in Energy and Environmental Design) certification to demonstrate to employees and visitors that building green is a practical and economically viable alternative to mainstream construction. Thus, the architectural teams applying for the contract had to have significant experience in green design. The contract was awarded to David Perry Architects and assigned to HKT Architects early in the design process. The assignment was required as part of a financial agreement between David Perry and HKT Architects, the contract was approved by TTOR.

Beginning in August 2001, the Staff Team convened on a monthly basis for almost two years, and collaborated extensively with the Design Review Team. The teams ensured that aspects of design and construction of the site and building would be consistent with the mission of the organization. The DRT guided the architects' draft of the Doyle Conservation Center by facilitating a dialogue between the architects, contractors, landscape architect, and others involved in the project. For example, the architects wanted to add a silo-like tower design element to the building. Team members felt that this feature would provide little functionality for the occupants and add significant cost to the overall budget. The DRT negotiated with the architects and the tower was left out.

[1] Master Plan for the Doyle Reservation 2001.
[2] Master Plan for the Doyle Reservation. 2001

4 Construction

Mullaney Corporation was hired to act as the construction manager, with the responsibility of budget management, value engineering and system selection. Mullaney identified and presented options to the TTOR team, who would make their selection based on price and performance criteria . The company was also hired to serve as general contractor to oversee the construction process and performance of contractors and sub-contractors involved. As part of their contract, Mullaney Corporation was held to a GMP, a guaranteed maximum price of $4 million. .

Throughout the design and construction process, effective communication proved to be an essential ingredient to success. With the DCC, this communication helped to clarify the expectation of thoroughness and completeness. According to Jim Younger, the TTOR Director of Structural Resources who oversaw the DCC project, “it is incredibly important that the owner opens lines of communication with all parties involved. Open communication that ensues between the various contractors involved in the project assures and facilitates proper planning and execution of the project.”

Because The Trustees for Reservations was an early adopter of green building practices, contractors and designers had a steep learning curve and had to face numerous challenges associated with technologies and building practices . For this reason, effective communication between the parties involved was especially important. The TTOR Staff Team enacted a matrix oriented management system to allow supervisors within the project to establish relationships with key people; this approach facilitated open communication with the contractors and sub-contractors. Team meetings that brought staff and contractors together helped to facilitate a smooth execution of the building project.

4.1 Materials

The concrete foundation and sub-structure contained concrete with a mix design including 20% fly ash, a recycled material that is a by-product from coal-burning power plants.

TTOR discussed the possibility of using native lumber milled from TTOR wood lots., but later learned that this option would not be viable for one important reason. Although native timber may be used to support a structure, the codes that govern commercial structures require the timbers to be graded and analyzed for structural integrity. Finding a structural engineer to agree to engineer this structure using these native timbers would add time for testing, time which had not be allowed in the construction process. Had the concept of using native milled timber been integrated into the design and construction process; time and the construction sequencing would have been adjusted accordingly.

Originally, the DCC had selected cedar clapboards for its siding. However, in the value engineering process, a lower-cost and environmentally preferable alternative was identified. Werzalit siding is made of hardwood particles derived primarily from timber harvested in Pennsylvania for the furniture market. It comes with a baked-on finish that does not need painting for 10-15 years. Werzalit does not warp, buckle, blister, flake or peel. No toxic chemicals, such as urea formaldehyde are used in the manufacturing process. This material is greener and less expensive than the original option.

Werzalit siding
Source: www.thetrustees.org/pages/3947_green_materials.cfm

4.2 Construction Debris Management

Another issue that arose in the construction process was the need for vigilance to assure that as much of the construction debris was recycled as possible. A clear plan and understanding of all involved parties should be delineated before the construction process begins. At the end of the project, over 50% of the associated construction wastes were salvaged or recycled. Although a waste management plan was implemented, reminders to sort the waste appropriately in the various bins were needed during daily clean-ups. In addition to posting signage on dumpsters used to sort the waste, continuous communication and education helped to ensure an understanding of the recycling opportunities amongst the contractors.

Based on their experience, TTOR suggests that those involved in a green building project take the time to research the local recycling opportunities for construction waste and integrate a waste management plan into the design. This effort could also result in the identification of recycled materials that can be used in the building project.

4.3 Value Engineering

Value engineering is commonly practiced in the construction industry to eliminate items that cost more but can be replaced by a less expensive but similarly functioning alternative. However, this can lead to decreased efficiency and fewer environmentally-friendly features. Value engineering was an important process to keep the budget from exceeding the maximum guaranteed price of $4,000,000. During this process the focus was on cost, with an eye towards preserving the elements that would maximize efficiencies. Although some changes had a negative effect on the building's efficiency, others improved its sustainability:

Value engineered features that decreased sustainability and efficiency of the building:

- The mechanical system was designed to include a central air handler with variable air volume (VAV) air distribution and ventilation displacement. Instead, 19 small, constant volume heat pumps were installed throughout the building. This system was less expensive but is less energy efficient, noisier and more difficult to maintain.
- The building envelope was designed to be built with structural insulated panels (SIPs), which would have resulted in wall R-values of 20-25. Final construction consisted of a conventional frame construction with R-11 fiber glass insulation. (see Building Envelope for details); and
- Greywater recycling was eliminated.[3]

Value engineered features that increased sustainability and efficiency of the building:

- Eliminated emergency generator (decreased energy use);
- Used Werzalit siding instead of cedar clapboards (see Materials); and
- Switched cherry wood trim and cabinets to poplar with low-volatile organic compounds (VOCs) paint.[4]

[3] Chris Schaffner, personal communication, June 9, 2005
[4] ibid

5 Energy

Modeling data predicts that the building will be 60 percent more energy efficient than the average for a comparable modern building. This is expected to result in annual savings of approximately $6,000 per year.[5] Due to an extended commissioning process (see Geothermal Heat Pump), TTOR is just starting to understand the true efficiencies gained. In the future they would like to make a computer monitor available in the conference center lobby where visitors will be able to learn more about the energy savings being achieved as a result of the sustainable building processes incorporated in the DCC.

5.1 Building Envelope

The building envelope was originally designed to include Structural Insulated Panels (SIPs); this would have provided wall insulation R-values of 20-25. However, because of structural engineering concerns related to using SIPs in a two story building, only the high clerestory roof was constructed with 8” thick SIP insulation with an R-value of 30. The final construction consists of a conventional frame construction with R-11 fiberglass insulation and an air barrier. The roof has fiberglass batt insulation rated at R-30. The foundation is insulated with R-10 rigid insulation made by Stryofoam™.[6] The concrete walls that surround the basement and the slab on grade of the assembly meeting hall are eight inches thick.

5.2 Daylighting and Windows

Daylighting concepts were integrated into the design to maximize southern exposure and solar gain. Although the design of the building originally suggests that 90 percent of the building is day-lit, several practical critiques surfaced once the building was occupied. When employees moved in there were several comments on the light extremes. On the first floor, a lack of natural light in one interior open area resulted in a few employees using desk lamps to generate enough light to work. On the second floor, solar daylighting patterns cast during the middle of the summer created glare of computer monitors of a few employees, this will be remedied with the installation of blinds in the clerestory windows.

The architects selected windows based on high insulation values and competitive pricing. They chose Smartsash III, 5/8” Insulshield argon-filled, multi-layer low E coated dual seal insulating glass. These windows have a clear triple glazing panel with 13/16” of air space. The DCC used Pella Designer Series aluminum clad casement/awning units with an outward-opening sash.

5.3 Geothermal Heat Pump

The Doyle Conservation Center is cooled and heated by a geothermal heat pump, also referred to as ground-source heat pump, a technology that is gaining popularity in the U.S. Two geothermal heat pumps are housed in two 1,500’ wells located in the landscaped area near the parking lot. The two 5-horsepower Gould pumps are 200’ below surface. The well pumps move the water to and from 18 heat pumps that are distributed throughout the new building and one heat pump that is located in the refurbished Garage building. The cooling load is 45 tons, and the heating load is 41 tons.

At a constant year-round temperature of approximately 50° F, the ground water drawn from the wells provides an efficient media to transfer heat energy to or extract it away from the facility. During the winter, heat is transferred from the ground water to create warm air for heating; water enters the building at 50° F and leaves at 42° F. During the summer, heat is absorbed by the water to create cooler conditions; water enters the building at 50° F and leaves at 58° F. The heat pumps operate an “open loop” system, meaning that the water is returned back to the well after it is used.

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[5] Quote from Chris Schaffner, Arup, The Trustees of Reservations Discover Secret of Successful Green Architecture. 2004.

[6] Chris Schaffner, personal communication, June 9, 2005.

The geothermal system presented a series of challenges to the DCC and the system was not fully operating until eight months after the opening of the building. The relatively new technology and the underground location made diagnoses difficult. An initial test to understand the hydrology and expected performance of the wells that is typically mandatory for geothermal installations was never performed, according to DCC records. Also, the original pump that was installed was not powerful enough to draw the water to the second floor of the building. This error in design was corrected, and a more robust pump was installed. During the commissioning process it was learned that water was being drawn out of the wells at a faster rate than they were able to replenish; city water had to be added to maintain necessary water levels until the proper adjustments were made.

While the necessary adjustments were being made to the geothermal system employees had to use temporary electric space heaters during the winter months until the system was fully functioning. This extra demand skewed energy usage data that is needed to evaluate the efficiencies of a green building. The geothermal system has been fully functioning since the spring of 2005; performances of the pumps are monitored via an automation system that can be accessed remotely and automatically generates an email notice when adjustments in temperature, water, or pumping levels are required.

The use of geothermal energy for heating and air-conditioning is still a relatively new technology. Not many contractors are experienced in designing and installing these systems. It is therefore essential to assure that an experienced and reliable contractor is selected. The well test must be performed, and the well also must have proper maintenance that includes initial cleaning.

5.4 Energy Recovery

The new building has two energy recovery ventilators (ERVs) manufactured by Semco: Models FV-500 and FV-3000. Fresh air is brought in through an enthalpy valve and warmed or cooled as it is brought in by a heat wheel in the ERV that transfers excess energy from the exhaust to the fresh air. The heating ventilation and air conditioning (HVAC) system has air exchanges of 2,400 cubic feet per minute (cfm) for the main building and 700 cfm for the conference area.

5.5 Commissioning

Chris Schaffner of ARUP was hired as the mechanical engineer and project manager for mechanical, electric and plumbing systems. The commissioning agent was Brad Jones, an engineer with Sebesta Bloomberg & Associates, and a member of TTOR. Interested in the project, Jones became involved halfway through the construction of the mechanical, electrical, and plumbing systems. Mostly volunteering his time, Jones worked on issues such as overseeing the heating, ventilation and air conditioning (HVAC) system. Regular monitoring and tweaking are still taking place, as efforts continue to commission systems to maximize their performance efficiencies.

In hindsight, TTOR realized that it would have been valuable to have an independent commissioning agent involved early in the project. Having an experienced commissioner involved in all aspects of the design and build process would ensure smoother communication between contractors and improve project timeliness.

Having a rigorous selection process of the various sub-contractors in the project could also have ensured the project being built on time and with fewer glitches. Reviewing qualifications, references, and prior work of all contractors is vital to selecting a successful team and creating the desired final product.

5.6 Energy Consumption

The facility uses an estimated annual 200,000 kWh of electricity. Because the new construction is heated and cooled with its geothermal wells, no natural gas or oil is used in the new building. The 3,568 square feet of the two pre-existing structures use approximately 155 mmBtus of fuel oil per year.

5.7 Renewable Energy

The original design called for photovoltaic amorphous shingles to be used on the DCC. However, upon further examination of building design and panel performance, an alternative plan was adopted. Amorphous shingles are ideally installed at locations that have an attic or plenum space for necessary wiring. The final design of the DCC building included an open office space with a clerestory roof above. Due to this design, installation of amorphous shingles would have required drilling over 2,500 holes in the roof deck for the wiring and installing a tray into the ceiling to house the wiring. The ceiling is constructed of laminated Douglas fir, hence such a tray would have negative aesthetic consequences. Finally, when comparing expected electrical output, the solar shingles were out performed by the chosen crystalline photovoltaic (PV) panels by approximately 30%.

The DCC's contractor, Global Resource Options, installed 144 Sanyo HIT 190 PV modules covering 1,831 square feet of the uppermost west and east clerestory and lower west gable roofs. The arrays are 73 feet long by 8.75 feet wide on both of the high roofs and 73 feet long by 4.4 feet wide on the low west roof. A panelized rack system supports the photovoltaic modules, which are pitched at 23°, on top of the asphalt roof surface. This rack system is fastened through a plywood sub-structure and into rafters. All wiring between modules occurs above the roof, behind the modules. There are 12 SMA SB2500 Sunny Boy inverters located in the basement to change direct current (DC) into alternating current (AC) power for building consumption.

Panels are expected to decrease TTOR's electricity bill by approximately $2,000 per year. The 26K volt system is expected to produce approximately 28,000 kWh a year, nearly 25 percent of the building's average annual electricity consumption. In the first year of operation, the PV system produced 22,349 kWh (June 2004 through May 2005). The DCC's solar electricity is net-metered with TTOR's electricity provider Massachusetts Electric (National Grid); excess electricity is exported to the local grid and in turn the utility bill is decreased. A grant for $361,515 from the Renewable Energy Trust Green Buildings Initiative at the Massachusetts Technology Collaborative (MTC) partially offset the total cost of $228,277.

Table 2: DCC Photovoltaic Array Production

Production Month	Energy Produced (kWh)	Pounds of CO2 Reduced
June 2004	2,277	2,914
July 2004	2,277	2,914
August 2004	2,672	3,420
September 2004	2,721	3,482
October 2004	1,974	2,526
November 2004	1,230	1,574

December 2004	776	993
January 2005	554	709
February 2005	1,131	1,447
March 2005	414	529
April 2005	4,404	5,637
May 2005	1,919*	2,456
Total	**22,349**	**28,606**

*A failure of two inverters caused a decrease in production in May.

Source: Renewable Energy Trust Tracking System
www.masstech-pts.org/Statistics.aspx

6 Water

The Trustees Of Reservations and its architects designed the facility to minimize water consumption. The Doyle Conservation Center's water-saving features include composting toilets, waterless urinals, landscaping that requires no watering, and low flow sink faucets. The DCC uses water that is supplied by the Town of Leominster.

Originally, a greywater system was included in the building design; however, this was omitted during the value engineering phase. Although TTOR would like to have this feature as a part of the facility and they have received the necessary permits, it is not likely that they will install it soon, given the expense and the minimum amount of wastewater generated on site.

6.1 Composting Toilets and Waterless Urinals

A composting toilet system is used to treat their human waste. Originally developed in Sweden in 1939, the Clivus Multrum composting toilets use foam for flushing. The foam-flush toilet looks and functions much like a conventional toilet fixture. It uses a mixture of bio-degradable soap and three ounces of water to carry toilet waste to the composting system below via a conventional 4" drain line. These toilets use 80 percent less water than typical efficient toilets.

The waste from the six toilets is treated on site in the Clivus Composting unit. There is no leaching field. Efficient composting creates only one wheelbarrow full of odorless topsoil once every four years. Although initially met with great skepticism in the design phase, these toilets are now widely accepted by both employees and visitors as a novel and user-friendly concept.

Standard waterless urinals were installed in the Men's rooms.

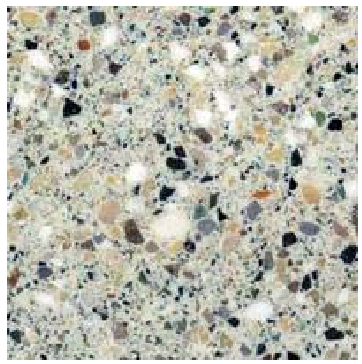
6.2 Sewer Permitting

The DCC obtained necessary documentation and allowance for its composting waste treatment two years in advance of the sewer system installation. However, in the "eleventh hour" Leominster town officials announced that the project could not continue without a tight-tank system due to a temporary town-wide sewer moratorium. Although the DCC's Clivus composters need no leach field, there were concerns that there could be a breach of the sewer moratorium due to the construction of the DCC. In the end, after much discussion with the Town of Leominster and the Massachusetts Department of Environmental Protection, a 2,000 gallon tight tank was installed for the sinks, shower, and urinals. Although this greatly exceeds the building's needs, it is the minimum size allowed by state code based on the building's capacity.

7 Build-out Materials

Use of green materials was a design priority for TTOR. As described on their website, materials were chosen based on their environmental sensitivity, simplicity, and efficiency. As described in earlier under Site, some of the landscaping materials, including light posts, originated from the site itself.

Desktop made of sunflower hulls



Counter top made from reclaimed solid waste

Flooring made from bamboo

Source: www.thetrustees.org/pages/3947_green_materials.cfm

7.1 Desktops

The desktops in the Doyle Conservation Center were locally crafted from a composite made of sunflower hulls and other agricultural production by-products. Rather than entering the waste stream, hulls from sunflower seed production are bound with wheat and natural resins and pressed to form Dakota Burl, a unique composite material offered by Biocomposites, LLC.

The material resembles and works like traditional burled woods. Dave Decker, a furniture maker with Wayne Woodworks, encased the desktops in Douglas fir to match the interior frame of the DCC. These custom designed desks proved to be less expensive than ordering office-systems furniture, and supported the local economy.

7.2 Sink Counters

The Avonite Surfaces™ sink counters from the Recycled Collection line were made with a minimum of 40 percent post-industrial waste, reclaimed solid waste materials, such as concrete, glass, and metals. The company's production diverts over 300,000 pounds of waste from landfills annually. The manufacturer's processes also recycle water, reduce volatile organic compound (VOC) release, and the waste byproduct is sold to create sanding powder.

7.3 Bamboo and Cork Flooring

Much of the flooring in the Doyle Conservation Center is made from bamboo, a more environmentally friendly alternative than hardwood. Because bamboo is a grass, it has an extensive underground root system and can be harvested in a sustainable manner every three to five years. Bamboo flooring has a higher fiber density than wood, and resists wear well. The bamboo used in the DCC was grown in the Hunan Province in south-central China.

A portion of the flooring at the DCC is made from cork recycled from the waste by-product generated during the process of manufacturing wine-bottle stoppers. Cork is harvested from the bark of the cork oak, *Quercus suber*, which predominately grows in the Mediterranean. A cork oak can be first harvested when it is 25 years old, when the bark is carefully cut from the tree. Thereafter, cork can be "stripped" from the tree every nine years for about 200 years. The cork provided for the DCC came from Natural Cork Incorporated, headquartered in August, Georgia. Cork floors are durable, fire resistant, and provide thermal and acoustic insulation.

7.4 Carpeting

The carpeting was chosen for its high recycled content and its recyclability. The Eco-Solution Q® carpet from Shaw Fiber is made with 25% recycled fiber, the highest available at the time of purchase. This product line follows the "cradle to cradle" model, where products are designed to minimize their environmental impact and maximize their reusability. The carpeting was installed in tiles, which allows for sections to be replaced as needed. The carpet can be returned to the manufacturer at the end of its useful life to be recycled into carpet fiber.

7.5 Acoustic Tile Fabric

The acoustic tiles throughout the DCC reduce noise levels and are covered in fabric made from 100% recycled materials. Made by Maharam, these particular fabrics are a blend of recycled polyester, with nearly 50% post-consumer content.

Flooring made from cork

Carpet with 25% recycled fibers

Acoustic tile fabric with 50% post-consumer content

Source: www.thetrustees.org/pages/3947_green_materials.cfm

7.6 Recycling

The Doyle Center manages some of its waste with great success (e.g. composting toilets and storm water treatment). However, when the DCC opened it did not have an adequate recycling system. However, the placement of recycled paper, glass, plastic, metal, or compost stations was not incorporated in the design plan. Efficient and well-designed recycling stations have since been purchased.

8 Occupant Comfort

Green buildings typically—as is the case with the DCC—are designed to take into consideration the long-term health effects of occupants that spend considerable time in such buildings. Air quality is one such feature, as is thermal comfort, and access to daylight.

8.1 Indoor Air Quality and Ventilation

The DCC has carbon dioxide (CO_2) monitors to assure carbon dioxide does not approach unsafe levels. When CO_2 levels become too high, ventilators are electronically set to automatically increase air exchanges into the building.

When outside temperature and humidity are considered comfortable by outside sensors, an email is automatically circulated that informs building occupants that they can open their windows and the ventilation system shuts down. This alert also prompts the users to open vents at the top of the building to release hot air.

Most of the furnishings are made of recycled and natural materials that cause little off-gassing of toxic fumes. The paints, glues, and varnishes throughout the building were chosen for their low levels of volatile organic compounds (VOCs). Specifics on the materials used for the various furnishings are detailed in the Build-out Materials section.

Operable windows allow occupants the ability to maximize the flow of fresh air through the building.

8.2 Daylighting

The sun provides the majority of the lighting in the building; the original design of the building suggests that 90% of lighting needs are covered by daylighting. As discussed earlier (Daylighting and Windows), initially, the amount of natural light entering the second floor space made it difficult for employees to view their computer screens. A lack of natural light entering the first floor area resulted in employees using desk lamps to generate enough light to work. With a better system of blinds now installed, occupants have commented that the lighting extremes have been mitigated.

8.3 Connection to Nature

All offices in the building were designed to have a view of the outdoors, which gives occupants the feeling that they are connected to nature. The DCC is located within a nature preserve with an extensive surrounding forest. The manmade wetlands also attract much wildlife that is visible from many parts of the building.

8.4 Indoor Aesthetics

The objective of the DCC in this project was to make a building that reflected the conservation-minded mission of the organization, and the $5 million price tag on actualizing this was well spent on the major systems and features that make it an outstanding building. Employees and visitors to the DCC find the aesthetics comfortable and inviting, much of the focus is on the transparency related to bringing the nature around the building within.

9 Financial

The DCC began with a vision and a $5 million donation. The soft costs totaled $900,000, and the hard costs were $4,300,000, for a total investment of $5,200,000. The building's square foot cost was $236. The Trustees of Reservations estimates that incorporating green features in their headquarters resulted in a 15 percent cost premium.

Funds were augmented with a Massachusetts Technology Collaborative grant of $361,515 that offset the costs of the photovoltaic panels. Additionally, rebates of $2,009 from National Grid were secured through the "Cool Choice Application," for the HVAC system and $6,405 was procured through efficient lighting incentives from Mass Electric.

10 LEED Certification

Leadership in Energy and Environmental Design (LEED) is a program of the United States Green Building Council (www.usgbc.org). Using a point based system for a variety of energy efficient and environmentally friendly measures, buildings can be certified in the categories: LEED, Bronze, Silver, Gold, or Platinum. HKT Architects is still gathering the necessary information and is expected to submit the application in September 2005; the Doyle Conservation Center is aiming to become a Gold rated building with 46 points.

The TTOR team and others emphasize the value of following LEED standards for guidelines in decision making. Additionally, the recognition of efforts taken to minimize environmental impact is important. However, some express frustration regarding the cumbersome application process, awarding of points and related expense. A significant amount of data and paperwork needs to be organized and filed. Point awards do not always coincide with environmental value. For example, a point is gained for having a relatively inexpensive bicycle rack, which has little benefit to the environment if it is not used. Comparatively, the more expensive and more environmentally beneficial solar panels also receive only one point. Finally, LEED certification is expensive—funds could be spent to increase the amount of green features in the building rather than paying for official USGBC certification.

11 Education and Outreach

The environmentally friendly aspects of the Doyle Conservation Center are made available to the public through two channels—visiting the building, and perusing the website. Tours can be arranged by calling the DCC at 978-840-4446. Further, many events are held in the DCC's conference room, where many of the green features of the building can be observed firsthand. The facility is often rented out to various groups and organizations; a discount rate is offered to organizations whose mission aligns with TTOR. Banners hanging on the wall of the entrance lobby describe some of the details of the various building systems and materials. With nearly 5,000 visitors in its first year alone, the Doyle Conservation Center provides an incredible opportunity to educate a wide range of decision makers and consumers. Its story weaves together the promise of renewable resource use and the future of land conservation. Open to the public for tours and a wide variety of programs and events, the Doyle Center is a public resource, a demonstration of how we are managing consumption and using renewable resources for clean sources of power.

The webpage for the Doyle Conservation Center can be easily accessed though the main The Trustees of Reservations website www.thetrustees.org. The DCC website has pertinent information available, such as a brief introduction to the green features, details of green materials used, a Facts and Figures page, and a photo gallery. Additionally, there are links to many of the contractors and material sources used, for those who want to learn more.

12 Conclusion

This report highlights lessons learned in the hope to provide information for future green building designers and builders to facilitate the success of more efficient and environmentally responsible buildings. Challenges in the green building movement are to be expected. As ecological building processes and products enter the mainstream, a process of experimentation is expected, and occasional glitches should be expected. However, building on the lessons learned—as summarized here and in other case studies—will help facilitate future success and acceptance of more sustainable building practices.

13 Doyle Conservation Center Contacts

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Materials:

Dakota Burl Desktops:	http://www.environbiocomposites.com/dakota.php
Bamboo Flooring:	http://www.hawabamboo.com
Cork Flooring:	http://www.naturalcork.com
Carpeting:	http://www.ecosolutionq.com
Sink Counters:	http://www.avonitesurfaces.com
Photovoltaic System:	http://www.globalresourceoptions.com
Werzalit Siding:	http://www.wags-system.com

Designers and Contractors:
Master Planning: *The Halvorson Company*
Landscape Architect: *Hines and Wasser* (Blair Hines)
General Contractor: *Mullaney Corporation* (Jack Tata)
Architect: *HKT Architects*
Photovoltaic Contractor: *Global Resource Options*
Geothermal System: *Affiliated Mechanical* and *Water Energy Systems*
Geotechnical Engineering: *Jaworski Geotech, Inc.*
HVAC Engineers: ARUP
Structural Engineer: *Souza, True, and Partners* (Terry Louderback)
Commissioning Agent: *Sebesta Bloomberg & Associates* (Brad Jones)
Waste Treatment: *Clivus Multrum* (Bill Wall)

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Interviews:
Jim Younger, Director of Structural Resources, TTOR
(November 23, 2004, June 10, 2005, September 21, 2005)
Chris Schaffner, ARUPpersonal communication, June 9, 2005.
Dick O'Brien, Central Region Director, TTOR
Lisa Vernegaard, Director of Planning and Stewardship, TTOR
Blair Hines, Landscape Architect, Hines and Wasser
Brad Jones, Commissioner, ARUP
Ananda Hartzell, Photovoltaic Installer, Global Resource Options
Eric Kluz, HKT Architects

All photos were taken by Sarah Hammond Creighton