CASE STUDY

History's Keeper

A lone cannon stands in a field at the Gettysburg Battlefield. The new Gettysburg National Military Park Museum and Visitor Center opened in 2008 to provide visitors with an understanding of the scope and magnitude of the sacrifices made at Gettysburg. The Battle of Gettysburg was a turning point in the Civil War, the Union victory that ended Gen. Robert E. Lee's second invasion of the North in 1863. It was the war's bloodiest battle with 51,000 casualties and the setting for President Abraham Lincoln's "Gettysburg Address."

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BY TATYANA SHINE, P.E.; AND ELIZABETH PAUL

Museums consume massive amounts of energy. From exhibit lighting to temperature control and relative humidity, their costs are much higher when compared to a similar size traditional office building.

The Gettysburg National Military Park Museum and Visitor Center houses what most Civil War enthusiasts consider to be the largest collection of civil war artifacts, including a massive historic oil painting that depicts the battle. Storing these pieces of American history requires a specific dry-bulb temperature and relative humidity level be maintained on a daily basis.

The museum and visitor center design team selected a geothermal system to maintain the precise conditions required for preservation and reducing long-term energy costs. Since its opening in 2008, the facilities team has maintained and improved the original energy-efficient design by performing a daily walk-through to check building systems and look for ways to improve performance. The careful attention to operations demonstrates that it doesn't matter how efficiently a building is designed, it will never perform to its full potential without a knowledgeable staff to operate the systems.

A Decade of Planning

The Civil War and the aftermath of the Battle of Gettysburg spark lively and sometimes heated conversations. The same can be said of the plan to build a new museum and visitor center. Everyone wanted to weigh in and offer an opinion, including residents of the Gettysburg area, tourists, Civil War reenactors, historical societies, supporters of the existing facilities, and Congress.

After more than 10 years of planning and collaboration, two Congressional hearings, and more than 50 public outreach meetings to help define a project steeped in American history and tradition, the Gettysburg National Military Park Museum and Visitor Center (GMVC) opened in 2008.

The design team worked closely with the owners, a public/private partnership between the National Park Service and The Gettysburg Foundation, and the contractor to deliver a LEED Gold museum that operates one of the largest geothermal systems on the East coast.

The facility features more than 20,000 ft^2 of interpretive exhibit space, two 150-seat state-of-the-art theaters, a full-service restaurant and separate catering kitchen, museum and bookstore, visitor center, and park and foundation administrative offices. It also houses the historic Gettysburg Cyclorama, which depicts the battle. Exhibited for the first time in December 1884 and painted by Paul Dominique Philippoteaux, the painting was carefully restored and is now at its original size, 377 ft long and 42 ft high.

Photo by Bill Dowling Photography

This view of the facility features the large Cyclorama building as well as the museum gallery and Ford Education Center and book/gift store. Endangered grasses on the site of the visitor center and museum were harvested and transplanted during construction. The native vegetation requires no irrigation.

Making the Case for Geothermal

The project team believed that a geothermal system promised the greatest long-term savings, but knew the benefits needed to be proven given the increased upfront costs. The team collected return on investment data for other projects that used geothermal systems and hired a geothermal specialist.

This specialist designed the system, ran the energy models, and helped convince the owners that the system would meet the stringent temperature and humidity controls required to preserve the artifacts, and that the future cost savings on energy bills would be worth the higher upfront costs.

Energy models suggested energy cost savings of 40%. A life-cycle cost assessment compared two systems, a geothermal heat pump system and a conventional four-pipe (hot water and chilled water) system with water-cooled chillers, cooling towers and gas-fired boilers. Both systems were selected to comply with the International Mechanical Code and International Energy Code standards.

BUILDING AT A GLANCE

Name The Gettysburg National Military Park Museum and Visitor Center

Location Gettysburg, Pa.

Owner The Gettysburg Foundation and The National Park Service

Principal Use Museum and visitor center

Includes Cyclorama building, galleries, temporary exhibit spaces, lower level storage and archive areas, restrooms, two theaters, full-service restaurant, catering kitchen, classrooms, gift shop/bookstore, staff offices, and conference room

Employees/Occupants 65 full-time staff off-season; 105 in season, with more than 1 million visitors annually

Gross Square Footage 140,000

Net Conditioned Space 122,440 ft^2

Total Cost $29.4 million

Cost Per Square Foot $210

Substantial Completion/Occupancy May 2008

Occupancy 100%

Distinctions/Awards LEED Gold

Photo courtesy of LSC Design, Inc.

The assessment data suggested that the geothermal system's energy savings would pay for the upfront costs in seven years. The results helped the owners understand that a great investment at the beginning of the project could result in years of future savings.

Geothermal Operation

The geothermal system contains 168 wells, drilled to an average depth of 550 ft. The closed loop hybrid system uses multiple chillers and is designed to maintain the specific temperature and humidity controls at maximum capacity for 24 hours a day, seven days a week, 365 days a year. Based on the types of artifacts in this collection, it was determined that a temperature of 75°F (±3°) and a 50% relative humidity (±3%) was necessary to preserve the collection.

The prepackaged cooling and heating plant includes 10 50-ton each heat recovery chiller modules, 14 pumps, four plate heat exchangers, hydronic specialties such as air separators, expansion tanks, valves, sensors, etc., and the plant digital controller.

The heat recovery chillers are equipped with 20 scroll compressors that sequence on and off to maintain a 42°F chilled water temperature. The heat recovery chillers operate on cooling mode year round and generate the chilled and hot water simultaneously.

Hot water is generated by the condenser. During summer operation it is used for the reheat coils (leaving condenser hot water temperature at 90°F). During winter operation the hot water is used for the hot water coils (leaving condenser hot water temperature at 130°F).

The heat exchangers are installed between the return hot water loop and

Above The museum and visitor center is designed to blend into the rural Pennsylvania countryside. It is adjacent to the battlefield, but sited at a low point in the terrain so it is not visible from the major interpretive points.

Below The facility uses more than 30 types of wall materials, including insulated metal panels, textured masonry, and stone veneer.

Photo courtesy of LSC Design, Inc.

KEY SUSTAINABLE FEATURES

Water Conservation
Native landscaping eliminates irrigation, underground storage system for collecting storm water to eliminate runoff, underground storage system for fire suppression system, low-flow toilets and sinks

Recycled Materials
Exterior wood timbers harvested from a local barn built more than 100 years ago; landfill impact reduced 75% by diverting metal, cardboard, and wood construction waste to a recycling center

Photo by Tim Schoon Photography, courtesy of LSC Design, Inc.

The porch of the bookstore and gift store and Ford Education Center features timbers harvested from a local barn that was more than 100 years old.

BUILDING ENVELOPE

Roof
Type Preweathered standing seam metal roof panels with structural insulated panel system
Overall R-value R-31.12
Reflectivity 25.37

Walls
Type More than 30 wall types are used on this facility, including insulated metal panels, textured masonry, and stone veneer
Overall R-value R-31.1 (average of all wall types)
Glazing percentage 10%

Basement/Foundation
Basement wall insulation R-value R-3.39
Basement floor R-value R-0.38 (4 in. concrete slab

Windows
U-value 0.5
Solar Heat Gain Coefficient (SHGC) 0.4785 or 0.55 shading coefficient

Location
Latitude 39.81

the geothermal water, and between the return chilled water loop and the geothermal water. During summer operation, if the hot water return temperature exceeds its setpoint, the two-way control valve at the condenser heat exchanger modulates open, allowing excessive heat to be rejected into the geothermal water.

During winter operation, the cooling loads are not sufficient to provide adequate hot water temperature. The two-way control valve at the evaporator heat exchanger modulates open, allowing heat from the geothermal water into the return chilled water flow and then into the condenser hot water loop. The chillers' energy efficiency ratio (EER) is 30 and the heating coefficient of performance (COP) is 5.5. These are the nominal cooling and heating efficiencies, which vary with the building loads and the geothermal water temperatures.

Designing the system with 10 heat recovery chiller modules makes it possible to run partial loads by only using the number of chillers necessary to maintain the temperature and humidity setpoints. This setup is more cost effective than running partial loads on a system designed with one 500 ton chiller that consumes more kW/ton. The multiple module system also serves as a backup so that if one chiller goes down, nine more can pick up the slack.

The plant also contains the geothermal heat exchanger, which provides the condenser with geothermal water for the heat recovery chillers, energy recovery units with built-in heat pumps, and multiple water-to-air heat pump units. No water-to-water heat pumps were used in this system. The condensing gas-fired boilers, working on 98% efficiency, were installed as a backup system in case of emergency.

Twelve air-handling units (AHUs) supply hot or cooled and dehumidified air into 12 zones throughout the facility. Each zone is controlled by its own AHU to maintain the required thermal properties. Since each zone requires humidification during winter operation, a VAV type system was not recommended.

Each AHU is equipped with hot water preheat coils, chilled water coils, and reheat coils. Two of the AHUs supply approximately 50% outside air and are equipped with enthalpy wheels. The AHUs in the museum's critical zones such as the Cyclorama, collection storage, gallery, and photo storage are equipped with five air filter modules, including carbon filters.

The five energy recovery units (ERUs) with built-in heat pumps supply outside air into the food service areas, offices, and theaters. The ERUs for the food service and theater spaces have outside air dampers that modulate in response to the CO_2 setpoints and fully open when the CO_2 levels exceed 1,000 ppm. The ERUs have a cooling EER of 15.5 and heating COP of 4.

Multiple horizontal type heat pump units (HPUs) serve the offices and are located above the ceiling. The HPUs have a cooling EER of 15.8 and heating COP of 4.5.

During summer, the geothermal heat exchanger performs as a heat sink for the cooling operation. The building heat is rejected into the hot water loop to maintain the 95°F water temperature required for the humidity control system.

Any excess heat is rejected into the geothermal field. The majority of this heat stays in the ground and is used to heat the building during the winter season. Also, the solar energy is stored in the ground and is transferred through the geothermal system into the building when heat is needed.


Photo by Tim Schoon Photography, courtesy of LSC Design, Inc.

Longer than a football field and as tall as a four-story building, the Gettysburg Cyclorama painting immerses visitors in the fury of Pickett's Charge during the Battle of Gettysburg. In the late 1880s French artist Paul Philippoteaux spent months on the battlefield researching the Battle of Gettysburg with veterans, a battlefield guide and photographer. It took Philippoteaux and a team of assistants more than a year to complete the painting.

Lighting Design

Museum lighting must maintain a delicate balance between lighting artifacts so that visitors can view them appropriately, but also protecting the artifacts from future deterioration.

At the GMVC, a variety of controls help maintain efficiency, and power density is minimized in the public spaces. Low mercury lamps are used throughout the remainder of the building to reduce hazardous materials waste.

Occupancy sensors are used throughout the building, and time clocks control exterior lighting as well as lighting in some of the public spaces. The administrative office spaces use an efficient fluorescent lighting system.

Inside the main gallery, the theaters, and the Cyclorama, an extensive dimming and control system maintains lighting levels. This system is designed to direct people's attention to museum features, minimize the lighting that could directly affect the preservation of artifacts, and create visible pathways for the safety of visitors.

Building Envelope Efficiency

The facility uses two roofing systems for two different parts of the facility. The flat roof area is comprised of a 60 mil fully adhered thermoplastic polyolefin (TPO) roof system in beige and white to reduce heat island effect.

The Cyclorama, museum gallery, and refreshment saloon roofs are composed of light gray standing seam metal panels layered above a structural insulated panel (SIP) system. The SIP contains a 7 3/8 in. extruded polystyrene insulation core, which optimizes energy performance. The light gray reflective metal panels minimize the heat island effect and comply with the

BUILDING TEAM

Building Owner/Representative The Gettysburg Foundation and the National Park Service

Architect LSC Design, Inc.

General Contractor Kinsley Construction, Inc.

Mechanical Engineer Century Engineering, Inc.

Electrical Engineer and Plumbing Brinjac Engineering

Energy Modeler Century Engineering, Inc.

Structural Engineer C. S. Davidson, Inc.

Civil Engineer, Environmental Consultant LSC Design, Inc.

Landscape Architect Andropogon and Associates

Lighting Design Available Light and Fisher Marantz Stone, Inc.

LEED Consultant SDK and LSC Design, Inc.

ENERGY STAR guidelines used for LEED purposes.

Creating the optimal building to house the Cyclorama painting was challenging. The design team drew on its past experiences designing cold storage facilities and determined that the same metal panels used to maintain temperature and humidity in a freezer warehouse could do the same for America's largest painting.

The skin of the Cyclorama building is composed of 3 in. isocyanurate insulated metal panels. In addition, special measures were taken to ensure that this part of the facility would remain free from condensation.

Fully adhered 40 mil flexible flashing and expandable foam insulation seal the joint where the metal wall panels meet the underside of the SIP. The sealed eave joint creates an extra barrier to keep moisture out.


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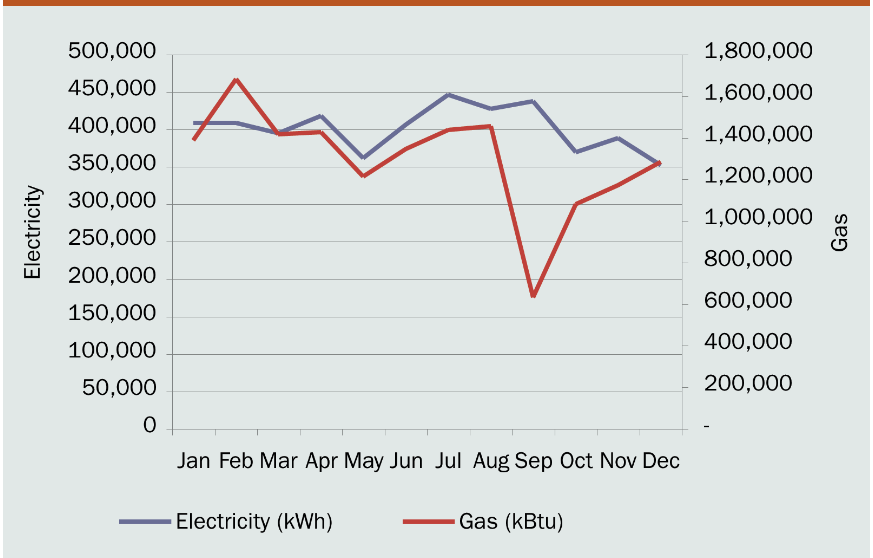
Right This statue recognizes Maj. Gen. John Sedgwick, who commanded the Sixth Corps Army of the Potomac at the Battle of Gettysburg, which took place July 1–3, 1863. The Sixth Corps was the last to arrive on the field after a 30 mile night and day march. Although much of the corps remained in reserve during the battle, various portions were committed as needed at scattered points about the field. At one point Sedgwick found himself commanding units on both the extreme right and left flanks of the army.

Below One of the two 150-seat state-of-the-art theaters shows a short historical film that describes the context of the Battle of Gettysburg.


Photo by Tim Schoon Photography, courtesy of LSC Design, Inc.

2010 ELECTRICITY, GAS USE



Two, 2-by wood blocking serves as a buffer between the structural steel trusses and the SIPs used for the roof. Bolting the SIPs directly to the 2-by wood blocking and not the steel trusses allows the wood to absorb any temperature transfer and therefore eliminate condensation on the steel truss. This technique is also used in the museum gallery, which houses the artifacts.

A vapor barrier installed in the Cyclorama building and museum gallery walls, ceilings, and flooring elements blocks invading moisture from the exterior and reinforces the facility's ability to maintain the temperature and humidity setpoints.

Additional Sustainable Elements

- Low flow toilets and sinks decrease water use.
- Twenty percent of the facility's materials were manufactured locally and 50% were harvested locally, reducing the energy expended in shipping the materials. Examples of these materials are the granite pavers, flooring, and countertops from a local quarry and exterior wood timbers harvested from a local barn built more than 100 years ago.
- Native vegetation used in landscaping requires no irrigation.
- Stream channel and wetland restoration brings the site back to its original form.

2010 ENERGY USE BY LOAD TYPE

	kBtu
Receptacles (Includes computer and general use)	621,693
Miscellaneous (General loads such as trash compactor, small kitchenette type refrigerators, coffee makers, microwaves, etc)	938,518
AV/Projection (Some load for this category may also be in receptacles and miscellaneous)	37,361
Kitchen (All major food service equipment)	7,764,257
Specialty Lighting/Receptacles (Cyclorama/exhibit area)	1,836,936
Main Telecom Room Equipment	135,088
Elevator/Escalator	787,080
Building Lighting	1,861,843
HVAC/Plumbing/Fire Protection	18,002,176
Total	**31,984,953**

ENERGY AT A GLANCE

Energy Use Intensity (Site) 228 kBtu/ft^2
Natural Gas 117 kBtu/ft^2
Electricity 111 kBtu/ft^2

Annual Source Energy 507 kBtu/ft^2

WATER AT A GLANCE

Annual Water Use 4,132 gallons

2010 ELECTRICITY AND GAS CONSUMPTION BY ZONES*

	Gallery Spaces	Cyclorama	Theaters	Store	Restaurant/ Kitchen	Lobbies/ Corridors	Offices	Storage	Data Spaces	Education Spaces	Average
Annual Energy Consumption kBtu/ft^2	176.6	313.08	166.9	176.54	1030.9	162.27	176.5	162.26	344.32	174.67	**288.404**
EUI Hourly Energy Consumption Btu/h·ft^2	20.15	35.74	19.05	20.15	117.7	18.52	20.15	18.52	39.3	19.9	**32.918**

*Note: Based on total conditioned space of 122,440 ft^2.

Photo by Tim Schoon Photography, courtesy of LSC Design, Inc.

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Above The Refreshment Saloon at the museum and visitor center is a full-service restaurant and has indoor seating capacity for up to 344 people with additional seating on the adjacent outdoor patio during warmer months. It is modeled after actual refreshment saloons that existed during the Civil War to offer weary soldiers a place to have a meal and a brief respite from the harsh realities of war.

Above Left The halogen spotlights originally installed in the book/gift store have been replaced with LED fixtures to decrease temperature and reduce energy costs.

LESSONS LEARNED FROM DAILY OPERATIONS

The facility team meets every morning to review building automation system operating data from the previous night and to do a complete walk-through of the facility. The walk-through gives the team the ability to address any concerns on the spot and to determine the best way to remedy the issue.

Weekly scheduling meetings keep the team up to date on special events occurring after normal business hours. The team adjusts the building automation system according to that week's operating hours to reduce energy consumption during partial occupancy loads.

Since the museum and visitor center's soft opening in the spring of 2008, the operational staff has made several critical adjustments to optimize energy and cost savings.

The facility team determined that the AHUs in noncritical areas of the facility such as those in the offices, restaurant, and gift shop could be cut back when the facility is closed, saving 12 hours per day of running time. This unoccupied night setback schedule varies depending on special events or building thermal performance.

The AHUs that control the temperature and relative humidity in the lobby areas (the main lobby and the group lobby) run at 30% capacity, resulting in a 70% reduction in these units' electricity use. Variable frequency drives installed on the supply and return fans are controlled by time and temperature and CO_2 levels, respectively.

The ERUs' enthalpy economizers have been adjusted to use more outside air, as opposed to recirculated air, during mid-season days.

Two chiller banks each containing 10 compressors were installed to handle the peak load of the facility. Initially, both chiller banks were active. After adjusting the building control system, the facility team was able to maintain building thermal properties by running only one chiller bank. The second chiller bank works as a backup and is enabled during peak load conditions.

One of the initial boilers installed for the mechanical system backup was used to generate hot water for the domestic hot water system. It proved to be inefficient due to its higher than required capacity. This boiler was replaced with a smaller modulating condenser, which offers major gas savings compared to the previous unit.

Many of the halogen spotlights have been replaced with LED fixtures, which use less electricity and emit less heat, reducing the building's cooling load. Emergency lighting was initially set to stay on 24 hours a day, 7 days a week. The facility team later programmed the building automation system to turn off the emergency lighting when the building alarm is armed at night. The lights turn on if an alarm is triggered or in the event of any emergency.

Regular maintenance of the HVAC system helps reduce downtime and keeps the system running efficiently. Pleated, HEPA, and carbon filters are changed on a regular schedule and are monitored and tested to ensure they are functioning at the highest capacity.

The system is monitored by three full-time facilities personnel, on site as well as off site. Changes can be made from either location. Alarms initiate an e-mail as well as printed notification on site. Two facility staff members have access to e-mail through their phones to allow for the fastest possible response time.

- Endangered grasses were harvested and transplanted during construction.
- An underground storage system collects storm water to reduce runoff.
- Green energy credits are purchased so that a significant portion of the facility's power use is generated from green sources.
- A facility-wide recycling program reduces waste.
- Landfill impact was reduced 75% by diverting metal, cardboard, and wood waste during construction to a recycling center.
- Preferred parking spaces were designated for low-emission vehicles.
- Off-gassing was reduced or eliminated by selecting low-emitting materials such as carpet and vinyl flooring, adhesives and sealants, and paints and coatings.

Photo by Tim Schoon Photography, courtesy of LSC Design, Inc.

The entry to the museum gallery houses artifacts in glass exhibit cases with independent temperature and humidity controls. Inside the gallery, exhibits include a portable wooden desk used by Confederate Gen. Robert E. Lee and the journal of a physician who listed and identified the location of several thousand Confederate soldiers who died on the battlefield.

Conclusion

The GMVC is designed to be a state-of-the-art, high performing building. Design cannot be the only factor taken into account when determining a facility's efficiency. Every member of the team plays a role in overall building performance including the design team's research and ability to consider innovative solutions, the contractors and their ability to value engineer, and the owners and their commitment to operate and maintain an efficient facility.

The facilities team's daily walk-through and careful analysis of data from the building automation system help catch operating abnormalities and solve potential problems before they damage the artifacts.

This case study shows how effective communication, skilled design, creative material selection, and knowledgeable facility operations staff can contribute to a facility's long-term efficiency goals. ●

ABOUT THE AUTHORS

Tatyana Shine, P.E., designed the geothermal system for the GMVC. She is the chief executive officer of Shine Allen & Shariff, in Columbia, Md.

Elizabeth Paul was previously a marketing coordinator at LSC Design, Inc., an architecture and engineering firm in York, Pa.

Advertisement formerly in this space.