CASE STUDY **31 TANNERY PROJECT**

Back to the Grid

BY JOHN GRABOWSKI

What appears as an ordinary prefabricated building produces from renewable energy all the electricity needed to run an approximately 42,000 ft^2 commercial facility for a full year. In addition, it produces a surplus of energy equivalent to a full month's electricity supply that is pushed out to the grid for others to use. Documented energy use for one year shows 31 Tannery Project generated more electricity from renewable energy than it consumed, making it a net zero commercial electric building.

Building Components

The 31 Tannery Project, located in Branchburg, N.J., serves as the corporate headquarters for Ferreira Construction and Ferreira Group. The building includes nine miles of radiant heat (80 zones), high performance rooftop units, a 96% efficient condensing boiler plant, 223 kW dc solar photovoltaic system, solar domestic hot water, integrated Web-based direct digital controls (DDC) system and pervasive voice/data/video system with kiosk displays.

During construction, monitoring for the two-story building's renewable energy systems, conventional energy systems and high-efficiency systems was installed along with standard building controls. This allowed the building team to learn from operations and interactions of the systems, a critical component of commissioning. System integration and interactivity, employee awareness, dedication and feedback, and visualization and commissioning displays contributed to the sustained level of performance.

Performance Process

How did a company that builds roads and bridges achieve a net zero building? Ferreira's Vice President of Construction Management Operations, Joseph Grabowski, AIA, and Director of Engineering, Edward Brzezowski, P.E., Member ASHRAE, codeveloped the project, drawing on their experience in building design, sustainability, construction management, commissioning and renewable energy. Using standard construction materials and readily available resources, the team applied three approaches to maximize results and return on investment: energy efficiency, renewable energy, and real-time monitoring and visualization of energy.

To explain the process and benefits of energy efficiency + renewable energy + monitoring and visualization, the Ferreira team uses a diet + exercise + personal trainer metaphor. Dieting or adding energy efficiency is a good start for an out-of-shape building.

BUILDING AT A GLANCE

Building Name 31 Tannery Project

Location
31 Tannery Road, Branchburg, N.J.

Size 41,508 ft^2

Started 2005

Completed 2006

Use Office and warehouse

Cost $6 million

Distinctions N.J. Clean Energy Award; N.J. Business and Industry Award for Environmental Project of the Year; Perfect 100 Point ENERGY STAR® Score; First building in N.J. to meet N.J. Executive Order 54; Radiant Flooring Association Commercial Project of the Year Award

BUILDING TEAM

Owner Ferreira Construction

Architect Joseph Grabowski, AIA

Engineer Edward Brzezowski, P.E.

Grid-tied photovoltaics allow 31 Tannery to send surplus electricity supply to the grid for other companies to use.

The Ferreira Companies builds roads and bridges.

Adding exercise or renewable energy increases results. However, having a personal trainer, or a monitoring and visualization solution, to watch the progress, track results, motivate by showing the progress, refocus efforts when slipping, say what to do next, and say if things are being done right provides the greatest results in the shortest period of time and allows for continuous improvement. All three components helped achieve the net zero electric building.

Model Comparisons

The building's electric and gas consumption as well as Btu/ft^2 are monitored and recorded. These readings are compared to DOE 2.1 models for the project, developed prior to construction when the best fit of energy efficiency and renewable energy systems was determined. Energy modeling evaluated the design's energy efficiency and projected energy requirements. Comparing actual recorded data to DOE models for high-efficiency systems and renewable energy reveals that Ferreira's natural gas consumption has been reduced by 13% and electric consumption by more than 100%.

The performance of 31 Tannery is measured against two energy models: a typical preengineered model or base building and a high performance design model. The base building is constructed using standard techniques and outfitted with conventional energy systems. A high performance design model uses state-of-the-art renewable and energy conservation systems and methods.

When compared to the base building, 31 Tannery's gas consumption was reduced by 77% and electric consumption by 104%. The calculations factor in the use of renewable energy and energy conservation.

Grid-Tied Photovoltaics

Attached to 31 Tannery's standing seam metal roof are 1,276 solar photovoltaic panels. Being new construction, rooftop penetrations and systems, such as the rooftop unit (RTU) and shop ventilation system, were kept to the north side of the building to maximize performance of the rooftop solar photovoltaic array. The solar electric system produces on average 500 kWh per day in the winter and 1,300 kWh per day in the summer. On a cloudy or overcast day, the combined inverter output typically measures 30–40 kW ac. On a sunny day, design conditions of 200 kW ac have been reached.

Ferreira constructed 31 Tannery with standard materials and readily available resources.

PROJECT COST

Total Building Cost	$6 million
Individual Component Costs (already included in total above)	
Photovoltaic System	$1,700,000
Walkways	$22,000
Solar Thermal System	$15,000
Radiant Flooring	$160,000
Additional High-Efficiency HVAC and Controls Systems	$700,000

The total payback for adding solar electric, solar thermal, additional high-efficiency systems, and monitoring is approximately five to seven years. This factors in the cost of electricity saved, cost of gas saved, renewable energy credits earned, state rebates and federal tax credits.

Electric Room

The electric room includes the building's main and distribution panels, two 100 kW ac 277/480V three-phase solar inverters, and a transfer switch for a future 200 kW gas-fired emergency generator. Although solar panels generate electricity in dc (direct current) power, most building systems use ac (alternating current) power. Inverters connected to the rooftop solar panels convert the dc (kW dc) power from the solar panels to ac (kW ac) power. The inverters have a capacity of 223.3 kW dc and allow LAN-based communications. Custom software monitors, in real time, the energy use and flow in and out of the building.

Utility Metering

The utility company's gas and electric meters have pulse output signals monitored by the building's DDC system, providing a visualization tool and important feedback. For the electric meter, as the building's photovoltaic array output approaches the building load, the pulse meter slows and then stops. During these periods, additional meters are needed to determine building load and the amount of surplus electric energy sent to the grid.

Solar Thermal Hot Water

In addition to the solar photovoltaic system that provides electricity for the building, a solar thermal system provides hot water for domestic use (showers, kitchen and bathrooms). Two 80 gallon preheat tanks serve an 80 gallon backup electric hot water heater via a double wall heat exchanger in the closed loop solar system. The solar

The 42,000 ft^2 commercial facility produced more electricity than it used in one year.

The boiler plant operates in full condensing mode with 96% efficiency.

thermal system eliminates the need for fossil fuels by heating water for sinks, showers and the dishwasher. Two preheat tanks store hot water during night hours and on cloudy/rainy days. Cold water is preheated by a 160 ft^2 rooftop closed-loop solar hot water system from approximately 50°F to 150°F–160°F and regulated by a safety/tempering valve to 120°F. A solar thermal system was selected to heat the domestic water because it is more efficient than a solar photovoltaic system in providing hot water. However, because 31 Tannery Project is grid-tied and produces surplus electricity that can be shared, an electric, rather than gas, water heater was chosen as the backup system for cloudy days and night use.

A solar thermal system heats water for sinks, showers and a dishwasher, eliminating the need for fossil fuels.

Radiant Heat

A commercial size radiant heating system serves a 26,190 ft^2 shop and 15,318 ft^2 two-story office. Approximately nine miles of in-slab PEX tubing and 16 manifold headers serve 146 loops with 80 radiant zones. During installation, 18 slab sensors were embedded in the concrete throughout the building. The loop service areas are divided into RTU-1 variable air volume (VAV) hot-water-coils, radiant-first-floor, radiant-second-floor and shop-radiant areas.

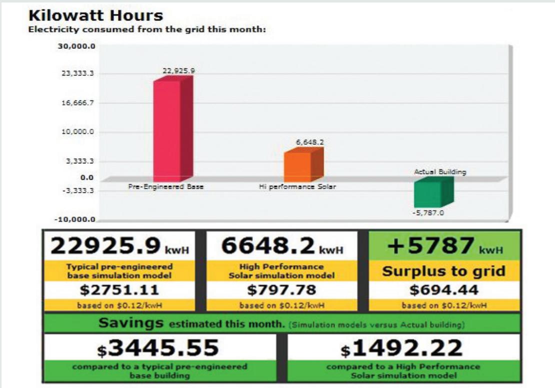
Generally, the boiler plant operates in full condensing mode with maximum efficiency. The majority of the time the water in the radiant flooring is 80°F. During the coldest winter days, the highest temperature in the radiant loop is 100°F. Because human body temperature is 98°F, visitors to the building often are surprised that the floor seems cool to the touch. Visitors are satisfied after placing one hand through the garage bay doors on the exterior parking surface and the other on the radiant heated slab. The visualization of the embedded sensors and thermal imaging from the infrared camera also intrigues visitors.

In the boiler room, a 14,000 Btu/h gas-fired, low nitrogen-oxide, full-modulation condensing boiler serves four main loops. The hot water loops are provided with variable speed and temperature controls. Loop service is divided into VAV hot-water-coil and radiant-first-floor, radiant-second-floor, and shop-radiant areas. The room also includes a wall-mounted, foldout workstation with network connections and the main control panels for the DDC system. Provisions have been made for future connections to a ground-mounted solar thermal heating plant.

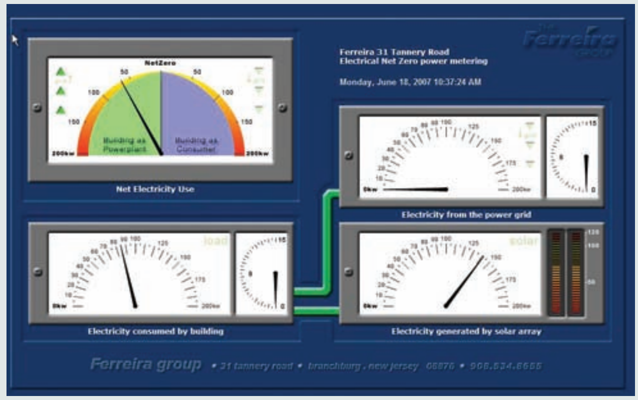
The standing seam metal roof of 31 Tannery holds 1,276 solar photovoltaic panels.

Rooftop Units

High-efficiency U.S. Environmental Protection Agency (EPA) ENERGY STAR® HVAC systems heat, cool and ventilate the building. RTU-1 serves the office wing, RTU-2 serves the shop offices, and MUA-1 serves the main shop. The two rooftop units are equipped with factory-installed controllers. RTU-1 is a 50 ton VAV system with premium efficiency motors, enthalpy economizer, and embedded network controls that serve the two-story office area. RTU-2 is a 7.5 ton constant volume system for the shop office

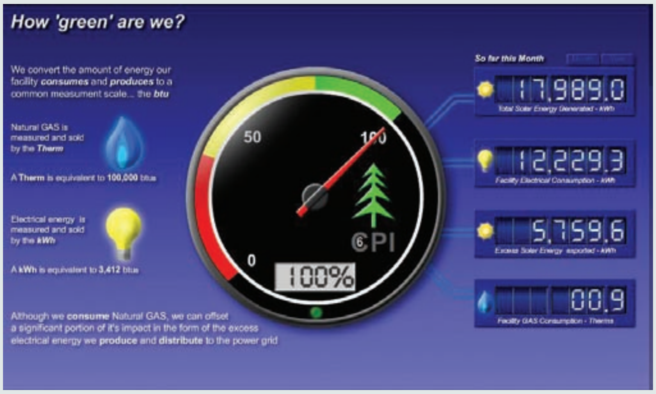


Occupants have daily Web-based access to the building's energy savings.

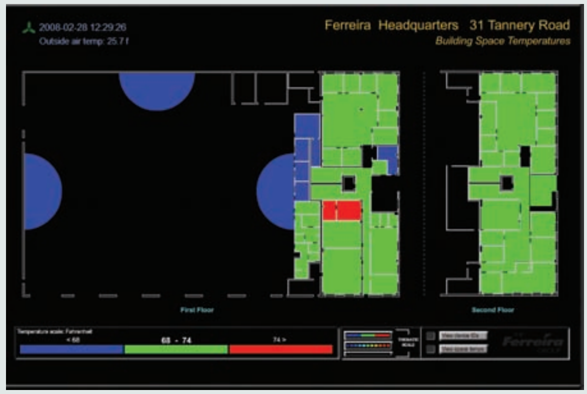


Noveda Technologies system shows the net status of the building's renewable energy production and consumption.

Approximately nine miles of in-slab PEX tubing and 16 manifold headers serve 146 loops with 80 radiant zones.



Ongoing and real-time monitoring for the renewable energy, conventional energy and high-efficiency systems was installed during construction.



A real-time display with graphics conveys space temperatures, setpoint deviations and radiant slab temperatures.

and is equipped with high-efficiency motors, an enthalpy economizer and embedded network controls.

Monitoring and Visualization

Ferreira's team designed and built its own system, now known as Noveda Technologies™, providing graphics, real-time energy and building systems monitoring, diagnostics, and a tracking system. The system provided necessary information to achieve and surpass the goal of a net zero electric commercial building. Following the success of 31 Tannery, Ferreira began deploying the system in its commissioning work.

Occupant participation was an unexpected benefit of displaying the energy use and building information. A social dynamic began the day the kiosk system was placed in the front lobby. People turn off lights if a room is vacant more than a few seconds and turn off computers during lunch and before leaving for the day. They quickly close doors in the summer and winter to conserve cooling and heating. The changes occurred without any instruction from management. No one was told to be more efficient. Instead, people wanted to participate because they could see the results of their actions on the lobby monitor. Even visitors to the building are engaged in the lobby kiosk by the visualization of the energy being produced by the solar electric system and of the building's efficiency. Some people actually return to the building to check the lobby kiosk to see how the building is performing on a particularly sunny or snowy day.

Independent studies from various universities to the National Renewable Energy Laboratory (NREL) and DOE have stated that a monitoring and visualization system can have an immediate impact of 5% to 15% on reducing energy use and improving efficiency. This has been true for 31 Tannery Project. Energy savings projections were exceeded by almost 20%, and it is estimated that up to 5% of the additional savings can be attributed to the human factor.

ENERGY USE AND COST FOR 31 TANNERY PROJECT IN 2007

Month	Btu/ft^2	$
January	4,923	3,989
February	7,086	4,554
March	5,360	3,406
April	1,492	1,869
May	(836)	569
June	(1,178)	609
July	(731)	(1,670)
August	(329)	477
September	(226)	528
October	492	496
November	2,534	1,435
December	6,230	5,107
Total	**24,817**	**21,369**

LESSONS LEARNED

Slow Radiant Flooring Radiant flooring is energy efficient and a comfortable method of heating, but it is extremely slow to cool down or heat up. Early on, Ferreira found that meeting occupant requests to increase or decrease heat just a few degrees could take hours instead of minutes. From the building's monitoring and visualization system, a discovery was made that helps keep the building temperature comfortable while maximizing energy efficiency. By lowering the radiant flooring a few degrees below the desired building temperature and using the rooftop units to augment the difference, quick adjustments to the building's temperature can be made to satisfy occupant requests.

Heating the Open Shop Area The six-bay shop area is used for servicing Ferreira Construction's heavy road and highway equipment, as well as a fleet of trucks and SUVs. When Ferreira decided to use radiant flooring to heat the approximately 26,000 ft^2 shop area, some people were skeptical about the system's ability to meet the demands. Often several bay doors are open, or opened and closed throughout the day, exposing the shop and making it difficult to maintain heating or cooling. After implementing the radiant flooring and using it for over a year, Ferreira found that the plan worked better than expected. Because the cement slab retains the heat and radiates it upward, mechanics were comfortable in the shop. The feedback has been unanimous that radiant flooring in the shop area provides a high level of user comfort while being efficient and low in cost.

Construction Diligence Even with thorough plans and well-designed systems, constant diligence by construction managers and commissioning agents was required to bring the building and systems from design to occupancy. From pressure testing the radiant flooring before the concrete slab was poured to inspecting the electrical systems, problems and errors were identified and eliminated before they were almost literally set in stone. The entire system had high pressure air pumped into it. If a leak occurred during the pouring of concrete, a drop in pressure would be seen.

Sloping Solar Panels Ferreira decided not to slope the solar panels installed on the north side of the building's roof. Sloping the panels at an upward angle would compensate for the reduction in sun exposure from the pitch on the north side, but it also would increase the wind load. Comparing the potential lost efficiency of the panels to the support that would need to be added for the roof to account for the potential wind load showed that sloping the panels was not cost effective. The decrease in production was estimated to be less than 5%, and the wind load from angling the panels would add significant construction costs. Because 31 Tannery Project is creating more power than it consumes, the increased construction cost outweighed the production loss. After installation, monitoring the panels proved the calculations correct. Because the pitch on the roof is slight, a minimal amount of efficiency was sacrificed, and adding a considerable amount of structural support was avoided.

Real-Time Monitoring Having a real-time display with dynamic graphics has allowed everyone, the licensed professional engineer, the CEO and the occupants, to participate in how the building is managed. The professional engineer has been able to identify problems and increase efficiency, the CEO sees how the investment is paying off, and occupants are able to participate in lowering energy use without affecting their workloads.

Future Plans

The 31 Tannery Project received a 100 ENERGY STAR score and was cited by New Jersey Governor Jon Corzine as being the first business in that state to meet his Executive Order 54 for the reduction of greenhouse gases. The company reduced its carbon footprint 83%.

With a payback of five to seven years, the building proves that building green and designing for sustainability is commercially viable.

The Ferreira team is not ready to stop. They are working on a plan to implement a solar thermal system to heat the radiant flooring system and eliminate the building's carbon footprint. This was not included in the original design because of cost. Current solar and high-efficiency systems added 35% to cost, and the owner required a short payback.

Additional projects are underway. Ferreira is working with the state of New Jersey, Liberty Science Center, and Newark Public Schools to implement a renewable energy learning program to be taught from grade school through high school. The Ferreira team also hosts visitors on a regular basis to let other businesses learn how they can apply the same techniques to their building and achieve similar results. Upon visiting 31 Tannery Project, many business owners have expressed interest in investing in renewable energy and energy efficiency for their buildings. ●

ABOUT THE AUTHOR

John Grabowski, vice president of Noveda Technologies, Inc., served as project coordinator for 31 Tannery Project.


Adding Value to People through Education
BOMI INTERNATIONAL®
BUILDING OWNERS & MANAGERS INSTITUTE INTERNATIONAL
Increase your knowledge, contribution and earning potential!
BOMI International has been educating property and facility management professionals worldwide for over 35 years.
Industry-standard designations include:
• Real Property Administrator (RPA®)
• Facilities Management Administrator (FMA®)
• Systems Maintenance Administrator (SMA®)
• Systems Maintenance Technician (SMT®)
HPB.hotims.com/18426-6
For more information and to enroll in a program or course, visit www.BOMI.org