Verified Zero Net Energy Building Case Study

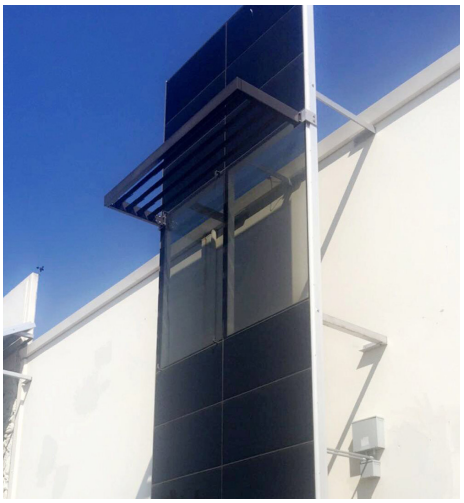

Photo: Nick Bagatelos

Photo: Google Earth

OVERVIEW

Location: Sacramento, CA
Project Size: 63,000 SF
Construction Type: Retrofit
Construction Date: 1969, Retrofit in 2008, additional PVs added 2012
Building Type: Manufacturing facility
CA Climate Zone: 12
Total Building Cost: $2,000,000
Cost/Sf: $32
Hard costs: $2,000,000

Measured Energy Stats

17.1 - 17.5 = -0.4

BUILDING'S TOTAL EUI	RENEWABLE PRODUCTION RPI	BUILDING'S NET EUI

Site Energy Use Index (EUI) kBtu/SF/year

The Energy Equation: **the building energy use** *minus* **the renewables production** *equals* **the net energy of the building**. Buildings may be 'Getting to Zero' and have a net EUI above zero. If renewable production exceeds energy use its net EUI is below zero (negative) and it is creating surplus energy.

nbi new buildings institute

For more information:
newbuildings.org/zero-energy

BAGATELOS ARCHITECTURAL GLASS SYSTEMS MANUFACTURING FACILITY

The Bagatelos Architectural Glass Systems (BAGS) manufacturing facility is a retrofit of a 1969 concrete warehouse that was renovated in 2008 to be a zero net energy (ZNE) building. The 63,000-square-foot Bagatelos Architectural Glass Systems manufacturing facility produces custom glass curtain wall systems for buildings throughout the state of California. Approximately 80% of the facility is dedicated to the manufacturing of glass and aluminum components, while the remaining space houses offices. After the company's production increased, in 2012 an installation of additional photovoltaic (PV) panels was necessary to return the 50-person operation to ZNE. Efficient lighting and mechanical systems reduced the energy consumption of the facility by 40% of the average for comparable building types, and the PV panels produce enough electricity to offset the remaining energy load.

Planning & Design Approach

The first step of the project was to design an ultra-efficient building. Because budget was a primary concern, Bagatelos gave strong preference to highly efficient systems, and deployed technologies that are commonly used in construction, rather than higher cost advanced technologies. Bagatelos used building energy modeling and daylighting modeling to estimate the building's energy performance and provided valuable studies to identify opportunities for additional efficiency improvements. Energy consumption that could not be economically reduced further was offset with PV panels.

Policy

As a company, Bagatelos upholds high standards for environmental performance and offers cutting-edge energy efficient building solutions. The company also

Team/Owner Details

Owner: Nick and Chris Bagatelos

Utility: Sacramento Municipal Utility District

Awards

2012 Sacramento Business Journal Green Leadership Award for Energy Efficiency

integrates this passion for sustainability into its operations, promoting the environmental, financial, and promotional benefits of this ideology.

In 2008, Bagatelos was able to take advantage of a newly implemented California Senate Bill 1, which required utilities to offer an incentive of $2.80 per watt of PV system installed on a building. These funds offset the cost of the PV system by approximately 25%. The federal Solar Investment Tax Credit offset an additional 30% of the cost of installation, which is available for all residential and commercial developments.[1] These policies provided a financial motivation for the manufacturing facilities retrofit at BAGS.

Design Process

Rather than hiring an outside contractor, owners Nick and Chris Bagatelos managed the retrofit, and selected independent subcontractors. They worked collaboratively to select energy efficient solutions which improved the building's performance by an average of 40% compared to the baseline code standard.

Financing Costs & Benefits

Operating Costs & Income

The retrofitted facility saves BAGS approximately $40,000 to $50,000 annually on utility bills with a 25 year warranty that assures 90% of performance goals. The ZNE building has also yielded many other income-generating benefits. As a company which builds highly efficient wall systems and incorporates tested, high-performance products, the BAGS ZNE headquarters aligns well with Bagatelos' mission. The facility helped Bagatelos distinguish itself as a committed leader in the movement toward ZNE development and attract customers with a similar focus.

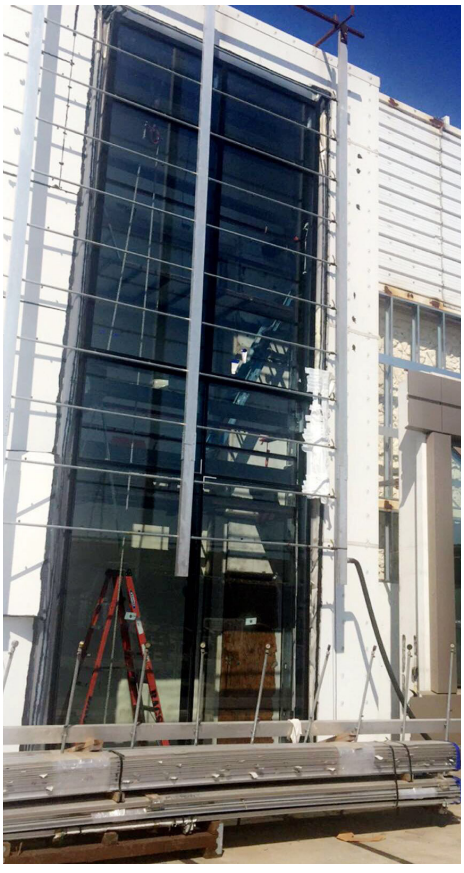

Photo: Nick Bagatelos

Financing & Incentives

Conveniently located across the street from the Sacramento Municipal Utility District (SMUD), Bagatelos worked closely with SMUD to identify available incentives. Bagatelos received an initial $250,000 utility incentive credit from SMUD and an investment tax credit of $300,000 for the installation of the PV system. This worked to offset more than half of the $1 million investment in the resulting PV system.

The Modified Accelerated Cost Recovery System (MACRS)[2], a depreciation system implemented to encourage businesses to install renewable energy, allowed for a five-year investment recovery period, which provided tax deductions to offset approximately 25% of the total cost of the PV system.

Legislation creating these incentives allowed the solar industry to gain momentum over the ten years prior to the design of the project. This helped cut the market price of PV panels in half compared to when they were first introduced to the market, which made them an affordable choice for Bagatelos. By the time Bagatelos installed the second phase of PVs in 2012, the market price had been halved again.

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1 The $2.80/watt incentive decreases at a minimum rate of 7% per year. SMUD reached its maximum funding limit in April 2015 and no longer offers the credit.

2 The $2.80/watt incentive decreases at a minimum rate of 7% per year. SMUD reached its maximum

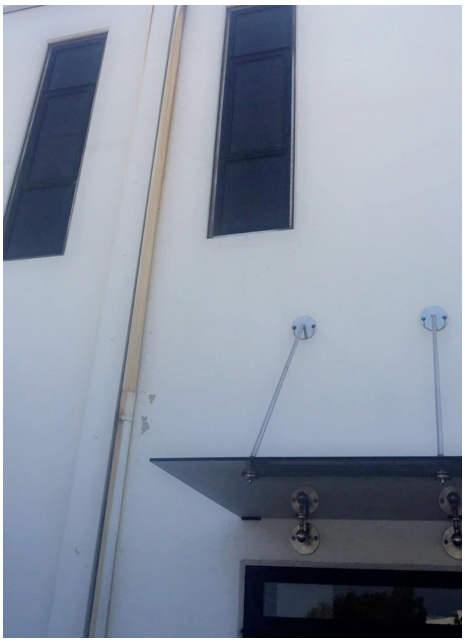


Photo: Nick Bagatelos

"Any building, especially a warehouse, can be retrofit to zero energy fairly easily, and you can take advantage of some great tax credits."

– Nick Bagatelos, President, Bagatelos Architectural Glass Systems

Return on Investment

Generous incentives and tax credits helped reduce the total investment outlay and provide the opportunity for a better financial return. After incentives and tax credits, this offered a 33% return on investment for the PV system and yielded a three-year payback period. The first phase of PV installation cost $1 million and then couple with the energy efficiency measures resulted in $26,000 energy-cost savings per year. Factoring in the second PV system, Bagatelos now saves $30,000 to $50,000 in annual electricity costs.

The "3-30-300" principle of green buildings likely offers additional gain for Bagatelos. Businesses spend approximately $3 per square foot on energy, $30 per square foot on space, and $300 per square foot on staffing annually. Though the retrofit facility offered a measureable value in energy savings, the increase in occupiable square footage resulting from a downsized HVAC system, as well as environmental benefits for employees, likely far exceed the energy cost savings benefits. Employees now enjoy good daylighting and natural ventilation achieved with the deep energy retrofit. Studies have shown that this can improve health, satisfaction, and productivity—an even greater benefit than savings from energy conservation.

Energy Efficiency Strategies & Features

Lighting & Daylighting

Daylight from a total of 60 skylights illuminates the factory portion of the building, allowing the manufacturing facility to operate primarily with daylight alone. Additional skylights, coupled with 16 operable windows, illuminate the office space and reduce the need for electric lighting. Bagatelos chose high-efficiency fluorescent lamps, the most common low-energy lighting solution in 2008, to supplement the natural daylight. A daylight sensor allows these lights to automatically adjust to daylighting received through the windows and skylights, reducing the need for user control. Occupancy sensors conserve energy by shutting off lights in rooms that are not in use.

Envelope

The design incorporates three layers of insulation to reduce the load on the heating and cooling system. These added layers of standard fiberglass batt insulation are a cost-effective strategy to achieve an R-value of 30 for the exterior wall area—more than twice that required by code.

HVAC

In the moderate Sacramento climate, an electric heat pump provides an efficient solution to both heat and cool the facility. Operable windows, including casement windows in the office space and large roll-up doors in the manufacturing area allow workers to passively condition their space, reducing the running time of the heat pump system and improving outdoor air ventilation.

Plug & Process Loads

Bagatelos chose to focus its primary efforts on reducing the electricity consumption of its facility through changes in the building design and process loads to allow the manufacturing process and behavior to remain similar to operations in the previous facility. The company converted its manufacturing

equipment to efficient computer numerical control (CNC) machines imported from Germany to reduce energy consumption. Though the system runs 10 to12 hours per day, the renewable energy system completely offsets the company's substantial process loads.

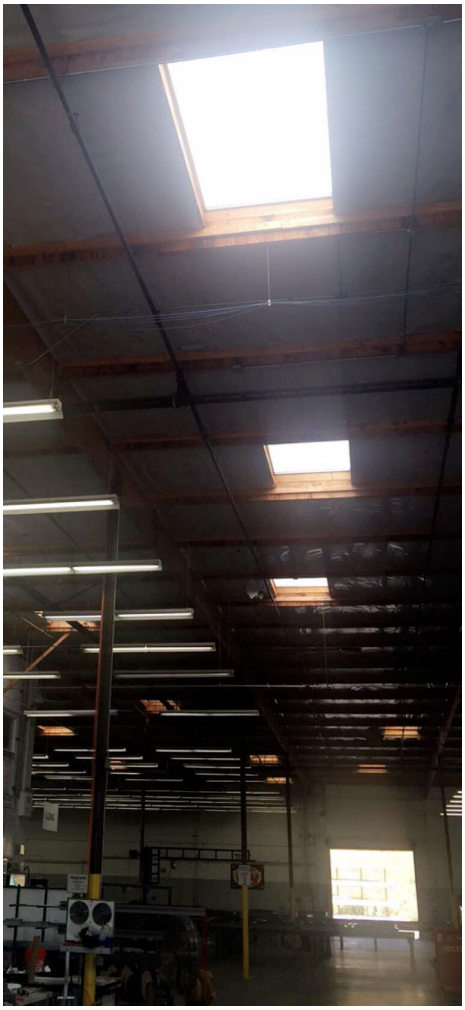


Photo: Nick Bagatelos

Occupant Engagement and Training

One goal of the design for the retrofit of the facility was to allow the factory to operate normally by focusing design strategies on the building components themselves. Bagatelos' unique approach was to select systems that are common and intuitive, so no company-wide occupant training was necessary.

Renewable Energy Generation and Storage

The initial warehouse retrofit in 2008 included the installation of 92 kW of rooftop PV panels. At that time, this was sufficient to offset all energy use of the facility as well as generate a 30% surplus. As the business grew, the factory's operational demands resulted in increased loads that surpassed the renewable energy generation at the time. In 2012, Bagatelos installed an additional 160 kW of PV panels on the building to return the facility to ZNE performance. The entire PV system, which sits exclusively on the building and covers the majority of the roof, now generates 108,500 kWh per year.

New Buildings Institute has evaluated the building's energy performance data from utility bills dated July 2015 to June 2016 and verified Bagatelos' facility is a ZNE building. It consumes only 5.5 kBtu/sf/yr, while it produces 5.9 kBtu/sf/yr.

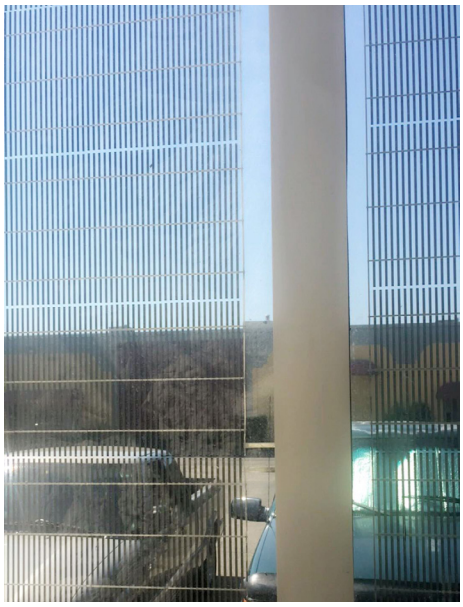
Post Occupancy

Commissioning

Subcontractors helped select, install, test, and balance conventional lighting and HVAC systems. No formal commissioning took place. Simple monitoring of the utility statements during the first few months of operation identified any issues in building energy performance. Aside from a few simple adjustments required, the building systems have performed as expected.

Monitoring

Bagatelos reviews monthly utility bills to identify any major concerns. Because the individual mechanical components are durable, owners have not detected any issues since occupancy. The systems require no facilities manager, which further reduces operational costs.



View through PV curtain wall

Photos: Nick Bagatelos

Successes

A crucial factor in the success of the building retrofit was that it was extremely cost effective taking advantage of all available incentives, tax credits, and energy savings. The project demonstrates that ZNE is attainable for manufacturing facilities; and a ZNE project does not necessarily require massive financial backing or high-tech, state-of-the-art systems.

"I took ideas I learned from my net zero building that were in or close to it, took my curtain wall system and modularized a photovoltaic wall and roof system to it, and I'm able to put 460kW on a 40,000 square foot building."

– Nick Bagatelos, President, Bagatelos Architectural Glass Systems

Bagatelos also benefitted from the rapidly decreasing prices for PV systems as the technology became more commonplace. At the time of the initial retrofit, that wasn't the case and even still, PVs offered a financially advantageous solution for the retrofit. Because the design incorporated energy-efficient mechanical systems and the overall energy intensity of the building was low, PVs did not need to cover all the available roof surface area to offset energy use. Due to the declining costs of renewable energy systems, Bagatelos was able to cost-effectively install additional panels four years after the initial retrofit in order to compensate for increased machinery runtime and added process loads.

Lessons Learned

- Through its thoughtful retrofit design, Bagatelos discovered that a highly efficient building could be created by simply selecting the most efficient mechanical and electrical components individually. The result is a flexible building system which is cost effective and operates as a ZNE building. The creative design process used for this project resulted in a loose prototype for an ultra-efficient warehouse retrofit which can be readily applied to other building retrofits across the country.

- A major challenge in working toward a widespread goal of ZNE lies in monitoring the building's energy consumption and generation. Bagatelos experienced an increase in the cost of monitoring services for its PV system and discontinued the service. This means they no longer have a record of how much energy the system produces each month. Though utility bills show the net metered amounts the difference between energy consumed

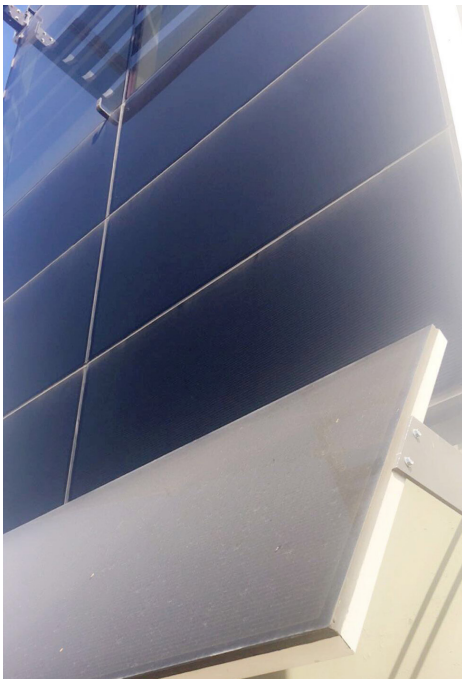


Photo: Nick Bagatelos

and produced by the building each month, the bills do not include total energy consumed. This makes understanding energy consumption and calculating a gross energy use intensity (EUI) or renewable production intensity (RPI) difficult. Ongoing energy tracking is an important step to maintaining a zero net energy facility.

- Once the building achieved ZNE, Nick Bagatelos realized just how feasible it is to achieve a ZNE retrofit. The owner also discovered that a market exists for efficient design and technologies, despite the industry's slow transition in that direction. He decided that if he could find a ZNE solution for his building, he could do the same for others. In this way, his factory design inspired him to apply select ideas from his project toward the development of a building-integrated PV curtain wall system.

  By identifying the most cost effective individual components, similar to his approach to the factory's design, Nick Bagatelos, with his company BISEM Inc., designed a modular glazing system, the Net Zero Envelope™. This product enables 460,000 kW of solar potential to be installed on a 40,000-square-foot roof. An exterior which generates this much energy can transform a simple, efficient building to a ZNE building. This amount of generation allows a small building (sizes range from 20,000 to 60,000 square feet) to operate at ZNE without the need for advanced mechanical systems. Bagatelos hopes this innovative system will soon attract the attention of developers.

Resources For More Information

- NBI Buildings Database: http://newbuildings.org/resource/getting-to-zero-database/#70377
- Bagatelos Architectural Glass Systems: http://bagatelos.com/index.html