Bank of Italy Building's Net Zero Energy Renovation: A Case Study

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The designation of Net-Zero Energy describes a building that meets all of its energy demand with on-site renewable energy generation. The Bank of Italy Building, in Downtown San Jose, California, is currently undergoing design-development to transform a landmark historical site into a modern, Net-Zero Energy building. This paper will analyze the project team's design approach to minimizing energy demand and meeting this demand with on-site renewable energy. It will also evaluate the unique challenges associated with preserving the historical character of the existing structure, while converting it into a high-performing building. The research will consider similar past projects and approaches; the goals and rationale for choosing a zero-energy design; the specific project approach and associated challenges; and the economic rationale behind the project. The research employs both quantitative and qualitative approaches to gather information on the project, as well as relevant cost and energy data from governmental and private publications. This data is used to develop an understanding of the project approach and economic rationale behind the Net-Zero Energy conversion of a historic landmark building. The results of this study reveal that the project is economically feasible, with a favorable payback period on the initial investment.

Key Words: Net Zero Energy, Renewable Energy, Solar Energy, Historic Renovation

Introduction

Buildings account for about 40% of total energy consumption in the United States. Recently, owners have begun to realize the financial and environmental benefits of constructing more efficient buildings, which consume less energy, have lower utility bills, and result in a smaller carbon footprint. Compounded with growing concerns of increasing energy costs, impending repercussions of climate change, and a desire to move away from the existing energy grid, developers have increasingly focused on renewable energy sources to meet demand. As of 2016, renewable energy made up 15.6% of total energy generation in the U.S., up from 9.5% a decade earlier. (US Dept. of Energy, 2016). This conversion from fossil-fuels to sustainable sources of energy implies significant benefits to building owners.

Within the past two decades, the concept of the Net-Zero Energy building, which meets all of its energy demand with on-site renewable generation, has become a reality. In 2000, the first commercial building of this designation was constructed. Oberlin College's Adam Joseph Lewis Center made use of photovoltaic panels, natural lighting and ventilation, and passive solar design to significantly reduce demand and meet this demand on-site. (Peterson). Since then, this process has been repeated and modified through numerous iterations. According to the New Buildings Institute, in the U.S. as of 2016, there are 53 Zero Net Energy Verified Buildings, defined as those whose "total consumption of energy, from all sources, has been fully balanced by onsite renewable energy generation on an annual basis." (New Buildings Institute, 2016, p. 4). Of that number, 18 are located in California. (New Buildings Institute, 2016).

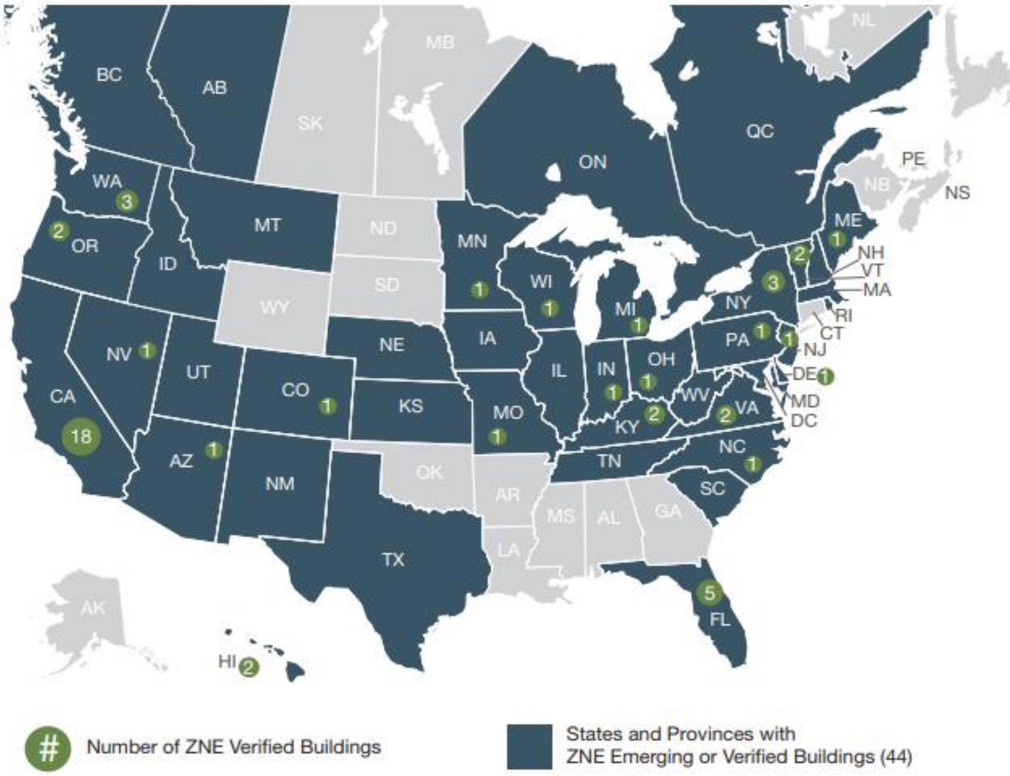

Figure 1: Zero Net Energy Building Locations in North America
Source: New Buildings Institute (2016)

Approaches

Approaches to designing Net-Zero Energy Buildings (NZEBs) can be categorized into demand-side and supply-side strategies. According to the National Renewable Energy Laboratory's Classification System, "A good NZEB should first encourage energy efficiency, and then use RE sources that are available within the building footprint—the definitions and classification system support this." (Pless, S., & Torcellini P., 2010, p. 3). Demand-side strategies that improve energy efficiency include passive solar heating, daylighting, natural ventilation, and high-efficiency lighting and HVAC systems. On the supply-side are most typically on-site generation sources within the building footprint, such as rooftop photovoltaics and solar water heating systems. Renewable energy may also be generated on-site but outside the building footprint, for example, through photovoltaic systems located on the site's parking lot. These options are less preferable due to the possibility that they will be removed or covered in the future (Pless, S., & Torcellini P., 2010).

In other cases, the building cannot adequately meet its demand with only on-site generation. Under some definitions, NZEBs may meet some demand through off-site generation. One option is to import renewable sources produced off-site, and use them to generate energy on-site. Specific strategies include biodiesel, ethanol, and other biofuels. Lastly, under some cases, a building may meet its demand by purchasing off-site energy in the form of renewable energy credits, or through negotiations with local utility companies. The National Renewable Energy Laboratory's hierarchy of NZEBs places on-site generation within the building's footprint as the most desirable approach, while off-site energy purchasing is the least preferable option. (Pless, S., & Torcellini P., 2010).

Oberlin College's Lewis Center

In 2000, the Adam Joseph Lewis Center at Oberlin College became the first commercial building in the United States to achieve Net-Zero Energy status. This project has since been used as a gold standard for sustainable design, and a living laboratory for studying and tracking energy consumption. All aspects of the design were considered in regard to its goals for achieving Zero Energy. Windows were designed to minimize air conditioning through convective cooling, with low windows on the south end and high windows on the north side. The roof is designed to maximize available solar area and angled to maximize solar gain, equipped with 4,800 square feet of photovoltaic panels. (Peterson, J., 2011)

The building introduced several innovative technologies and approaches that have become increasingly common in high-performing buildings. HVAC and lighting are controlled by a building automation system that includes motion sensors and daily timers. A ground source heat pump system circulates water through an underground system to heat the building. Operable windows allow occupants to control heating and cooling in their environment. In addition to the rooftop system, additional photovoltaics are located in the site parking lot. Altogether, on the supply-side, the building actually produces more energy than it consumes, which it sells back to the city of Oberlin. (Peterson, J., 2011).

Objectives

The objectives of this case study are as follows:

- Analyze the design approach taken to minimize energy demand and generate on-site renewable energy.
- Evaluate the initial investment in renewable energy sources and demand-reduction strategies.
- Compare the initial investment with the projected long-term returns.
- Demonstrate the viability and long-term financial benefit of converting historic buildings into Net-Zero Energy facilities, and inspire building professionals to follow this example.

Methodology

The research will employ both qualitative and quantitative approaches to evaluate the planned renovation of 12 South First Street to a Net-Zero Energy building. The report will consider the project approach, as well as the financial incentives behind the conversion. The design approach and project rationale will be explained, and the process will be described in the context of its unique challenges and characteristics. Project data was gathered primarily from the developer and construction manager, Kevin Bates of Sharp Development. At its current stage, the Bank of Italy project is undergoing design development, so all accounts will be preliminary and subject to change.

Cost data was developed through information gathered from government and private publications. A broad financial analysis was conducted, comparing the cost of the initial investment with the projected value added by the renovation. The added cost of renovating to Net-Zero Energy was estimated, with particular attention given to the cost of photovoltaic installation. Energy cost projections were then calculated, and used to provide a payback period estimate, comparing the initial investment cost with the projected value of costs saved.

Case Study

The Bank of Italy building was originally constructed in 1925 by Amadeo P. Giannini, the founder of the Bank of America, at a cost of $1 million. Located in Downtown San Jose, California, at 14 stories it remained the tallest building in San Jose for the next 61 years. The Renaissance Revival building, which was owned by the Bank of America until 1970, was designated a San Jose Historical Landmark, and today is considered one of San Jose's most iconic structures. (Bank of Italy Building, n.d.). In 2017, a group of investors led by Gary Dillabough purchased the building for $25 million. The new owners plan to perform a complete interior renovation, revitalization of the historic core, and conversion into Class A office spaces. The focus of the renovation project will be to convert the building into a Net Zero Energy facility, while retaining the original historic character. Significant work is planned to demolish the existing interior walls, MEP systems, and rooftop equipment, and install a new high-efficiency MEP system. The Net Zero plan contains a number of innovative technologies in order reduce demand and meet that demand with on-site renewable energy.

Project Specifics

The following are key specifics of the Bank of Italy project:

- Location: 12 South First Street, San Jose, CA
- Building Size: 118,371 square feet
- Purchase price: $25,088,000
- Expected duration of design/permitting/construction: 24 months
- Interior improvements: exposed ceilings, open floor plan, new flooring/paint, new elevators
- Exterior rehabilitation: repair façade to original condition, clean exterior stone and brick, replace existing windows, restore light to Light Tower
- Structural retrofit: added stiffness with K bracing or shotcrete, new stairwell
- Tenant spaces: Class A offices, full floor tenants
- Renewable energy: bifacial photovoltaic panels installed on roofs
- High-efficiency technology: electrochromic operable windows, high performance insulation, Circadian Rhythm lighting system, high performance MEP system
- Developer: Kevin Bates, Sharp Development
- General Contractor: Build Group, Inc.
- Architect: Steve Stenton, RMW

Net Zero Goals and Rationale

The primary goal of the development team is for the Bank of Italy building to become to most desirable office location in San Jose. As part of this goal, the developer (Kevin Bates) has identified several key reasons for the conversion to Net-Zero Energy.

- Economic: the primary motivator behind the conversion is an economic rationale. The developer anticipates significant added value in terms of energy cost saved and above-market rent generated.
- Energy rate scale: the Net Zero status will eliminate dependence on the PG&E rate scale, which is expected to increase in future years.
- Reliability: the MEP system is considered high-performing, reducing the need for future maintenance and costly repairs.
- Environmental impact: the designation will align with the owner's corporate values, and its reputation will further increase the value of the property.

Design Approach

The design approach is focused on reducing energy demand, and meeting this demand with on-site production through the use of photovoltaic panels. The solar panels will be installed on three sections of flat roof. The layout of the roof, shading, historical significance of the building, and lack of parking lot access created some unique challenges that required novel approaches. In order to reduce energy demand, the developer has focused on two areas: controlling HVAC loads and controlling artificial lighting loads. Energy Use Intensity (EUI), a measure of energy consumption per square foot per year, will be used as a baseline for measuring overall building efficiency. The developers aim to reduce EUI from an estimated 92 kBtu/ft2 in its current state, to 18-20. This aggressive goal requires a number of strategies aimed at limiting HVAC and Lighting loads as much as possible.

HVAC loads will be minimized through development of a high-performing insulation system, use of exposed concrete as a natural air conditioner, and a complex Building Management software. The exterior walls will be insulated to R-20 value, and existing windows will be replaced with operable electrochromic windows, which continually adjust to control the amount of light that passes through. The system will eliminate the need for blinds, replacing them with an automated system that limits solar heat gain while increasing natural lighting. The floor slabs will be designed with exposed concrete, which acts as a heat sink due to its high thermal mass and further eliminates the need for air conditioning. Temperature sensors will be embedded in the slabs and walls, and will be connected to a Building Management software. The program will control the HVAC system, as well as automatically open and close windows in order to control heat and improve indoor air quality. The system will further eliminate the need for artificial ventilation by exchanging air in the middle of the night.

Lighting loads will be controlled by maximizing the availability of natural light within the building. Electrochromic windows will maximize natural light while controlling thermal gain. Additionally, operable skylights will be installed and connected to the Building Management system. In addition to limiting energy demand, the existing MEP system will be removed and replaced with a high-efficiency system.

Challenges of Historic Landmark

The Bank of Italy Building's status as a Historical Landmark presented a number of unique challenges, which set this project apart from past Net-Zero Energy developments. The developer identified the following issues and the strategies planned to address these challenges:

- Due to its designation as a Historical Landmark under the City of San Jose, the governing body required that the overall look and feel of the building be maintained. As part of this requirement, the city required that the original exterior of the building be preserved. As part of a typical strategy of creating an NZEB, the developer attempts to control HVAC loads by enclosing the building envelope in high-performing insulation. The most effective way to do so is by insulating the exterior of the walls. However, owing to the historic nature of the Bank of Italy Building, the exterior façade could not be altered in any way. This limitation required that the developers insulate the interior of the walls instead.
- The design strategy calls for electrochromic windows that continually adjust in transparency, in order to maximize natural lighting and control solar heat gain. This strategy required removal of the existing windows, which necessitated that the development team submit additional documentation in order to approve this process. The team was required to convince the City of San Jose that this process was necessary in order to drastically improve the efficiency of the building. The removal and replacement with electrochromic windows is expected to be approved, an indication that the City is motivated by environmental goals and seeks to incorporate new technology with historic structures.
- The ability of the structure to generate solar energy is limited by space restrictions. There exist three flat roof sections capable of supporting photovoltaic panels, and no additional parking area. The roof sections are further complicated by issues of shading and access; the fire department requires that these areas be accessible. These limitations necessitated a novel approach by the developers. In order to maximize availability of solar energy, while allowing for roof access, photovoltaic panels will be constructed at 12-14 feet above the roof. In order to work around the space limitations, the roof will incorporate a reflective surface, and bifacial solar panels will be used. This system, which calls for Lumos bifacial solar cells, will allow for energy capture from both faces as light passes through a transparent panel, reflects off of the roof surface, and energy is produced by the underside of the system.

Energy Cost Savings

The following calculations are performed based on specific project data given by the development team, and average energy prices given by the Bureau of Labor Statistics. These calculations attempt to quantify the total amount of energy cost saved by implementing an on-site renewable energy generation system.

Estimate	**EUI (kBtu/ft2)**	**Building Size (ft2)**	**Energy/year (kWh)**	**Energy Cost ($/kWh)**	**Total Energy Cost ($/yr)**
Initial	92	118,371	3,191,583	0.204	651,083
Planned	18	118,371	624,440	0.204	127,386

Table 1: Estimated Total Energy Cost per Year

Energy costs are estimated at $0.204/kWh, based on data provided by the Bureau of Labor Statistics for the average price of electricity in the San Francisco Bay Area, as of January 2018. (Bureau of Labor Statistics, 2018). At an initial EUI of 92 kBtu/ft2, and a gross square footage of 118,371 ft2, the building in its un-renovated state would consume approximately 3,191,583 kWh/year (using a conversion rate of 1kWh = 3.412 kBtu). At a cost of $0.204/kWh, the total cost of energy is approximately $651,083 per year. By improving the building to 18 EUI through the strategies outlined previously, the total cost of energy drops to $127,386 per year. Generating this energy entirely with on-site photovoltaic panels constitutes a savings of approximately $651,083 per year, based on a current EUI of 92 kBtu/ft2.

Initial Cost of Photovoltaics

The developer plans to use roof-installed photovoltaic panels to generate all energy. While renewable energy generation aligns with environmental goals, there also exists a significant economic rationale. The proposed system is a Lumos GSX BiFi Module System that is capable of generating energy from both sides of the panel. The system is rated at 330 Watts. Dimensions of the Module are 66.9"x39.4", resulting in 18.3 square feet per Module. The building's installable roof area is approximately 12,700 square feet. Utilizing the entire roof, the building is capable of housing approximately 694 Modules. At 330 Watts each, the total Wattage of installed panels will be 229,020 Watts. According to the National Renewable Energy Laboratory (NREL), the average cost of installation for a commercial photovoltaic system is $1.85/Watt. (Fu, Feldman, Margolis, Woodhouse, & Ardani, 2017). NREL defines cost as the "aggregated expenses incurred by a developer/installer to build a system." (Fu, et al., 2017, p. i.v.). The resulting cost of installing the system is $423,687, calculated by multiplying the Total Installed Watts by the approximate number of modules. At 118,371 ft2 of building area, the cost per square foot comes out to $3.58/ft2.

Roof Area (ft2)	**Module Size (ft2)**	**Modules (ea)**	**Watts/ Module**	**Total Installed Watts (W)**	**Cost/Watt ($/W)**	**Total Cost ($)**	**Cost/ft2 ($/ft2)**
12,700	18.3	694	330	229,020	1.85	423,687	3.58

Table 2: Estimated Total Cost of Photovoltaic Installation

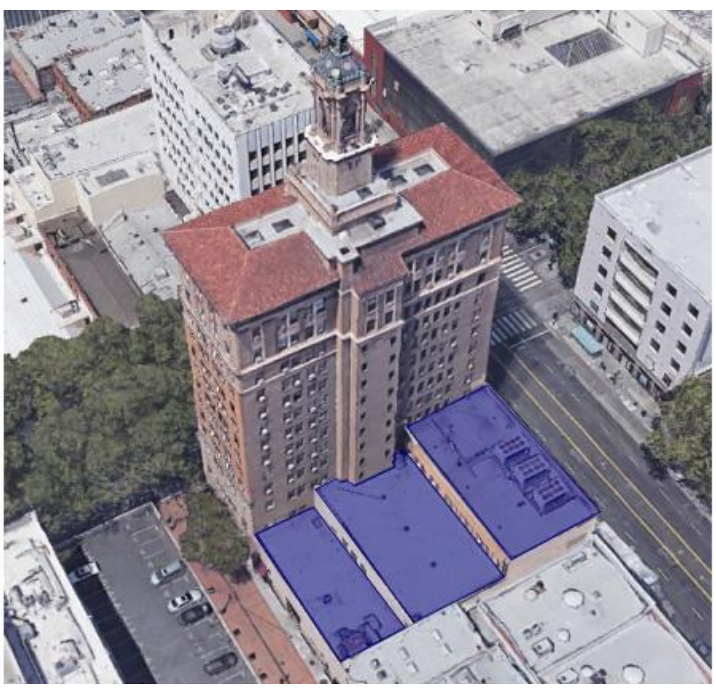

Figure 2: Installable Roof Space

Payback Period

Using historical data from past projects, the developer has estimated that the additional cost of renovation to meet Net-Zero Energy goals is approximately $49.84 per square foot. This estimate represents the difference between minimal code and Net-Zero performance. Of this cost, energy generation in the form of photovoltaic panels represents $3.58/ft2. The remaining cost is realized by the added cost of reducing demand through high-performance systems and advanced technologies. At an estimated $49.84/ft2, and 118,371 ft2 of building area, the total initial investment of the conversion is approximately $5,899,611.

The reduction in energy cost by converting to on-site renewable energy represents a savings of approximately $0.46/ft2 per month, or $651,083 per year. Additionally, the developer anticipates that the added investment will generate above-market rent at an additional $0.20/sf per month, or $284,090 per year. Total added value is estimated at $935,173 per year. Using a simple payback period to relate initial investment cost to projected cost savings, the developer can expect to recoup the initial investment in 75.5 months, or 6.29 years.

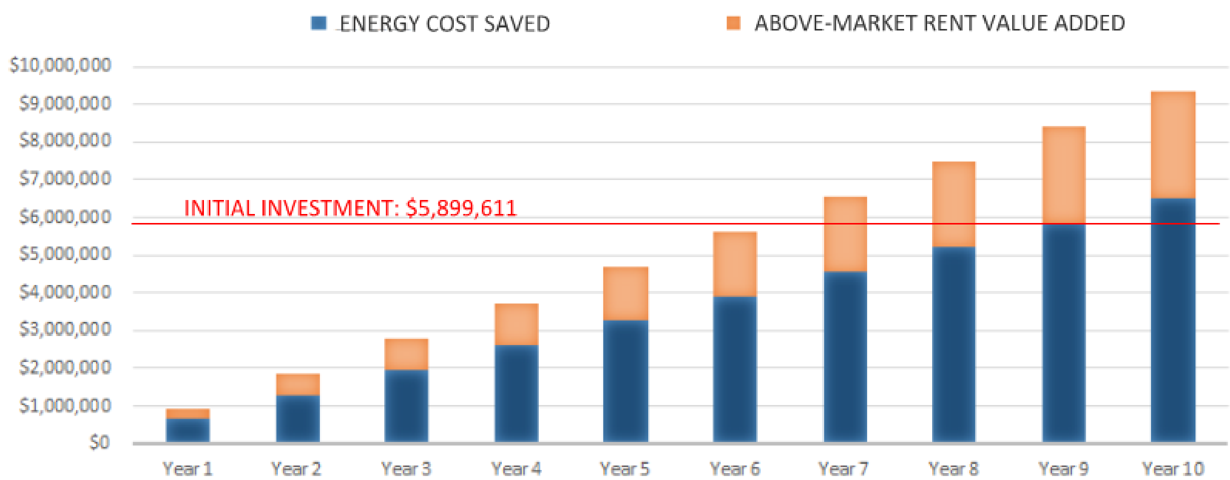

Figure 3: Payback Period Graph

Lessons Learned

When converting a building to Net Zero Energy performance, one cannot ignore the significant environmental benefits. These benefits translate to an alignment with the owner's own ethical goals, as well as an added interest in the reputation of the building itself. There is, however, a significant economic rationale behind construction of Net Zero facilities. This economic gain manifests itself in more ways than the obvious energy savings. A high-performing HVAC system, for example, can be expected to save the owner significant maintenance costs. Additionally, while the cost of installing photovoltaic panels continues to decline, future energy rates remain a substantial concern. Building owners in the San Francisco Bay Area can expect to pay 20.5 cents per kWh, a rate 51.9% higher than the national average. (Bureau of Labor Statistics, 2018). At the same time, the initial investment into photovoltaics may be surprisingly cost-effective to some building owners. The NREL notes substantial declines in Commercial PV costs, down from $2.17/Watt in 2016 to just $1.85/Watt in 2017, owing to several factors including lower module price and higher module efficiency. (Fu et al., 2017). If this trend continues, then on-site renewable energy generation may become standard in new construction. As of 2016, there existed just 53 Zero Net Energy Verified buildings in the United States. With declining renewable energy costs, compounded by a growing awareness over the environmental and economic benefits that can be realized through Zero Energy buildings, this number may increase substantially in the near future.

Conclusions and Future Research

The planned renovation of the Bank of Italy building into a Net-Zero Energy facility serves as an example of the economic feasibility of such a project. The design incorporates unique strategies to overcome unique obstacles relating to the building's status as a historic landmark. The project approach can be used as an example for future building owners and construction professionals. While the design comes with significant added investment, data suggests that this investment will be recovered in a relatively short amount of time. The payback period of the initial investment is projected at just 6.29 years. Meeting energy demand entirely through on-site generation will yield significant cost savings. A number of factors, including high local energy costs and the inefficiencies of the building in its current state, generate a compelling rationale behind the conversion. These results demonstrate that Net-Zero Energy buildings represent a financially feasible investment.

Future research may investigate the relationship between local energy costs and the prevalence of Net-Zero Energy and high-efficiency buildings. The Bank of Italy building demonstrates high projected cost savings, a finding that is largely dictated by the high cost of energy in the San Francisco Bay Area. It may be beneficial to analyze financial savings across a wider geographic sample, taking other factors into consideration, such as the feasibility of on-site solar energy. Subsequent studies may monitor rising energy costs, and analyze how this factor influences building owners and designers.

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