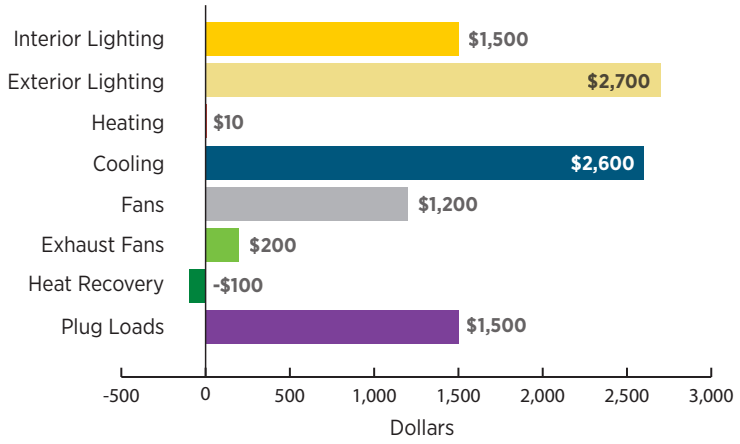
PNC Financial Services – Net-Zero Energy Bank Branch

PNC Financial Services (PNC) partnered with the Department of Energy (DOE) to develop and implement solutions to build new, low-energy buildings that are at least 50% below Standard 90.1-2004 of the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), the American National Standards Institute (ANSI), and the Illuminating Engineering Society of North America (IESNA) as part of DOE's Commercial Building Partnerships (CBP) Program.[1] Pacific Northwest National Laboratory provided technical expertise in support of this DOE program.

PNC Bank N.A. is the nation's fifth largest bank, with over 2,900 branches and 5 million customers across 19 states and Washington, D.C. When PNC partnered with DOE's CBP Program, PNC brought a strong design team that had already developed a prototypical bank branch package that was more efficient than ASHRAE 90.1-2004. This prototype design achieved Leadership in Energy and Environmental Design (LEED) New Construction certification. PNC decided to exceed the CBP goal of 50% reduction in energy consumption (per ASHRAE 90.1-2004) and constructed a branch that produces as much energy as it consumes on an annual basis—a net-zero energy building. Cutting-edge modeling techniques, onsite metering of an existing branch, and a dedicated design team accelerated innovative strategies for PNC's new building design.

Expected Energy Cost Reductions



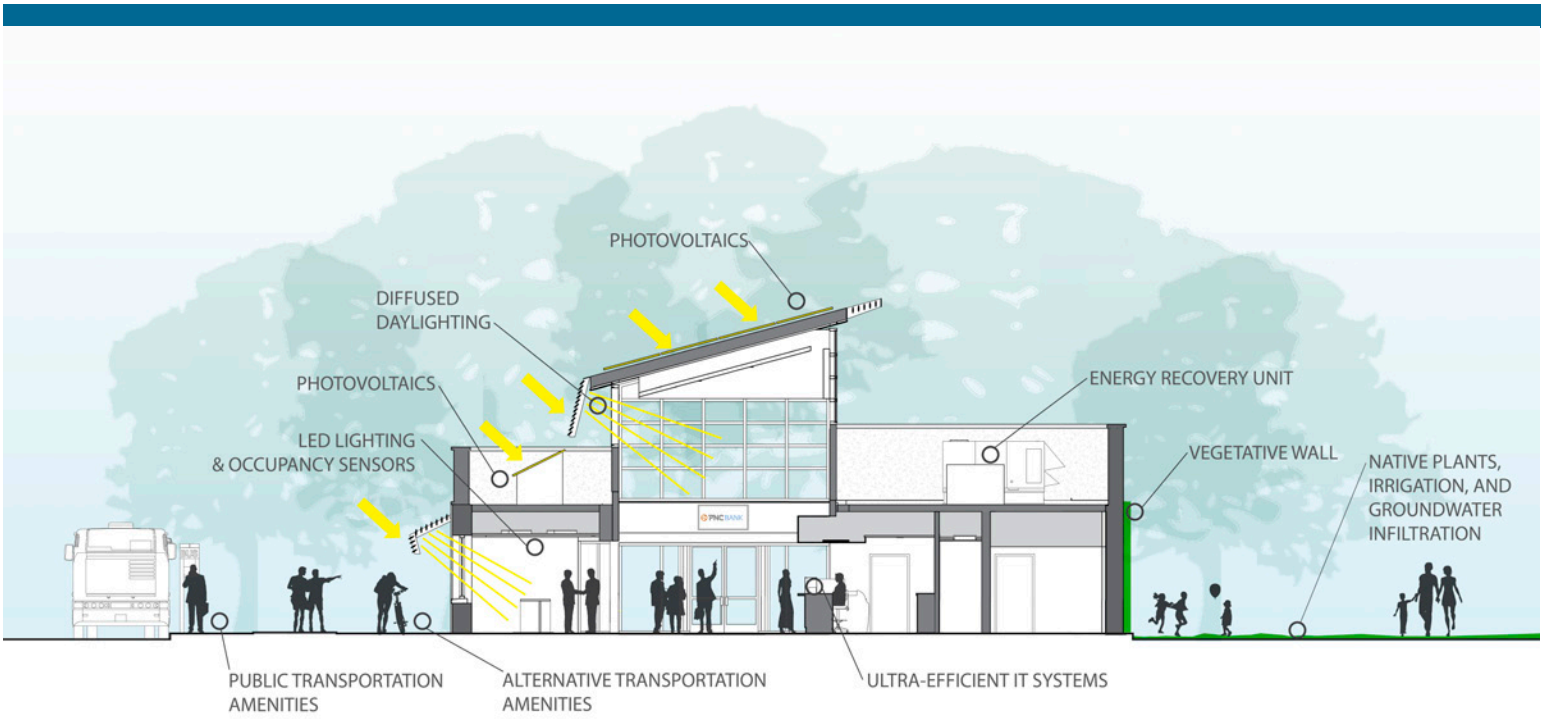
PNC has opened a zero-energy building that is 57% more efficient than ASHRAE 90.1-2004. Exterior features include shading to control glare from sunlight and photovoltaic solar panels to produce as much electricity as the building consumes annually.

Project Type	Bank Branch, New Construction
Climate Zone	ASHRAE Zone 1A, Very Hot-Humid
Ownership	Owner Occupied
Barriers Addressed	• Security considerations and standards for banks • Cost and limited space for photovoltaic generation • Lack of information on loads
Square Footage of Project	4,620
Expected Energy Savings versus Prototype	49%
Expected Energy Savings (versus ASHRAE 90.1-2004)	56%
Expected Energy Savings (to be verified)	96,000 kilowatt-hour (kWh)/year
Expected Cost Reductions (versus ASHRAE 90.1-2004)	$9,600/year[2]
Project Simple Payback	6 years
Estimated Avoided Carbon Dioxide Emissions	Approximately 67 metric tons/year[3]
Construction Completion Date	January 2013

[1] The Commercial Building Partnerships (CBP) Program is a public/private, cost-shared initiative that demonstrates cost-effective, replicable ways to achieve dramatic energy savings in commercial buildings. Through the program, companies and organizations, selected through a competitive process, team with U.S. Department of Energy (DOE) and national laboratory staff who provide technical expertise to explore energy-saving ideas and strategies that are applied to specific building project(s) and that can be replicated across the market.

[2] Utility rate of $0.1011/kWh was supplied by PNC.

[3] Greenhouse Gas Equivalencies Calculator: http://www.epa.gov/cleanenergy/energy-resources/calculator.html.



Energy-efficient facilities are combined with other sustainable building practices. Carefully designed windows and light-emitting diodes provide lighting in the new PNC branch. ENERGY STAR® rated computers, office equipment, and electronics equip the branch.

Modeling showed an estimated reduction of nearly $10,000 per year in energy costs compared to a building constructed to meet minimum levels of an ASHRAE 90.1-2004 baseline. PNC considered five representative climates for locating the new prototype branch. Preliminary energy modeling and business criteria led PNC to select southern Florida. From a business perspective, the market had high demand for a new branch and was a priority area for PNC. From an energy efficiency perspective, high cooling and dehumidification demand, high energy costs and high solar energy potential combined to create a strong opportunity for improvements. The final location in Florida was selected based on local input and project timing.

To understand key loads, PNC selected a prototype branch similar to the net-zero building for study and PNNL conducted onsite energy consumption metering. Metering data revealed that over 75% of total building consumption came from plug loads and lighting. These data were used to recalibrate the initial building simulation model. PNNL researchers found initial recommended measures would result in 27% energy savings rather than hitting the 50% goal. These results meant that design strategies had to focus on plug loads and lighting in addition to heating, ventilation, and air conditioning (HVAC) equipment. Two important loads that may have otherwise been overlooked were decorative lighting and signage.

Decision Criteria

PNC has made energy efficiency and sustainable building practices important parts of its corporate culture. For this project, PNC officials decided to exceed the CBP goal of 50% reduction in energy consumption and design a net-zero energy building. With this ambitious goal, PNC balanced the need to replicate savings in future buildings while relying on energy efficiency to keep the photovoltaic system as small as possible.

Economic

PNC set a net-zero energy goal for the new bank branch. As a result, an important economic criterion was to select energy efficiency measures (EEMs) that provide energy savings at a cost that would be less expensive than the cost of producing energy with the photovoltaic system. Although the costs of photovoltaic systems are dropping over time, the cost of producing energy is still typically more expensive than saving energy with efficiency measures. PNC balanced this willingness to accept relatively high cost energy savings for this project with the likelihood that a particular measure could be applied across its portfolio. The higher the cost of saved energy, the less likely a measure would be suitable for broad use. Although some EEMs could beat the photovoltaic system costs, PNC selected measures with a greater potential to be applied across its portfolio. PNC does not intend to make all branches net-zero energy buildings.

Operational

Metering results showed that equipment plugged into electrical outlets accounted for 40% of total energy consumption. PNC recognized the importance of reducing plug loads in the building design and brought its Information Technology (IT) department into the design discussion.

"Our IT team was literally amazed at the monitoring study results. They had tried to look at nameplates before, but the metering results helped them see how first-hand our equipment really affects energy use," said Larry Miltenberger, Construction Manager at PNC Bank.

A small PNC team—which included IT—met every week and metered actual performance of different hardware and software combinations, from computers and monitors to routers, switches, counter equipment and automated teller machines (ATMs). This team worked with vendors to test new technology before it was released. PNC tested the equipment and metered performance under real bank operating conditions. Through this effort, PNC set more energy efficient, internal standards and provided feedback to manufacturers for developing the next generation of equipment that will be more energy efficient, saving energy and reducing costs for PNC and other businesses. This work can impact PNC's entire portfolio once the techniques are proven in the net-zero energy building.

Monitoring results demonstrated that HVAC equipment was oversized. PNC thus changed its sizing approach for its entire portfolio to reduce both capital costs and energy. Roof top units (RTUs) at existing branches reaching the end of their life will be replaced with RTUs of the correct size.

EEMs for the new branch were carefully selected not only to consider regular operational concerns but also security and safety concerns and overall customer and employee comfort.

Policy

PNC is recognized as a banking industry leader in sustainable design innovation. PNC began with an aspiration to build green bank branches to educate and inspire customers and the banking industry by demonstrating sustainability and improving the customer experience. The PNC design team has worked together on prototype building designs and rollouts for over a decade. This team has built a deep trust and a collaborative approach that supports full integrated design and continuous improvement. The team opened its first LEED certified branch in 2001 and partnered with the U.S. Green Building Council to define and pilot the volume built LEED certification process in 2004. PNC continuously seeks new collaborative partners to develop innovative standards to systematize improvements.

Energy Efficiency Measures

The final EEM package is anticipated to reduce overall energy consumption by 56% in comparison to an identical building designed to meet the minimum requirements of ASHRAE 90.1-2004. The EEM package is expected to reduce costs by nearly $10,000/year. Solar photovoltaic panels are expected to produce the remainder of the energy required to operate the bank branch.

Construction is complete, and PNC worked with PNNL to develop accurate cost information for recommended EEMs based on actual bids and maintenance savings. These data are under development and will be used to conduct a thorough financial analysis that will be added to future updates of this case study. Costs included in this case study are based on preliminary estimates.

> "We are seeing immediate benefits...The whole-building energy modeling detailed the costs and made rolling some of these in time into the prototype and other branches a no brainer. For instance, LED lighting and envelope research started out as measures under consideration for the net-zero building and are being rolled into all new branches."
>
> — Jim Kroner, PNC Senior Project Manager

Project Notes

Miscellaneous electricity loads in a bank branch include ATMs, servers and computers, printers, coffee machines, refrigerators, video screens, and other office equipment. Metering an existing branch showed the PNC team that electricity use for these items was much higher than expected. PNC metering by the numbers:

- 71 electrical panel meters
- 25 plug meters at receptacles
- 5-minute interval data collection
- 1-year collection period from November 2009 to November 2010.

Energy Efficiency Measures

Building energy improvements at the PNC branch included the building envelope, interior and exterior lighting, and the HVAC system. Reduced energy costs from the measures are presented in the following table. Energy and cost reductions are in comparison to the same building designed to meet the minimum requirements of ASHRAE 90.1-2004. The EEMs are presented ranked by expected annual savings.

EEM	Implementing in This Project	Will Consider for Future Projects	Expected Annual Saving		Expected Improvement Cost $	Expected Internal Rate of Return % (15 years)	Expected Cost of Conserved Energy $/kWh[1]	Expected Simple Payback yr
			kWh/yr	$/yr				
Lighting: 25% of Whole Building Savings								
Upgrade parking lot lighting to light-emitting diode pole-lighted luminaires	Yes	Yes	27,000	$2,800	$12,000	21	$0.10	4
Upgrade canopy, façade, and decorative lighting to light-emitting diode fixtures	Yes	Yes						
Install custom-designed light-emitting diode fixtures for signage lighting	Yes	Yes						
Install exterior lighting control system to reduce lighting levels when sufficient daylight is available and based on time of day	Yes	Yes						
Upgrade interior lighting to light-emitting diode task lighting to supplement overhead lighting	Yes	Yes	15,000	$1,500	$17,000	4	$0.25	11
Install new interior lighting occupancy sensors and daylighting controls	Yes	Yes						
HVAC: 23% of Whole Building Savings								
Install higher efficiency packaged (energy efficiency ratio of 11.5) roof top unit with adaptive fan technology*	Yes	Yes	39,000	$4,000	$20,000	18	$0.43	5
Install carbon monoxide sensors for demand-controlled ventilation*	Yes	Yes						
Install energy recovery wheel*	Yes	Yes						
Plug Load: 8% of Whole Building Savings								
Upgrade to ENERGY STAR-rated equipment	Yes	Yes	15,000	$1,500	$9,000	14	$0.08	6
Install software-controlled night-time turn off for central processing units	Yes	Yes						
Use plug-in strip occupancy sensors to turn off monitors and other bank-specific equipment	Yes	Yes						
Program schedule-based nighttime turn off for TVs, printers, and audio-video switchers	Yes	Yes						
Upgrade to light-emitting diode lamps in automated teller machine bezel	Yes	Yes						

* EEM is dependent on climate.
[1] Meier 1984.

Energy Use Intensities by End Use

PNNL supported the design process with whole-building analyses using DOE's EnergyPlus energy simulation software—a powerful and versatile tool that uses data on heating, cooling, ventilation, lighting, and other energy using systems to predict how EEMs will perform. Detailed and iterative modeling, coupled with verified branch monitoring data, drove design decisions and equipment selection. Monitoring results from a bank branch using similar equipment helped the design team target critical loads and calibrate the EnergyPlus model.

Early modeling demonstrated the viability of reaching project goals and helped to inform the concept design. To refine the model, PNC and PNNL designated six teams to research strategies and iterate design ideas. PNNL and the design team conducted additional modeling and analysis to evaluate opportunities for energy savings in each of six areas:

- HVAC options (including ground source heat pump)
- Renewable energy applications
- Glazing optimization (for thermal conductance, daylighting and light transmittance, aesthetics, and hurricane resistance)
- Envelope insulation
- Lighting (interior, exterior, and daylighting)
- Plug loads.

Whole-building savings were assessed using two different energy models.

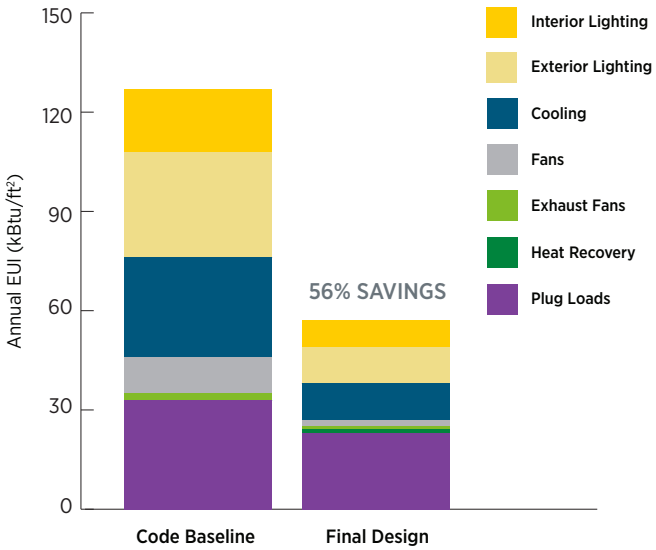
Model 1 - Code Baseline

The first EnergyPlus model represented the prescriptive specifications in an ASHRAE 90.1-2004 baseline. The baseline had an annual energy use intensity (EUI) of about 128 kilo British thermal units (kBtu)/square foot (ft^2).

Model 2 - Final Design

The second EnergyPlus model included the EEMs incorporated into the design. This model had an annual EUI of about 56 kBtu/ft^2 and an annual energy savings of 56% over an ASHRAE 90.1-2004 baseline.

Comparing Estimated EUI of Code Baseline and Final Design Models



Estimated Annual Energy Use and Percentage Savings by End Use

End Use Category	Code Baseline Annual EUI (kBtu/ft^2)	Final Design Annual EUI (kBtu/ft^2)	Final Design Percent Savings Over Baseline
Interior Lighting	19	8	58
Exterior Lighting	32	11	66
Cooling	30	11	63
Fans	11	2	82
Exhaust Fans	2	1	50
Heat Recovery	0	1	NA
Plug Loads	33	23	30
Total	**127**	**57**	**56**

Expected Building Energy Savings from Implemented EEMs by End Use versus Code Baseline

Electricity End Use Category	
Interior Lighting	15,000 kWh
Exterior Lighting	27,000 kWh
Cooling	26,000 kWh
Fans	12,000 kWh
Exhaust Fans	2,000 kWh
Heat Recovery	-1,000 kWh[1]
Plug Loads	15,000 kWh
Electricity Total	**96,000 kWh**

Natural Gas End Use Category	
Heating	2 therms
Natural Gas Total	**2 therms**

[1] Represents the energy consumption of the energy recovery wheel; more than offset by cooling energy savings.

Lessons Learned

Assemble Seasoned Design Team

Two important hallmarks of the PNC design team helped meet project goals. The team promoted cross communication and included key technical capabilities in engineering, architecture, and green design facilitation. The DOE CBP Program found a receptive audience to make use of DOE's advanced modeling capabilities at PNNL. PNC committed to explore viable efficiency measures, and the design team divided tasks to assess and incorporate potential technologies and approaches.

Monitor Energy Performance

Ambitious energy efficiency and net-zero energy goals led the CBP team to monitor energy loads at an existing branch. The results from this limited study had profound effects on the work for the net-zero energy branch, and PNC changed its equipment procurement and management approach. Owners of prototypical building portfolios should consider similar studies to gain insights into how their buildings actually perform and where to focus their energy efficiency investments. Outcomes of the monitoring study helped shape how PNC manages its portfolio of buildings. The monitoring showed that in PNC's prototype design, the HVAC equipment was oversized. PNC found it could save energy and reduce capital costs for new and replacement equipment. PNC also learned that its existing buildings were performing very differently than computer models had predicted. Knowing actual load characteristics helped PNC and PNNL create more accurate models and assisted the company in making better energy management investments.

Corporate Engagement

Monitoring also showed PNC that miscellaneous electric loads were a considerable part of its overall load. In banks, much of this load is used by computer equipment. This discovery led PNC to engage its IT department to help identify and implement energy saving measures for computer and communication equipment. These measures can help PNC's entire portfolio of buildings.

PNC takes energy efficiency seriously. One hallmark of this commitment was making goals for constructing the net-zero energy branch part of key staff's performance goals. Staff evaluations included energy efficient progress at the branch. This approach to management makes corporate goals into personal objectives for staff.

Continue Learning

Post-occupancy metering and validation will help the PNC team learn more and confirm what worked in the new branch. The lessons learned and innovation will extend to other PNC projects, and also to the thousands of other projects on which the design team members and their firms are working.

PNC and its design teams agree that their partnership with CBP was a "win-win." Already an experienced and committed team, PNC was able to move faster and farther with DOE's technical expertise.

PNC is moving forward to incorporate some net-zero elements in the next generation of PNC's green buildings.

References and Additional Information

1. ASHRAE. 2011. "50% Advanced Energy Design Guide for Small to Medium Office Buildings." American Society of Heating, Refrigerating and Air Conditioning Engineers, Atlanta, Georgia. Available at http://appsl.eere.energy.gov/buildings/commercial/resource_database/detail_cfm?p=349.
2. Athalye, R., Xie, Y., Liu, B., and Baechler, M. 2012. "A Case Study: Using Integrated Design Approach to Design a Net-Zero Energy Bank Branch." ASHRAE 2012 Winter Conference, January 21-25, 2012, Chicago, Illinois.
3. Meier, A.K. 1984. "The Cost of Conserved Energy as an Investment Statistic." ESL-IE-84-04-109, Lawrence Berkeley Laboratory. Available at http://repository.tamu.edu/bitstream/handle/1969.1/94751/ESL-IE-84-04-109.pdf?sequence=1.
4. Pacific Northwest National Laboratory. 2011. "Advanced Energy Retrofit Guide - Practical Ways to Improve Energy Performance, Office Buildings." PNNL-20761, Pacific Northwest National Laboratory, Richland, Washington. Available at http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-20761.pdf.
5. Rauch, E., Baechler, M., and Sullivan, G. 2011. "Assessing and Reducing Miscellaneous Electric Loads (MELs) in Banks." PNNL-20973, Pacific Northwest National Laboratory, Richland, Washington. Available at http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-20973.pdf.
6. Xie, Y., Athalye, R., and Baechler, M. 2012. "Measuring and Understanding the Energy Use Signatures of a Bank Building." Preprint. 2012 ACEEE Summer Study on Energy Efficiency in Buildings, August 12-17, 2012, Pacific Grove, California.

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