Grand Valley State University Checks Out Energy Savings at New Mary Idema Pew Library

Grand Valley State University (GVSU) 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 90.1-2007 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.

GVSU was established in 1960 and has more than 24,500 students. It is one of 15 public universities in Michigan, and like many higher education institutions, it is in need of new buildings. The Mary Idema Pew Library, Learning and Information Commons (library) is a landmark building for the GVSU Allendale, MI, campus. The library will be an academic and cultural hub to teach sustainable design by example.

Features of the library include the following:

- Concourse with an atrium that extends up three floors
- Multipurpose meeting room that holds more than 80 people
- Exhibition space
- Knowledge Market that will house peer coaching and mentoring services in the areas of researching, writing and presenting

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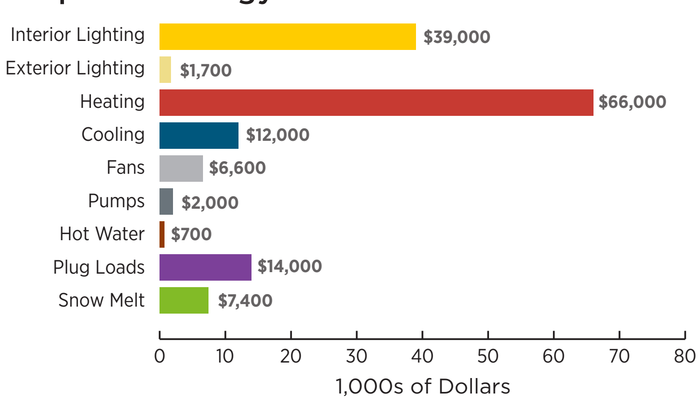
Expected Energy Cost Reductions



This artist's rendering of the future Mary Idema Pew Library at Grand Valley State University shows a building expected to achieve 51% energy savings over code

Project Type	Higher Education, New Construction
Climate Zone	ASHRAE Zone 5A, Cool-Humid
Ownership	Owner Occupied
Barriers Addressed	Public institutions must meet stringent payback requirements
Square Footage of Project	150,300
Expected Energy Savings versus Current Prototype	12%
Expected Energy Savings (versus ASHRAE 90.1-2007)	51%
Expected Energy Savings (to be verified)	999,000 kilowatt-hour (kWh) of electricity, 81,000 therms of natural gas/year
Expected Cost Reductions (versus ASHRAE 90.1-2007)	$149,000[2]
Project Simple Payback	Less than 5 years
Estimated Avoided Carbon Dioxide Emissions	Approximately 1,093 metric tons/year[3]
Construction Completion Date	April 2013 (expected)

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 rates of $0.075/kWh and $0.91/therm were provided by GVSU.

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

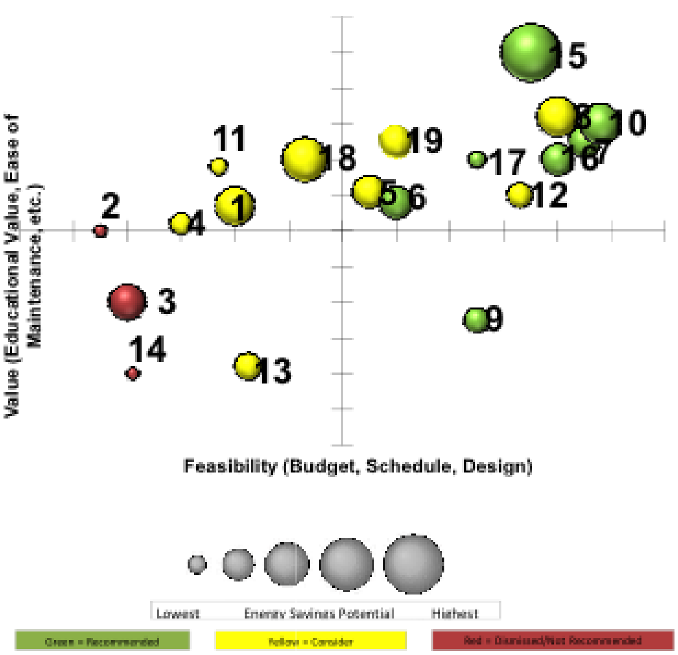
- Two bibliographic training rooms
- Two reading rooms
- Information Technology help desk
- Café with seating for approximately 100 people
- Approximately 20 collaborative work areas allowing for private, group work
- Open, browsable shelves with space for 150,000 books
- State-of-the-art automated storage and retrieval for up to 600,000 books.

The library was originally designed to be a high-performance LEED Silver building achieving energy savings of 38% better than ASHRAE 90.1-2007. The CBP team's challenge was to identify additional cost-effective energy efficiency measures (EEMs) to reach at least 50% savings. To find additional savings, the team looked at optimizing the building services infrastructure and educating occupants about how their behavior influences energy efficiency in the building.

Decision Criteria

Operational energy cost was the driving criteria at GVSU, and EEMs had to achieve strict simple payback requirements to meet the University's budget obligation to its board of trustees.

The design team set up a diagram to rank the value of each EEM in the design process for value (including education value) with feasibility for budget and design. The magnitude of possible energy savings for the project was captured by the size of each point in the diagram. This visual method for ranking the EEMs was used by GVSU to assist in choosing which energy measures made the most sense for this building.



Blip diagram ranking the EEMs

Economic

GVSU had a limited budget for the library and had guidelines for acceptable payback for energy-related investments, which were typically 3-5 years. The building was funded from private donations, university issued bonds, and university capital funding.

Some EEMs under consideration did not meet economic criteria. For example, solar walls were considered for the penthouse to preheat supply air. Early estimates for this measure indicated a payback of more than 40 years, and the measure was rejected.

Operational

In 2000, GVSU decided to manage utility costs based on both the cost and quantity of energy consumed. This strategy balances the long-term cost benefits with the loads of the university's central power plant. Cost control is paramount for the University, and the CBP team initially considered EEMs that would improve the efficiency of the central plant in addition to direct building measures.

Maintenance complexity and cost were considered by the design team as part of the evaluation of EEMs for the project. Several measures were considered very attractive for this reason—specifically the underfloor air distribution and the lighting improvements.

When making decisions in existing buildings, GVSU uses a unique budgeting approach to force implementation of efficiency measures after the decision has been made to invest in them. The University reduces the operating budget for a facility by the quantity of expected dollar savings. This forces the implementation of the EEM to function within the limited budget.

Policy

A unique aspect of the university's energy goal is the opportunity to educate students and staff about environmental impacts. In 2007, GVSU set LEED Silver as a target for all new buildings on campus and GVSU issues an annual accountability report about the university, its performance, and its finances.

For the library, LEED Platinum was identified as a possibility in the design process because of the CBP suggested enhancements. Current designs indicate the building may achieve this level.

GVSU is committed to green building concepts and is a member of the American Colleges and University Presidents' Climate Commitment. As such, the University has agreed to the following:

- Complete an emissions inventory
- Set a target date and interim milestones for becoming climate neutral
- Take immediate steps to reduce greenhouse gas emissions by choosing from a list of short-term actions
- Integrate sustainability into the curriculum and make it part of the educational experience
- Make the action plan, inventory and progress reports publicly available.

Energy Efficiency Measures

The technical team and PNNL recommended the following EEMs, some of which GVSU included in the library as of 2012 when the design was being finalized. This project joined CBP during the 50% construction document phase, which meant all proposed EEMs had to account for effects on the architecture and budget of the project. The proposed EEMs affect the lighting design, mechanical system, and equipment purchasing practices of the University.

The payback of the total package of EEMs is greater than the individual simple paybacks shown in the table. 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 Cost of Conserved Energy $/kWh[1]	Expected Simple Payback yr
			kWh/yr	$/yr			
Envelope: 5% of Whole Building Savings							
Implement other envelope measures*	Yes	Yes	315,000	$14,000	Design team is estimating installation costs.		
Install solar walls on penthouse to preheat outside air to the basement air handling units and recovery unit for the bathrooms*	No	Yes	Energy and cost were not estimated because EEMs were not feasible for aesthetic, schedule, or complexity reasons.				
Reduce glazing window-to-wall ratio	No	Yes					
Lighting: 5% of Whole Building Savings							
Improved lighting strategies including task lighting, lower illuminance in stacks, and daylighting	Yes	Yes	295,000	$13,000	$36,000	$0.03	3
Install occupancy sensors in stacks	Yes	Yes	24,000	$1,000	$11,000	$0.10	10
HVAC: 32% of Whole Building Savings							
Implement heat recovery in air handling units and wrap around heat pipes*	Yes	Yes	1,700,000	$75,000	$265,000	$0.03	4
Recover snowmelt condensate heat at the building and use it for preheat of the snowmelt system*	Yes	Yes	205,000	$9,000	$75,000	$0.08	8
Serve atrium space by radiant heating slab and sidewall displacement diffusers	Yes	Yes	148,000	$7,000	-$74,000	Immediate payback	
Use underfloor air distribution system	Yes	Yes	67,000	$3,000	$180,000	$0.59	> 60
Provide demand control ventilation in classrooms and multi-purpose rooms*	Yes	Yes	0	0	$236,000	Energy savings captured in whole building design package.	
Other Measures: 9% of Whole Building Savings							
Implement automated book storage and retrieval system for up to 600,000 books	Yes	Yes	441,000	$19,000	-$6,000,000	Immediate simple payback	
Use systems to educate occupants and provide real-time feedback on building performance and allow occupants to act on information to achieve savings	Yes	Yes	172,000	$8,000	Design team is estimating installation costs.		
Purchase high-efficiency computer equipment (not included in percentage savings)	Yes	Yes	Energy efficiency improvement not considered in the energy model.				

HVAC = heating, ventilation, and air conditioning.

* EEM is dependent on climate.

[1] Meier 1984.

Energy Use Intensities By End Use

Energy modeling was key to developing the EEMs proposed for the library. GVSU had already committed to a high-performance building (originally LEED Silver). Some recommended EEMs were eliminated as not being cost effective given the stage of design when the project joined CBP, and a reluctance to make changes that would affect architecture, schedule, and cost.

For some building systems, like lighting, several EEMs were grouped and modeled as a package for GVSU's consideration. In other cases, such as heat recovery measures, the business case was assessed by taking a baseline system and adding strategies cumulatively.

At each stage, the energy model of the proposed design was made as accurate as possible using eQuest, working from GVSU's design development documents, construction drawings, and GVSU's knowledge of occupant behavior.

To assess whole-building savings, three different energy models were created. Model 1 was the code compliance baseline model. Model 2 represented a building designed and operated according to GVSU's original design prior to CBP involvement and without the campus central plant. Model 3 included all of the proposed EEMs except computer upgrades and occupant behavior changes.

Model 1 - Code Baseline

The first model represented the prescriptive specifications of ASHRAE 90.1-2007. The library baseline had an annual energy use intensity (EUI) of about 161 kilo British thermal units (kBtu)/square foot (ft^2).

Model 2 - LEED Prototype

The second model represented a building designed and operated according to GVSU's target for a LEED Silver building and had an annual EUI of approximately 90 kBtu/ft^2, 44% below code. Savings resulted primarily from plug loads, heating performance, and interior lighting improvements over ASHRAE 90.1-2007.

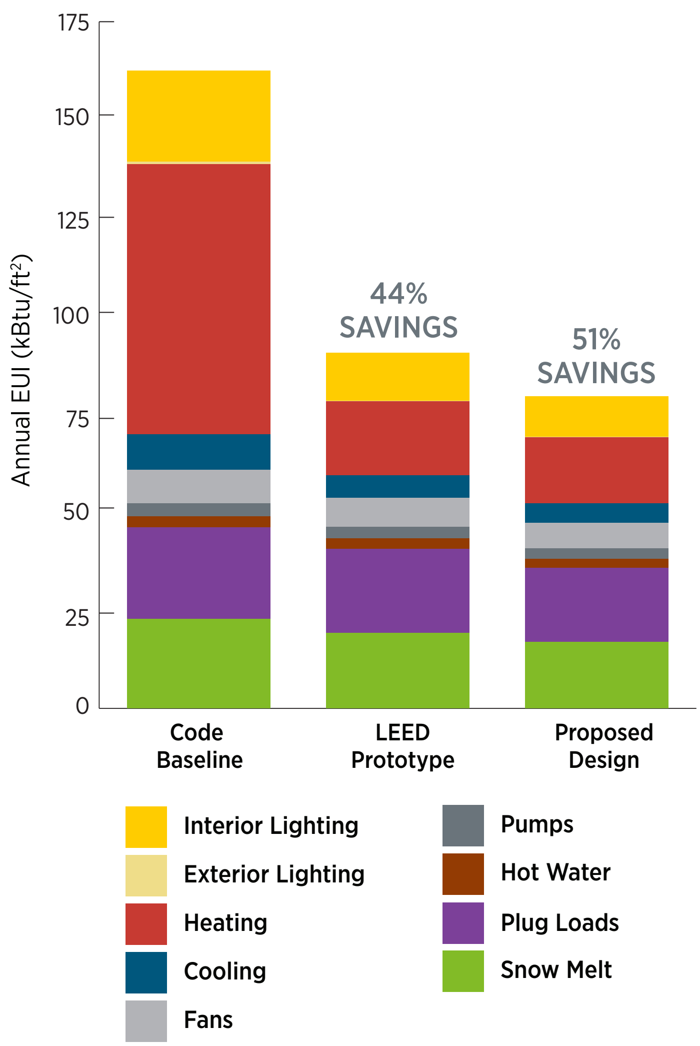
Model 3 - Proposed Design

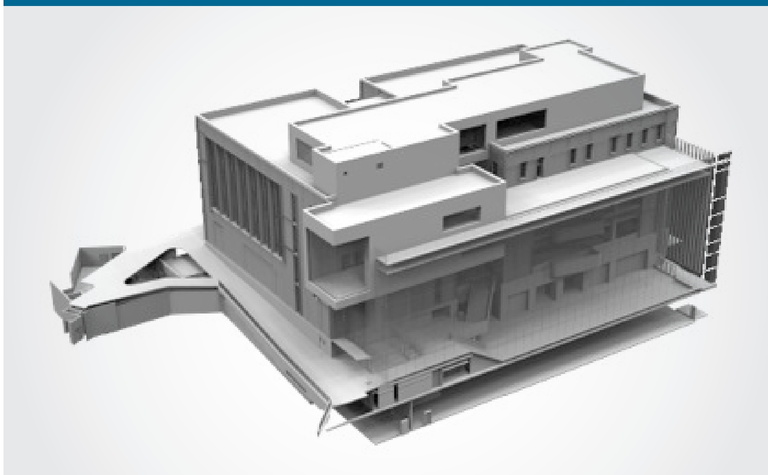
The third version included all the EEMs identified by the CBP team plus measures from the LEED Silver design. This model had an annual EUI of about 79 kBtu/ft^2 and an annual energy savings of 51% over ASHRAE 90.1-2007.

The library contains complex HVAC systems that have been optimized for energy efficiency including underfloor air distribution (UFAD), demand controlled ventilation, radiant floors, enthalpy recovery wheels, a flat plate air-to-air heat recovery unit, wrap-around heat pipes, condensate heat recovery, and high-efficiency mechanical equipment. Many of these complex HVAC systems, included in the original design, are not predefined in the whole-building energy simulation software eQuest. The systems were incorporated into the models by using workarounds and others were modeled separately using exceptional calculations. Combining multiple complex systems into a single model required careful consideration of the control strategies to ensure that systems will perform as designed.

Modeling the air handling units that serve the UFAD system presented the greatest challenge in eQuest. In addition to serving an atypical distribution system, these units contain enthalpy recovery wheels and wrap-around heat pipes that added an additional complexity to the model. Simulated hourly performance reports were run to verify that systems were operating as expected. Modeling strategies and key lessons learned were documented carefully by the project team to help future modelers.

Comparing Estimated EUI of Code Baseline, LEED Prototype, and Proposed Design Models





(Left) Artist rendering of the library layout. The automated storage and retrieval system for the books allowed the total square footage of the building to be reduced. *(Right)* Artist rendering of the future Mary Idema Pew Library at Grand Valley State University.

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

Electricity End Use Category

Interior Lighting	521,000 kWh
Exterior Lighting	23,000 kWh
Cooling	161,000 kWh
Fans	87,000 kWh
Pumps	26,000 kWh
Plug Loads	181,000 kWh
Electricity Total	**999,000 kWh**

Natural Gas End Use Category

Heating	72,000 therms
Hot Water	1,000 therms
Snow Melt	8,000 therms
Natural Gas Total	**81,000 therms**

Estimated Annual Energy Use and Percentage Savings by End Use

End Use Category	Code Baseline	LEED Prototype	Proposed Design	
	Annual EUI ($kBtu/ft^2$)	Annual EUI ($kBtu/ft^2$)	Annual EUI ($kBtu/ft^2$)	Percent Savings Over 90.1-2007
Interior Lighting	22.9	12.1	10.2	55
Exterior Lighting	0.6	0.1	0.1	86
Heating	68.1	18.7	16.6	76
Cooling	8.9	5.7	5.0	44
Fans	8.5	7.3	6.4	25
Pumps	3.2	2.9	2.6	20
Hot Water	2.8	2.6	2.3	19
Plug Loads	23.1	21.2	18.7	19
Snow Melt	22.5	19.0	16.7	26
Total	**160.6**	**89.6**	**78.6**	**51**

Lessons Learned

Become Involved in the Design as Early as Possible

It is more difficult to recommend EEMs for a building the further along it is in the design process. In this project, many EEMs that might have significantly changed the building envelope, site plan, or structure were not considered because changing the design dramatically would have been very expensive. This limitation required a more creative approach to EEMs than might otherwise have been necessary for a building of this type.

Modeling Unique EEMs

Many of the complex HVAC systems the CBP team used in the library are not predefined in the whole building energy simulation software eQuest and required additional calculations (outside of the software) to evaluate some of the EEMs. These measures included the occupancy behavior changes and the heat recovery on the snow-melt system. Developing accurate modeling and verification strategies for these measures was a key challenge for the CBP team.

Information Sharing is Key

Effective communication with the design team is key. It is very important to create and foster a good working relationship with the design team and become a member of the team. One specific recommendation is that as soon as the architect/engineer firm or other interested parties come on board the project, make sure they and those responsible for analyzing efficiency measures and meeting LEED or other certification requirements are familiar with each other and understand their mutual roles. The design team needs to be engaged in regular information exchanges. This is especially true with keeping up to date with drawings/documents, negotiation for EEMs, and construction issues and solutions that affect EEMs. Examples of construction negotiations include changes to mechanical equipment, which was originally specified for high-energy performance, but was no longer available when construction began. The CBP team flagged an equipment substitution and worked with the construction team to make sure the new system would have the same performance.

Exterior wall of the library under construction in spring 2012

Educate the Occupants

As a university library the GVSU administration was very invested in occupant education to aid energy performance in the building. The CBP team met with current occupants and facilitated a discussion about energy measures that would be most appealing to them. The meeting was also used to evaluate ways to encourage occupant behavior changes. These measures included methods for occupants becoming aware of the building usage, including: Virtual art display, lift elevator dashboard, large ink display, mobile heat map, and ambient feedback lighting. Similar measures may be implemented in future GVSU projects.

"Being a part of CBP has allowed us to take the energy performance of the library to the highest level. The CBP team modeling work allowed us to consider energy measures very specific to this space like the ARS. Cost control is a paramount objective for the University and we will ultimately be able to lower energy bills. These funds that would normally have been spent on energy bills will go towards building other efficient buildings on campus."

— James R. Moyer,
Assistant Vice President for Facilities Planning

References and Additional Information

1. ARUP 2012. Stage 2 Final Reports for the Mary Idema Pew Library. CBP Document.
2. 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.

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