EpiCenter

Headquarters for Artists For Humanity

Demonstrating Low-Cost Sustainable Building Strategies and Integrated Design Process

A Case Study of Challenges, Successes, Lessons Learned

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Commissioned by the Massachusetts Technology Collaborative

September 27, 2005

The Artists For Humanity EpiCenter

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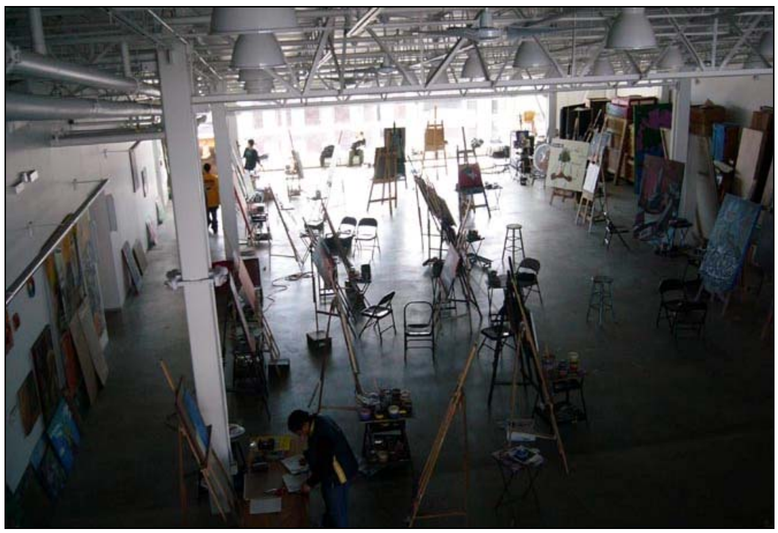
Executive Summary

Susan Rodgerson, founder and director of Artists For Humanity (AFH), "wanted people to understand the connection between sustainability and art. Both are about creating a good life." (1) Once she convinced the organization's funders of the importance of a green building, a design team was brought together to define the priorities for the new headquarters location, the EpiCenter. This team included AFH management, their student artists, sustainability engineer Mark Kelley with The Hickory Consortium, architect Pat Cornelison of Arrowstreet Inc., and others. Kelley and Cornelison explain that:

> *From the beginning it was clear that the client wanted an energy efficient building that would have an iconic presence in the community, would provide flexible accommodation of their varying arts programs, and would demonstrate a progressive approach towards sustainable design for the teen artists and the community as a whole.* (2)



Second Floor Studio

The three story building has 23,500 square feet and is located in South Boston (100 West 2nd Street), Massachusetts. It is comprised of studios, a large gallery, and offices.

The EpiCenter is the fist naturally **cooled** commercial building in Boston. The demonstration of a naturally cooled commercial building in an urban setting is very important milestone for sustainable construction. A 42kW photovoltaic system generates renewable energy that meets a third of their needs, glass walls maximize daylighting in the facility, a tight building envelope and high-efficiency lighting all further decrease energy use of the building.

The EpiCenter is expected to achieve a LEED platinum rating. It is quickly earning its reputation as a place where others, from grammar school students to architects, can come to learn about ways to minimize their impact on the environment. AFH is currently developing educational programs that will be offered to area schools to teach children about renewable energy, sustainable building practices, and environmental responsibility in a creative fashion.

With a final cost of $177/square foot (including soft costs, utility incentives and energy rebates), the building uses only 32% of the energy that the average building of similar size would, with 33.4 kBTUs per square foot (if PV production is included, these numbers drop to 25% and 25.75 kBTUs/sf).

At $177/square foot, the EpiCenter sets an example not just for environmentally sound building practices but also how green buildings can be built on a very tight budget.

1 Introduction

Artists For Humanity's mission is to bridge economic, racial and social divisions by providing at-risk youth with the keys to self-sufficiency through paid employment in the arts (www.afhboston.com/Information/Missionstatement.html). Founded in 1991 by Susan Rodgerson, AFH offers a four-year paid apprenticeship program that pairs teens with experienced artists in a broad range of fine- and commercial arts for product development and services to the business community.

The EpiCenter, the Artists For Humanity's new headquarters facility for 11 full-time staff and an average of 85 teen artists, opened in August 2004. Fundraising, location research and initial planning started in 1999; the selected site was purchased in 2000. Construction began in May 2003 and was completed in October 2004. The three story building has 23,500 square feet and is located in South Boston (100 West 2nd Street), Massachusetts. It is comprised of studios, a large gallery, and offices. True to their mentoring mission, AFH engaged in a uniquely inclusive and collaborative building design approach that involved teen artists and staff in the planning, design, and construction process.

Second Floor Studio

1.1 Site at a Glance

Table 1: EpiCenter Sustainable Building Features

Artists for Humanity EpiCenter Building Highlights	
Category	**Description**
Process	Sustainable design, systems approach with integrated whole building design
Site Selection	Minimal land disturbance, use of pre-existing lot
Transportation	Near subway station and bus stop, bicycle storage, alternative fueling station at parking lot
Energy Conservation	Naturally cooled building, heat recovery, well insulated building shell, optimized daylighting, daylight sensors, reduced plug loads
Energy Production	42 kW Photovoltaic panels
Storm Water Management	Rainwater collected for irrigation purposes
Water Efficiency	Low flow fixtures
Material Selection	Low VOCs paint, sustainably harvested wood, materials with recycled content, reused materials
Indoor Environment	Low VOCs, daylighting, fans, natural cooling, heat recovery ventilation systems, direct exhaust for darkroom and silk screen room
Contractors	Architects: Arrowstreet, Inc.; Contractors: TR White; Sustainability Engineer: Mark Kelley of Building Science Engineering; Mechanical Engineer: Mohamed Zade, Zade Co.

2 Design Process

To address the building priorities selected for the EpiCenter, a “whole building design” approach was applied to the design process. A feasibility study compiled for Artists For Humanity clarified nine activities that are a part of whole building design:

- *Inform and Include Decisionmakers in Selection of Sustainability Criteria and Goals.*
- *Integrate Site Opportunities, Community Goals, Minimize Direct and Indirect Impact.*
- *Minimize Functional Requirements Including Energy, Transportation, Water, Waste.*
- *Integrate Health and Materials Considerations.*
- *Minimize Envelope Loads.*
- *Use Available Renewable Energy.*
- *Maximize Equipment Efficiency.*
- *Plan for Occupancy, Maintenance and Reuse.* (3)

2.1 Involving Teen Artists

Artists For Humanity involved teen artists during much of the vision, mission and design process. Teen artists built a model of the building, studied daylighting options and designed various aspects of the building. Carlo Lewis, an AFH staff member and recent RISD architectural graduate, worked in the Arrowstreet’s offices during the design process to facilitate communication and exchange of ideas between teen artists, staff and designers. This unusual arrangement was mutually beneficial. Everybody involved commented on how exciting and fruitful the involvement of the teen artists was. Several AFH teen artists decided to pursue a career in architecture.

Utopia Notecard, Designed by AFH Teen Artist

2.2 Envisioning a Green Building

Artists For Humanity and its design team used an exemplary design process. They not only employed an integrated whole building design, but took the time early on in the process to think about their priorities and define their vision for the building.

In the early stage of the project, funders were skeptical about the practicality of a green building. It was because of the tireless efforts of the AFH Director Susan Rodgerson to educate them about the importance of sustainable design that the project could be realized. “I wanted people to understand the connection between sustainability and art. Both are about creating a good life.” (1)

The design team (Architects: Arrowstreet, Inc.; Sustainability Engineer: Mark Kelley of the Hickory Consortium; Mechanical Engineer: Mohamed Zade, Zade Co.) conducted two initial sustainability scoping workshops to define the priorities that the new building should reflect. Artists for Humanity directors, teen artists, builders and other key team members were all part of this scoping process. A paper written by the sustainability engineer Mark Kelley with The Hickory Consortium following is an excerpt and the architect Pat Cornelison of Arrowstreet Inc. on the process of envisioning and building the EpiCenter explains that:

From the beginning it was clear that the client wanted an energy efficient building that would have an iconic presence in the community, would provide flexible accommodation of their varying arts programs, and would demonstrate a progressive approach towards sustainable design for the teen artists and the community as a whole.
This project had several salient goals related to both the urban and the global environment. The design team applied the following steps for sustainable design:

10 Steps for Sustainable Design:

1. Achieve high level consensus on sustainability economics, indicators, values and goals.
2. Establish & prioritize sustainability vectors and metrics.
3. Develop a base case for comparing choices.
4. Identify highest priority opportunities.
5. Incorporate sustainability goals in the design process.
6. Maintain goals through value engineering.
7. Incorporate sustainability goals in the building process: articulate & discuss the goals.
8. Plan the process for communication, feedback, tracking, training, and flow. Time-based strategies save time and costs.
9. Measure the results, commission and test.
10. Follow through during occupancy.

The results of these workshops helped set the priorities for the design of the building. The ranking process considered the issues from the global perspective and from the point of view of what is best for the long-term health of Artists for Humanity as an organization. The final ranking, concerning overall the best long-term interests of Artists for Humanity, placed the energy conservation at the top of the list. The group emphasized energy autonomy when considering global impact of the building project. Having a clear identity was paramount when considering the long-term practicality and benefit to the organization, but that identity should be tied to energy and environmental performance.

In our sustainable scoping workshops, we first discussed the issues of sustainability, while encouraging the teen artists, board members, architects, and engineers to share their ideas of what the most important issues were. Teen artists, who had been considering these issues brought their designs and models of potential buildings, and some of their ideas became part of the final design. In the next workshop, we established a consensus on the meaning of sustainability for the Artists for Humanity organization and we identified the highest priorities for the project before the start of schematic design. Paramount was, of course, the educational goal of the Artists for Humanity organization. Within that goal, a sense of identity and energy efficiency were very high on the list. The workshops concluded with a rank order among variables that put the following priorities in the top half of the priorities discussed:

1. Energy autonomy
2. Identity
3. Practicality
4. Comfort
5. Health
6. Efficiency. (2)

3 Construction Process

Finding an architect who was willing to work within the budget limits was especially important to AFH, as they wanted to show that a sustainable building did not need to be expensive. From the very beginning, the design team worked closely with the construction company (T.R. White). This general contractor brought valuable sustainable building experience to the table, as they had been the main contractors for the Woods Hole Research Center's Gilman Ordway Campus in Falmouth, MA. The company helped write the requests for proposals (RFPs) for the architects.

An "owner's rep" was designated to ensure the environmental integrity of the EpiCenter project. The owner's rep for AFH had the responsibility of:

- Acting as the owner's cheerleader and watchdog;
- Managing general logistics;
- Researching materials and options to see that green standards are maintained;
- Facilitating communication and collaboration between contractors and subcontractors;
- Managing change orders and keeping the project on track; and
- Ensuring that the expectations and goals of the building owner are met. (4)

According to both the AFH operations director and the appointed rep, having someone active in this role is an especially worthy investment with green building projects because of the likelihood of questions pertaining to new systems or technologies being raised and the possibility of contractors working with these concepts for the first time.

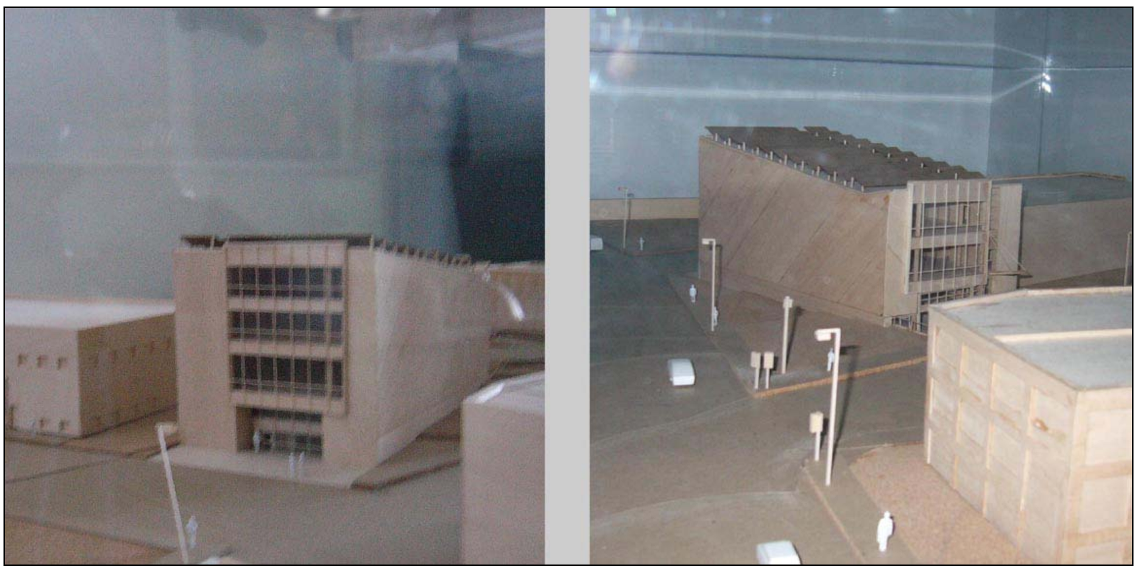
Construction began in May 2003 and was completed in July 2004. Throughout the process, frequent and clear communication was emphasized between all parties involved. Vision and goal setting meetings early in the design phase helped guide the construction process and clarified the decision process. For example, it was clear to all parties that during value engineering, efficiency measures were not to be cut. AFH took the unusual step of value engineering some of the finishing touches out -- e.g., many of the hallways did not get painted -- but other features that traditionally get cut such as high-efficiency appliances or pipe insulation, were kept in the project. The decision making process was not always easy. The construction phase is complicated and stressful with numerous subcontractors involved; therefore, keeping everybody informed can be a challenge. Mark Kelley, the sustainability consultant and engineer who was hired to conduct a feasibility study on the EpiCenter, highlighted some lessons learned from this project:

> *Clear documentation of design intent and good project management on the part of the architect helped considerably (…).*
>
> *The cooperation of the construction firm was essential to obtaining environmentally friendly materials (locally produced, recycled, etc.), protecting air quality, recycling construction waste, and documenting the process.*
>
> *The success of the project owes quite a lot to the robust design and construction process and its management.* (2)

4 Site

The Artists For Humanity EpiCenter is a three story building located on an 11,000 square foot lot at 100 West Second Street in South Boston. The building's footprint covers 7,700 square feet; a 1,200 square foot landscaped courtyard is situated on the southern side. An existing building on the parcel was demolished prior to construction (see below).

A prominent feature that affected the design significantly is the topographic change. The street frontage on the south (West Second Street) is approximately 8-feet above the street frontage on the north (West First Street). The grade change along the west side is essentially a gradual transition, but there is a precipitous drop in grade on the east. The designers created a South-facing courtyard at the minus 8-foot level to bring daylight into the lower level. Wheelchair accessibility requirements are met by bridging from West Second Street into a mezzanine overlooking the lowest level. (3)



Model of the Building

4.1 Site Remediation

Findings from a contamination survey performed by Green Environmental revealed that a remediation was necessary prior to construction. This effort was considered "relatively minor" and involved removing lead contaminated soil from an eight squarefoot area of the property. The lead contamination was due to the washing of tools in the metal workshop that had previously been onsite. The remediation process did, however, delay the start of construction by several weeks.

4.2 Demolition, Waste Management and Recycling

According to a 1998 EPA report, construction and demolition projects generate 136 million tons of debris per year. (5) This figure does not include waste associated with building public infrastructure (e.g., roads and bridges). Of 136 million tons of debris generated annually, the amount of these materials that is reused is estimated to be about 20 to 30%. Recycled materials, according to the EPA, tend to be mostly concrete, asphalt, metals and some wood.

When AFH purchased the site of the EpiCenter, a metal workshop was on the property. Following LEED requirements and their own environmental standards, AFH ensured that waste from the demolition of the structure was recycled to the extent possible. This building was demolished and 98% of it was recycled, including glass, asbestos roof tiles, bricks and wiring. Although no revenue was earned for the recycled materials, AFH believes that the cost of recycling these materials was equivalent to what it would have cost to dispose of the waste in a landfill. None of the old building materials could be used on site for the new building. The only exception is the retention wall on the South of the building and the rail road tracks found on the property that are slated to be used for a decorative awning.

4.3 Landscaping

The EpiCenter's lot is very small and much of the AFH property is covered by impermeable surface. There is little natural vegetation or landscaping on this urban site, with the exception of a small patch of grass in the courtyard and a tree in the rear. The one grassy area is located in a largely concrete courtyard situated below street level. Adjacent to the main gallery area, the courtyard doubles as an outdoor gallery and offers an additional 1200 square feet of exterior space for art installations and receptions. The grassy area was included with LEED accreditation in mind and planted with drought resistant grass species. Irrigation of courtyard grass involves water sourced from a rooftop rainwater collection system, which harvests and stores rain in a 1500-gallon tank. In addition to conservation-conscious irrigation, organic fertilizers are used on the grass and no pesticides are used on the property.

4.4 Zoning

A major constraint of the EpiCenter's design involved narrow property lines and related setbacks. Setback regulations maximize the distance between neighboring buildings and their fenestration. These setbacks are part of a fire code to prevent the spread of fires from building to building through windows.

The building's small parcel, coupled with setback regulations, prompted creative building design in order to maximize square footage. While AFH investigated creating inset windows on the western and eastern walls, this idea was cost prohibitive and would have taken up too much space. The fire code constraint led to more extensive fenestration on the northern and southern building walls. There are no windows on the east and west sides of the building.

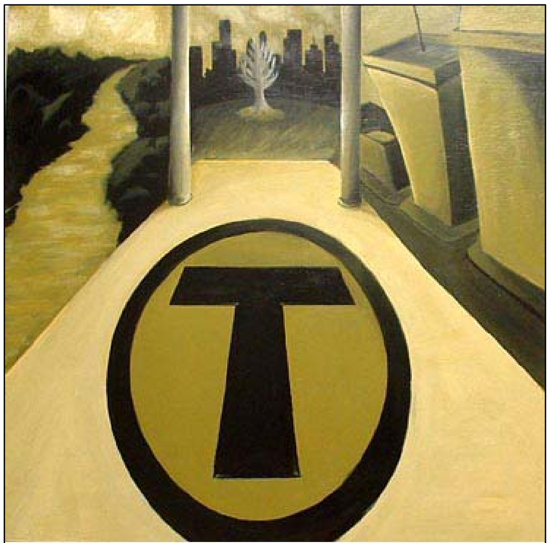
EpiCenter, AFH

4.5 Transportation

Traffic, congestion and air pollution are hallmarks of many large cities. A 2001 study conducted by Texas A&M University found: "Traffic congestion for 68 cities in 1999 [was] 4.5 billion hours, representing 6.8 billion gallons of wasted fuel and $78 billion in lost productivity." A 2003 study based on U.S. Census data ranked Boston as having the 10th-longest commuting time in the nation (www.bwc.gov/pdf/new_england/bos_biz_jrnal_3-12-04.pdf) These numbers indicate the extent to which transit-oriented building development is needed.

The EpiCenter's location was selected to accommodate their high-school apprentices who all commute to the center by public transportation. The MBTA Red line subway train is approximately three blocks away and a bus line runs close to the building. All of the teen artists and about 70 percent of the staff commute by public transportation. Bicycle storage and showers are available on site for those who bike to the center. Showers were included with LEED in mind and are currently not very frequently used.

Artists For Humanity was allotted 10 parking spaces but instead chose to increase the building footprint; they now have 5 parking spaces. Some parking spaces are reserved for car pool vehicles. There are plans to install an electric automobile charge station (in order to receive a LEED point); presently there is an outdoor outlet.



Salim Elijah 4'X4' enamel on wood

Massiel Grullon 4'X4' enamel on wood

Lee Beard 2'X2' enamel on wood

5 Energy

The goal for the EpiCenter was to create a building that serves as a model for financially feasible sustainable construction.

5.1 Energy Performance Summary

The goal of AFH is to be as energy neutral as possible.

Table 3 compares baseline, design case and actual energy usage data. Actual usage is based on data that was available for a relatively short time span -- October 2004 through August 2005. Only once the building has been in operation for a couple of years will it be possible to draw conclusions.

Though energy modeling predicts that the building will use more energy than it produces, it may be possible that the energy cost will be closer to zero or even positive, due to the high value of the electricity generated and the addition of Green Certificates and Carbon credits. These additional benefits may outweigh the cost of natural gas and some imported electric use (see below more detailed discussion on Green Certificates and Carbon credits).

Table 2: Energy Modeling and Actual Usage per Year

	Base Case ASHRAE 99 (Visual DOE 2.0 Results, Mark Kelley Sep 05)	**Design (expected usage/ production)** (Visual DOE 2.0 Results, Mark Kelley Sep 05)	**Actual (usage)**	**% reduction from ASHRAE Base Case**	**% difference from Design Case**
Average yearly kWh consumption	492,880 kWh	77,132 kWh (PV production not subtracted)	92,879 kWh (PV production not subtracted)	81%	+20%
kW peak demand average	117 kW	25 kW	42 kW	64%	165%+68%
Yearly PV kWh production	NA	58,000 kWh	52,486 kWh	NA	-9.5%
Average gas consumption (yearly in therms)	7,426 therms	3,653 therms	4673 therms	37%	+28%
Yearly CO2 emissions from gas in tons (Conversion Factor: 12 lbs of CO2 per therm)	45 tons	22 tons	28 tons	63%	+28%
Yearly CO2 emissions from electricity (total kWh minus PV production) (Conversion Factor: 1.3 lbs of CO2 per kWh)	320 tons	13 tons	26 tons	8%	+100%
Total yearly CO2 emissions from gas and electricity in tons	365 tons	35 tons	54 tons	14%	+55%
Total Energy Consumption in kBTU (PV production subtracted from total consumption)	2,424,799	430,598	605,151	25%	+41%

Energy per square foot in kBTU (PV not subtracted)	103.18	26.8	33.4	32%	+25%
Energy per square foot in kBTU (PV subtracted from total consumption)	103.18	18.32	25.75	25%	+41%

5.2 Modeling

Establishing a "base case" building is vital to understanding the effects of energy efficiency improvements on the building. The base case is used as a benchmark for energy savings estimates; it also allows for cost and materials estimates, which can help validate the costs and savings that may accrue as a result of the sustainable design.
Energy modeling of the EpiCenter was performed by the sustainability engineer on the team (Mark Kelley.) The modeling predictions helped establish priorities, and were used in applications for funding from the Massachusetts Technology Collaborative (MTC) and the utility companies (NSTAR and Keyspan) for energy efficiency technologies.


Mike Sanches enamel on wood

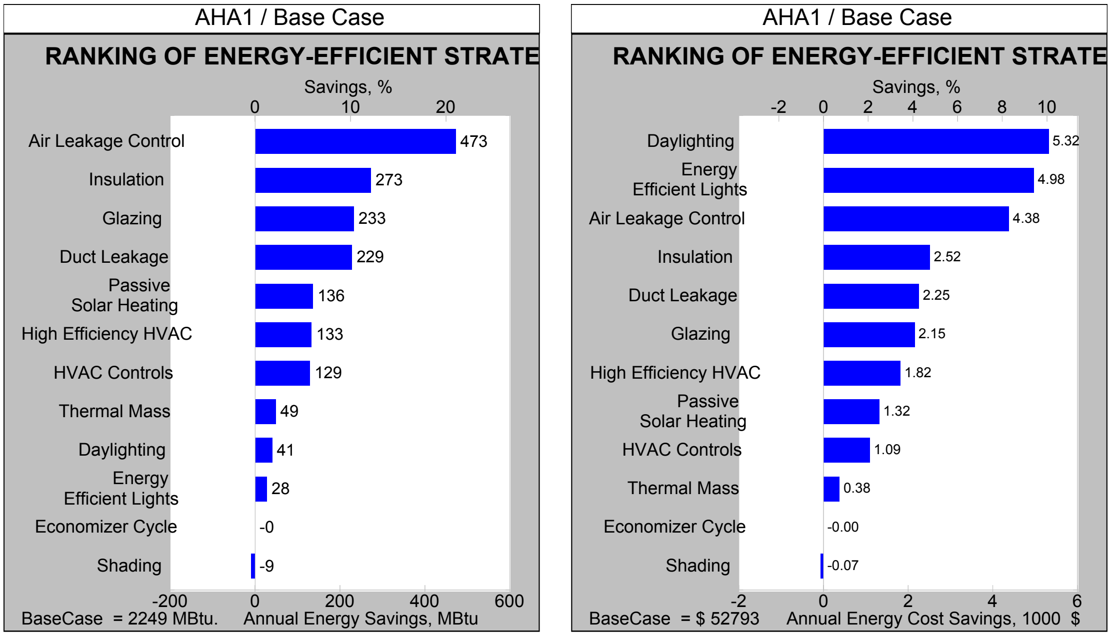
Several modeling tools were used during the design process to optimize energy performance:

- **Energy 10** was used very early on to get a fast picture of a base case building and evaluate the potential of various changes and technologies for improving performance.
- **DOE 2.0** was used once the schematic design was complete to evaluate more complex and detailed energy choices. DOE2 modeling was used to analyze technologies such as variable speed drives, high efficiency fans, daylight controls, heat recovery ventilation, and lighting improvements. This modeling also quantified the savings and helped AFH to qualify for utility incentives of over $225,000. (2)
- **COMCHECK** was used to verify Mass Building Code compliance.
- **RETSCREEN** International was employed to create a photovoltaic performance and cost analyses.
- **BLCC** was used as a life cycle cost analysis tool to compare different types of technologies integrated with the building (see Financial Aspects section).

In their feasibility study, the EpiCenter's engineers ranked energy efficiency strategies by the amount of energy saved and by cost savings. The two graphs in Figure 1 show that because electricity is more expensive than natural gas per BTU delivered, the greatest energy savings do not always correlate with the largest cost savings. For example, daylighting and energy efficient lights save little energy compared to other areas, but they are at the top of the cost list because the energy saved is all costly electricity.

Figure 1: Ranking of Energy Efficiency Strategies by Btu and $ Savings:

<u>**MBtu Savings of energy-efficiency strategies**</u> <u>**Dollar Savings of energy-efficiency strategies**</u>

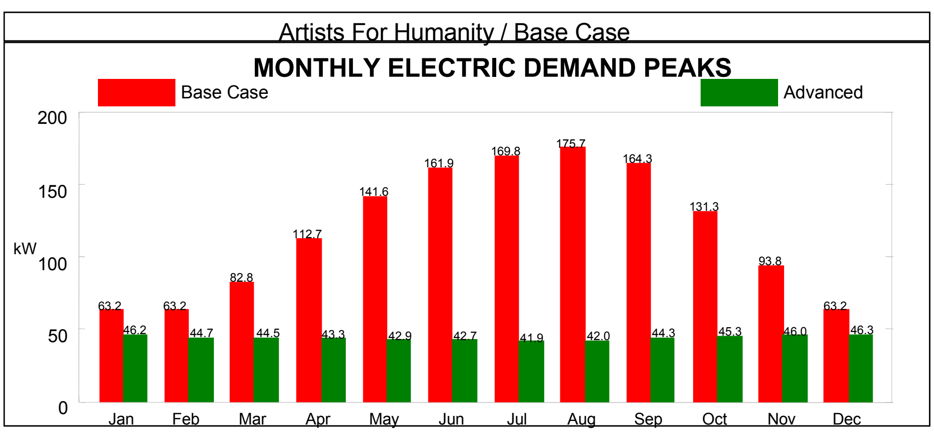


Energy saving opportunities do not directly correlate with cost saving opportunities because of the cost of the energy source. Source: (1)

Modeling for a base case building that met Massachusetts Energy Code showed that typical energy use is greatest for heating and lighting, followed by plug loads ('other' in Figure 2), and ventilation. (Part of the cost of ventilation is hidden in heating and fan electricity.) Since the occupants of the EpiCenter use artists' materials, ventilation needs were of special concern. Despite cooling's seemingly small contribution to the overall energy budget, eliminating cooling significantly reduced operating costs, since electricity is the mostly costly energy in a building.

In addition to the decrease in overall usage, the typical increase in energy demands that occurs during peak hours is eliminated with the chosen strategies (e.g., daylighting and photovoltaic panels). This will result in significant savings in utility bills.

Figure 2: Electric Demand Peaks



Energy efficiency measures selected dramatically impacted peak loads. Source (3)

5.6 Building Envelope

The **foundation** is insulated with two-inch extruded polystyrene below the floor slab and on the exterior of the below grade foundation walls. (6)

The **exterior walls** of the EpiCenter are constructed with one-inch interior gypsum board, metal studs with R-12.5 cavity insulation, one-inch exterior gypsum board, an external moisture barrier, two-inch extruded polystyrene and an exterior metal weather screen. This results in a total approximate insulation value of R-19.

The original design proposed a 2-inch foam insulation outside a steel stud wall with R-19 fiberglass batt insulation for a total R-value of approximately 25 for wall insulation. In later calculations, Mark Kelley the sustainability engineer determined that using R-19 fiberglass insulation might, under certain conditions, create potential moisture and condensation problems. (The dew point could possibly reside in the center of the batt insulation, so moisture from inside could condense within the wall. With less interior insulation, the dew point ended up within the foam insulation, where there is no air movement potential, so no transmission of moisture to that site.) These potential moisture issues could be avoided by choosing R-14 insulation batts. According to the sustainability engineer the lost efficiency results in additional heating and cooling costs of approximately $150 per year.

Wall detail, glass encased as educational tool

Interior steel frame with connector clips

The walls on the east and west sides have **interior steel frames** that are not integrated into the wall. This greatly reduces thermal bridging. The metal clips that connect the steel frame to the wall had to be modified to improve the esthetics. In conventional construction, where the steel frame is integrated into the wall, those clips are hidden in the wall and are very large. Smaller clips that are installed in a way that is less visible were used in the EpiCenter.

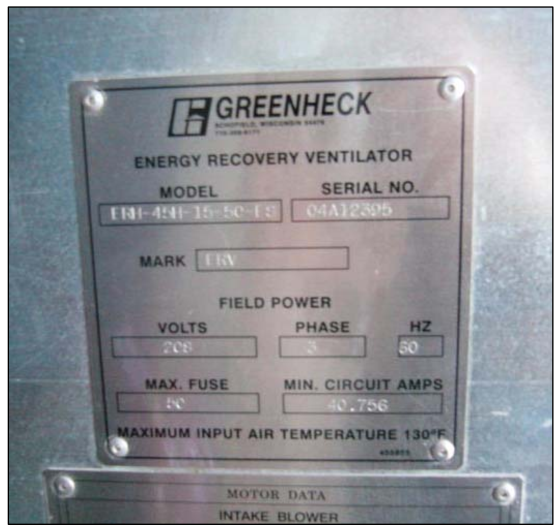
The **roof** insulation is six-inch extruded polystyrene (R-30). Combined with the roof structure and the waterproof membrane, the roof has a minimum R-value of 32. Urethane or isocyanurate foam is used most commonly for roof insulation; however, AFH chose extruded polystyrene because the long term R-value of the urethane or isocyanurate foams degrades as the foaming agent dissipates through the edges. Polystyrene retains more than 90 percent of its R-value for 20 years or more. Eventually, the R-values of the two products is essentially the same. (3)

A reflective roof membrane was chosen to reduce heat island effect and for added cooling of the building. Sloping the roof allowed greater density of photovoltaic panels and promotes snow clearing. Shading of the roof by photovoltaic panels also has the added benefit of reducing solar gain. (See Renewable Energy section)

5.7 Heating, Cooling & Ventilation

Because care was taken to optimize insulation and air-tightness of the building envelope, it was possible to down-size the boiler used for **heating**. The base line building would have needed a boiler of 1.2 million British thermal units (Btu) per hour, the high-performance building requires only 500,000 Btus.

Air Exhaust



Heat recovery

Two 500,000 Btu Powerfin by Lochinvar boilers controlled by Tekmar Pump Sequencer 132's were installed; the second boiler runs only if the additional heat is required. The closed combustion, low volume systems are “cold start” boilers that run only on demand and boiler temperature is maintained only when in use. (7) Dramatic reductions in distribution losses are also achieved through the hydronic distribution system which avoids the large losses inherent in ducted systems. Fan coils and short duct systems are entirely within the building and within the zone they serve. (3) The hot water heater is a 48 gallon HydroJet by Bradford.

The EpiCenter is the first naturally **cooled** commercial building in Boston. The demonstration of a naturally cooled commercial building in an urban setting is very important milestone for sustainable construction.

Because the building has relatively low occupancy and few appliances, internal heat gains are low. Cooling loads were drastically reduced by elimination of east and west glazing and the use of manually-operated shades that are lowered when solar gain (and glare) become excessive. Glazing, ventilation, and earth coupling[1] design choices further reduced cooling loads. Envelope and lighting measures result in a cooling load of approximately 300,000 Btus/hour.

Cooling Tower Air Grates

The elimination of a mechanical cooling system reduced equipment cost by approximately $120,000 and avoided lifetime operating costs of more than $400,000. (2) The cost for the natural ventilation systems and fans was estimated by Mark Kelley at $85,750. The models estimated that the base case building would have needed at least 80 tons of cooling at a cost of over $1,200 per ton, or at least $100,000. The annual electric energy savings are estimated to be $12,000 for cooling alone. (3)

The EpiCenter's cooling tower has an ingeniously simple design: The engineer explains:

Taking advantage of Boston's relatively cool climate, we designed a night ventilation system capable of exhausting the building air in 11 minutes or 5 1/2 times per hour. Variable speed fans, controlled by pressure sensors in the exhaust chase allow any or all of the large dampers to be opened on each floor, so selective ventilation is possible. Further, the system can operate without fans when natural forces are sufficient.

To provide additional daytime comfort, paddle fans were added throughout the building. These provide direct evaporative cooling in summer and destratification in winter. The fans chosen were industrial versions of the "Gossamer Wind" concept developed by The Florida Solar Energy Center, and as such, use far less power than typical models. With all fans running, the energy use is below 4 kW, comparing favorably to the alternative 85 kW for a mechanical cooling system (EER = 10).

The paddle fans improve comfort under cooler higher humidity conditions (Fig. 4 area B), while cooling the mass of the building at night, and closing it in the daytime improves comfort during hot but less humid conditions. When all 8760 hours of TMY (Typical Meteorological Year) weather data are plotted on a [psychrometric] chart, only one hour of the year lies outside the [comfort zone.] This makes Boston a prime candidate for passive cooling. (1)

In the summer, the cooling tower fans go on at 4:00 a.m. and exhaust all the hot air in the building. The cement floors act as thermal mass. Cooled at night, they slowly absorb heat during the day and allow for a comfortably cool environment.

An added benefit of the natural ventilation tower is the substantial reduction in the peak load electricity demand of the building. Brownouts occur on the hottest days of summer because of high air conditioning demands. Utilities have levied demand charges on peak use of energy. Because of the natural ventilation system the EpiCenter's need for utility peak power are estimated to be reduced by 76 percent in the most extreme conditions. This significantly lowers electricity cost by lowering peak demand charges. (3)

Ventilation is of special importance at the EpiCenter because many artists materials have high content of volatile organic compounds (VOCs) and other toxics. Therefore, sufficient air changes are vital to insure

[1] Connection of the foundation and floor to the earth results in heat being conducted away from the building year round – a positive factor in cooling season.

healthy indoor air quality (IAQ). Further, some zones within the building (e.g., the silk screen area) require higher rates of ventilation and direct exhaust rather than heat recovery.

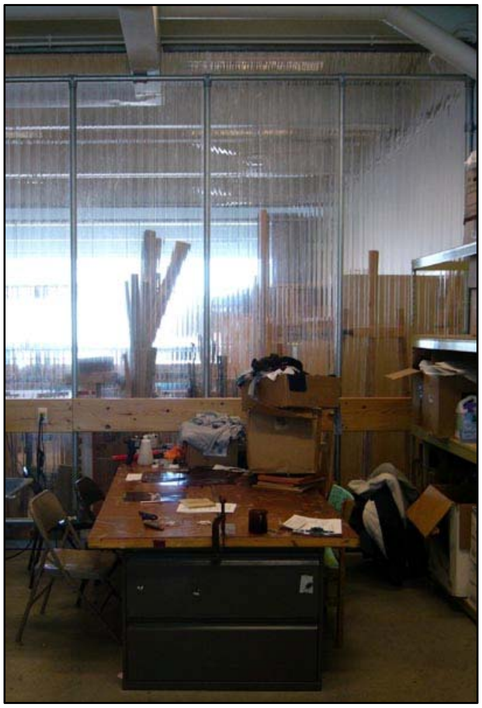
Reducing energy consumption of fresh air ventilation provides substantial savings. A central air supply and exhaust with a heat recovery ventilator recover heat from exhaust air. Modeling showed that annual ventilation energy use could be cut by 65 percent or more, compared to the base line building (65).
The first floor does not have a heat recovery system because, according to the sustainability engineer, heat recovery is only economically viable in high use areas. The large first floor space has generally low occupancy levels except for events, when windows and doors can be opened without energy penalty.

5.8 Daylighting & Windows

The best possible use of **daylighting** was very important to Artists For Humanity. Much effort was spent on optimizing daylighting while at the same time not compromising, perhaps even enhancing the buildings energy performance.

William Lam, an MIT alumnus, performed daylight models during the design phase. Modeling showed that integrating natural light and super-efficient electric lighting and controls may reduce the lighting energy use by as much as half. Using glass walls on north and south of interior studios allowed light from the high south and north glass to reach the interior. (2) Baffles and translucent studio walls were also included to facilitate the distribution of daylight.

Reduced heat output by lighting also decreased cooling loads as internal gains are reduced. Lighting typically contributes about 20 percent of the peak cooling load at about 1.5 watts per square foot. By reducing this to 0.5 watts per square foot, the resulting reduction in cooling load is about 7 percent. (3)



Day lit second floor studio

Venetian blinds second floor office area

Currently the only **shading** devices in the EpiCenter are manually operated Venetian blinds on the south facing windows. Heat gain on this side can be intense and building occupants reported that during several days in October 2004 the second floor south facing work stations were uncomfortably hot. Much of this problem has been remediated though better knowledge of building operations. On the other hand, staff and teen artists enjoy how cool the below-grade gallery space stays. Staff and teen artists are learning how to best operate the building to ensure best performance of the natural cooling system.

Glare was suspected to be a problem during sunny days, but according to the Operations Director Andrew Motta, this has not been an issue. The building users are very pleased with the daylighting strategies. They reported that it is more efficient and effective than they expected. During several site visits it was noticed that no lights were on in any of the day lit spaces, even on cloudy days.

Day lit below grade first floor

Daylight sensors were installed throughout the building. The sensors automatically adjust artificial lighting according to the amount of daylight available. According to Motta, in hindsight they might not have been a worthwhile investment because daylighting is so excellent that lights are hardly ever used during the day. Also, staff and teen artists are so well trained to shut off lights that they often manually turn off lights in the bathrooms and don't wait until motion sensors and timers in the turn them off.

The **glazing** decisions were informed by modeling; the output of this effort shows how important it is to employ detailed modeling factors that account for the specific circumstances of the building. It was expected that a high Coolness Factor would significantly influence the energy performance of the windows:

> *To the extent that daylighting allows tradeoffs in lighting input to cooling loads, it may be possible to reduce the size of cooling equipment - since daylighting availability is greatest at a time coincident with cooling peak load, and lumen for lumen, the wattage of sunlight is only 2/3 that of electric light. By selecting glazing systems with low solar transmissivity and high visible transmissivity, (also described as having a high Coolness Index - the ratio of visible transmissivity to solar transmissivity), glazing area can effectively be doubled with no impact on cooling load. At the same time the amount of daylight would actually be doubled, allowing a reduction in electric lighting that would reduce the cooling load.* (3)

Yet the modeling revealed that low solar heat gain coefficient (SHGC)[2] was not nearly as important as expected. There are no windows on the east and west sides of the building (because building was built

[2] SHGC is determined by two factors: 1. the U-value, or conductivity of heat from the outside air to inside, and 2. the shading factor or blocking of the direct rays of sunlight. This second factor is not important if the direct rays don't reach the glass.

right to the property line and code does not allow for windows in that case). Due to this fact, there is little direct sun light that penetrates the building and the south facing, partially shaded windows showed to have little impact on the cooling load. Modeling indicated that glazing with a higher SHGC and high visible transmittance resulted in a better overall building performance. Viracon VE-185 low emissivity glazing was specified with a U-value of .33, a SHGC of 0.53 and a visible transmittance of 76 percent. (2)

The building has a south-facing courtyard at a minus eight-foot level to enhance daylighting on the first floor. The large south facing door (approximately 24' wide by 16' tall) has single pane glass. This is not optimal in terms of efficiency, but code requires doors to have thick tempered safety glass. Double pane glass would have nearly doubled the weight of the door, which would make it more difficult to operate the door.

Large South facing door

5.9 Plug Loads

Plug loads include nine computers, six laptops and a refrigerator. Power tools are used in the shops. AFH made a conscious effort to reduce plug loads by choosing Energy Star rated appliances and by replacing computers with laptops. All computers use power management and the artists are trained to shut off all non-essential appliances at night.

5.10 Elevator

Low-rise elevators (up to six stories) are typically hydraulic and mid-rise elevators (up to 20 or 30 stories) are typically geared, traction machines. Hydraulic elevators pump hydraulic fluid, moving a piston that pushes the elevator cab up and lowers it back down. Traction elevators are driven by a motor and suspended from overhead cables. Traction elevators are inherently much more efficient than hydraulic ones because they use a counterweight to balance the weight of the cab. (8)

Artists For Humanity installed Kone monospace traction elevator (KCM-31). This elevator is one of the first ones of a new generation of American elevator that run much more efficiently. NSTAR, the AFH's utility company, helped research the appropriate model and paid for 90% of the incremental cost.
With its Kone monospace traction elevator, AFH is a trend setter, as the following excerpt of a recent *Environmental Building News* article shows:

> *The overall trend [among elevator manufacturers] is toward gearless, permanent-magnet motors using variable-speed, variable-frequency drives. These small motors can be mounted directly in the elevator hoistway, eliminating the need for an overhead penthouse to house the motor (in the case of traction elevators) or a ground-floor machine room (in the case of hydraulic elevators). Their smaller, more sophisticated motors require only one-third as much power, so the size of the electrical service to the*

elevator is dramatically reduced. They are also easier and quicker to install, and offer a smoother, quieter ride.

The gearless motors with variable-frequency drives are two to three times more efficient than hydraulics, and 30 to 50% more efficient than standard geared elevators.

Keeping hydraulic fluid out of the ground is another big benefit, since fluid leaking from jackholes under elevators can contaminate groundwater (unless the fluid is plant-based, in which case toxicity usually isn't a problem). Hydraulic elevators also require heaters to maintain the fluid at a constant temperature— these heaters use energy around the clock, even if the elevator is rarely used. In the case of overhead traction elevators, the roof penetration for the penthouse machine room is a notoriously difficult detail to insulate and air-seal effectively, so avoiding the machine room can reduce heating and cooling loads as well. (8)

Choosing a highly efficient elevator helped AFH further lower its energy demand. Also, artists and staff are instructed to use the stairs when ever possible.

6 Renewable Energy

Electricity is the highest form of energy used in buildings and is the most difficult conversion from the solar source, so the efficiency of conversion is low. However, because of its versatility, it is the most valuable energy type as well as being essential to most uses in buildings. Though the conversion efficiency is low, there is every reason to put electrical generation high on the list of desirable solar features, and the value of electricity as opposed to heat, gives PV an advantage. (3)

AFH's 42 kW PV roof array

6.1 Photovoltaic Panels

Photovoltaic systems include the photovoltaic panels and the Balance of System (BOS)[3] components. Roofs can provide large unobstructed areas ideally suited for PV systems. To maximize the effectiveness and power production of PV panels, a roof should be tilted towards the sun at an angle of ±15º latitude. For Boston, this translates to a pitch of approximately 35 degrees. Yet if a 35 degree angle is selected, the serrated roof front will shade the one behind it in deep winter when the sun is at a very flat angle. Yet, lowering the angle does not result in huge efficiency losses; a pitch of 5 degrees still captures 88 percent of the maximum output. (3)

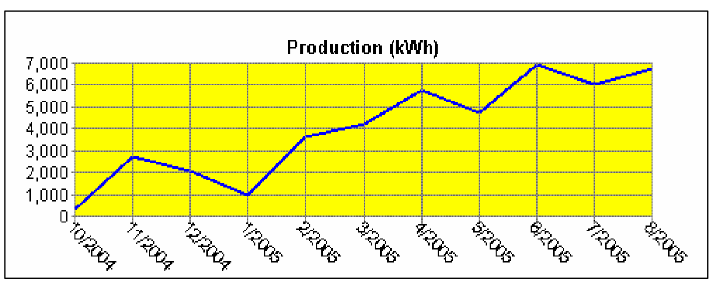
Northern Power installed a 42kW photovoltaic system of 159 panels (RWE Schott ASE-300-DGF/50), mounted on a galvanized steel superstructure on the EpiCenter's roof. The panels are mounted at 8 degrees above horizontal and are oriented at 195 degrees (15 degrees west of true south). There are 19 strings of eight modules and one string of seven modules, due to roof obstruction limitations. Each array is connected to a grid tied inverter (SMA Sunny Boy SMR2500U), rated at 2100 Watts, maximum, at 208 VAC, nominal.

Studies conducted by the sustainability engineer Mark Kelley found that a 0-30° change in the slope of the collectors from the "ideal" would result in little difference in performance. After the panels were installed it was learned that the slope helps with the removal of snow. Kelley now believes that a bit more tilt and separation between panels would further facilitate snow removal and provide space where snow could collect in front of a panel instead of on to the adjacent panel. (7)

The 42kW peak system is expected to produce roughly 58,000 kWH per year; this represented approximately 62% of the EpiCenter's electricity during the first year og building occupancy. (3) Production of solar electricity is highest during the summer months. (2) Together with the natural cooling system (see Heating, Cooling and Ventilation section) these strategies reduce peak demand and cost, since electricity demand is highest during summer.

Table 3: Renewable Energy Production of PV Panels

Production Month	Energy Produced (kWh)
November 2004	2,696
December 2004	2,061
January 2005	994
February 2005	3,652
March 2005	4,200
April 2005	5,745
May 2005	4,741
June 2005	6,904
July 2005	6,026
August 2005	6,718



Source: Renewable Energy Trust, Production, Data Summary for Renewable Energy Systems

www.masstech-pts.org/Production.aspx

3 Balance of System (BOS) components include everything in a photovoltaic system other than the photovoltaic modules. BOS components may include mounting structures, tracking devices, batteries, power electronics (including an inverter, a charge controller, and a grid interconnection), and other devices. (1)

PV panels have silicon cells that transform energy from the sun into an electric charge. There are currently many different types of silicon cells available on the market. The rigid crystalline silicone cells have the highest efficiency at 14-15%, polycrystalline products have an efficiency of 11-12 percent. The current high cost of PV makes strict optimization of the system especially important. For AFH, high efficiency cells made much more sense, since the incremental costs for the rigid crystalline silicone panels was neglible and since the lower efficiency cells would have taken up nearly 25 percent more roof area for the same power. The expected life span for crystalline PV panels is over 30 years.

The Massachusetts Technology Collaborative (MTC) provided a grant to Artists For Humanity to conduct a feasibility study for the EpiCenter's green building features in general and the PV system in particular (The Potential for Sustainability, Energy Conservation, and Power Production in the Artists for Humanity EpiCenter: *A Feasibility Study,* Artists for Humanity, Building Science Engineering, Arrowstreet Inc., March 11, 2002). The potential performance of the PV system was modeled using Retscreen software.

Unsubsidized PV systems are still prohibitively expensive:

> *The collector systems we have investigated fail to meet the return on investment (IRR) requirement of 8% or better unless we include an incentive. With no incentive, the production cost for renewable energy is 40 cents per kWh, and the system has a negative life cycle value. The simple payback is 108 years, and the ROI is 1.7%.* (3)

The unsubsidized cost per kWH for photovoltaic electricity was estimated to be about $.29/kWH. The MTC Renewable Energy Trust granted Artists For Humanity a $500,000 incentive to pursue the renewable energy technology. With this subsidy and an assumed 8 cent renewable energy credit, the internal rate of return (IRR) for the system with an initial cost of $515,000 is an estimated 11.9 percent – making it a financially attractive project. At this incentive level, the cost of renewable energy produced is about 8 cents per kWh, competitive with grid power. The MTC incentive will put the organization on a positive cash flow basis in approximately 10 years with a simple payback of a little over 13 years. (3)

According to the Director of Operations, AFH has been very pleased with the performance of the solar panels. The only small drawback is that the installer did not give consideration to how the panels would be cleaned. Dirt could decrease efficiency by up to 20%. They could be hosed down but it's a challenge to get a hose up on the roof.

6.2 Selling the Green Attributes of the PV

Using electricity generated by the photovoltaic system is expected to prevent 35 tons of greenhouse gas emissions per year. (3) AFH has been exploring options to sell its renewable energy credits or "green recs" as well as its avoided carbon credits. The organization has been in contact with Mass Energy, a "non-profit organization that both advocates and acts in the marketplace on behalf of consumers and the environment" (www.massenergy.com), who would buy the green recs. AFH has also signed a contract with International Carbon Bank and Exchange, an entity that "provides individuals and organizations the ability to profile their Greenhouse Gas (GHG) emissions in a bank-like environment" (www.icbe.com/0.asp) to sell its carbon credits, or emission reduction credits. On average, these credits can be sold for $4/ton of CO_2.

With the increased interest in lowering greenhouse gas emissions, the market for green electricity (electricity produced by renewable and non-nuclear power sources) has been steadily growing during the last few years. One way that green electricity is sold is by uncoupling the energy component from the renewable component. In other words, the actual delivered electrons come from the closest source yet the consumer pays a premium for the share of electricity produced in a sustainable manner. This avoids unnecessary distribution losses and makes sure the electricity is distributed most efficiently. It also enables green electricity suppliers to keep costs low. Producers of PV electricity can therefore sell their green attributes for a premium. Selling the recs makes financial sense for AFH, since they are a non-profit organization with a tight budget.

The drawback to selling green recs is that when the recs are sold, so are the "bragging rights." In other words, if AFH sold its green attributes, it could no longer claim to be (partly) energy independent (although it would still receive the financial benefits of the electricity produced on its roof). To put it simply, if a customer who currently gets electricity from the one of the "filthy five" (coal power plants located in Massachusetts) decides to buy AFH's green recs to offset his/her share of dirty emissions, AFH would in effect be responsible for this customer's air emissions. A very similar issue holds true when selling carbon credits. AFH would have to add the sold carbon credits to its green house gas emissions inventory.

As Andrew Motta, AFH Director of Operations, explains:

> *"We are still exploring our options. Neither selling our green recs nor selling our carbon will make us rich. For us it is more about the learning experience and it gives us yet another tool to talk and educate people about."(9)*

7 Water

Water conservation is a key component of green building and cost saving. Some water conservation strategies are as easy as changing existing fixtures to inexpensive and readily available low-flow types. To conserve water, low-flow fixtures were installed in the EpiCenter rainwater is harvested for landscaping needs. Water use is detailed in Table 4.

Low-flow showerheads use 2.2 gallons of water per minute, compared to the four gallons of water disbursed with conventional showerheads.

EpiCenter's urinals

AFH did not install waterless urinals because one of the engineers felt that they might create maintenance problems. Waterless urinals are becoming increasingly popular, as they are now easier to maintain and offer significant savings from decreased water consumption. The organization also chose not to install composting toilets, primarily because of the additional cost and zoning that requires to be connected to the public sewer.

A 1,500-gallon storage tank collects rainwater for reuse, primarily for irrigation of the courtyard grass. The rooftop harvesting system collects water from the top of the building and directs it through a transparent pipe that is visible in the gallery space of the building. This design is the result of a collaborative process that involved student input. Making water harvesting a visible feature of the building expresses the EpiCenter's mission to actively educate users about sustainable building practices.

Table 4: Monthly Water Consumption

Billing Date	Consumption	Meter Read
7/1/2005	1,420	17,090
6/1/2005	1,280	15,670
5/2/2005	4,880	14,390
4/1/2005	1,920	9,510
3/2/2005	1,230	7,590
2/1/2005	550	6,360
1/3/2005	830	5,810
12/1/2004	790	4,980
11/1/2004	1,020	4,190
10/1/2004	1,100	3,170
9/1/2004	460	2,070
8/2/2004	1,030	1,610
Total Year	**16,510**	**1,376 avg.**

Based on the first year's data, an average of 1,376 gallons of water are consumed per month.

Source: Monthly billing from Boston Water and Sewer Commission, www.bwsc.org

8 Sustainable Building Materials

Sustainable building materials enable developers to use construction supplies that reduce pollution, and conserve resources and energy. AHF used recycled steel and plasterboard. It is worth noting that this did not require additional effort as most steel and plasterboard used in construction has high recycled content.

The building design includes minimal finishing of walls and concrete flooring. Paint finishes in some areas of the building were value-engineered out; when paint was used, it was either low- or no- VOC paint. The raw surfaces create a rough, artistic aesthetic. Local artist Nick Rodrigues designed a decorative balustrade that included salvaged Crown Victoria windshields. Rodrigues also created innovative bathroom stalls using recycled corrugated plastic and plastic jugs. AFH promotes the use of salvage materials as art supplies in order to educate student apprentices about sustainable building practices.

Creative use of low-cost building materials: Plumbers pipe is used to hold up the transparent dividers between studios.

8.1 Build-out Materials

Increasingly, developers and researchers are paying more attention to indoor environments. Given that Americans spend greater than 90% of their time indoors, this interest is important to ensure occupant health. (10) Studies show that indoor environments can affect respiratory health. (10) Therefore, better ventilation coupled with benign materials that do not off-gas toxic fumes is a valuable addition to any construction project.

Reused and recycled materials: Toilet paper dispensers made from 5 gallon water bottles

Sustainable building materials must have several of the following characteristics:

- non-toxic or low in toxicity (e.g., low VOC paints);
- high recycled material content (e.g., cellulose insulation);
- easily recyclable (e.g., recycled steel);
- sustainably harvested (e.g., FSC certified wood);
- from a renewable source (e.g., bamboo flooring);
- low embodied energy (e.g., wood versus steel); high quality and versatility;
- long lasting.

The EpiCenter flooring is finished concrete. The interior is free of carpeting; reduced use of carpeting can help improve indoor air quality by preventing off-gassing of fumes and accumulation of dust and mites. However, the entry way is carpeted; this was added exclusively to add a LEED point. The same is true for the small amounts of FSC certified wood that was used (see section on LEED).

9 Financial Aspects

The total project cost was $6.8 million. This included $1.2 million for the property purchase, all design work, construction, legal and financing fees. For the very beginning of the planning process, AFH wanted to demonstrate that is possible to build a high performance building on a tight budget. Prioritizing energy efficiency proved vital in this process. The incremental cost for the energy efficiency measures was $263,865. (6) AFH expects that progressive design features will "pay for themselves" with the utility savings achieved and energy "buy backs." (11) The organization took some unusual steps in ensuring that even during the value engineering process, building performance was not compromised.

Value engineering at its best: All pipes have been carefully insulated, yet money was saved by cutting on finishes. To the left: the cooling tower interior was left unfinished.

To maximize the return on the technologies selected, The Hickory Consortium considered initial costs, operating and maintenance costs, and externality costs. They also considered the full range of related benefits, including the impact on other systems, building performance, and occupant comfort. (2)

Sustainability engineer Mark Kelley and architect Pat Cornelison comment:

> *The costs per square foot to construct commercial buildings vary widely across the U.S., but it is well established that Boston is one of the more expensive locations to build. In the report "Costing Green: A Comprehensive Data Base and Budget Methodology", costs for academic buildings of all types (Green or not), ranged from $180 to $430 per square foot across the country. The construction cost multiplier for Boston is 115% compared to the average, so we might assume that the lowest cost for Boston would be of the order of $207 per square foot.*
>
> *The actual cost for the complete Artists For Humanities building including soft costs, etc. was a respectable $208 per square foot. Included in that cost is the photovoltaic system at $375,000 or $8.27 per peak watt. Utility incentives and the grants from the Massachusetts Greenbuilding Initiative (Renewable Energy Trust), reduced the building cost by 728,000 to a final actual cost of $177 per square foot.* (2)

Feature/Service	Cost
Site Purchase	$1,200,000
Construction	$4,125,930
Photovoltaic Panels	$ 375,000
Architectural Services	$ 260,000
Professional fees (legal, executive director, artistic, educational, owners rep)	$ 422,537
Pre-development/testing	$ 81,093
Furnishings, equipment, out-of-scope expenses	$ 67,287
Studio space buildout	$ 63,977
LEED Commissioning	$ 20,000
Financing expenses	$ 191,305
Total Project Expense	**$6,807,129**

Source (12)

During the years 2001-2004, more than $5,400,000 was collected in donations and in-kind support. This included $520,000 in grants from the Mass Technology Collaborative and $226,628 earned in rebates on conservation technologies. A goal is in place to raise the remaining $1,400,000 to cover the costs and eliminate the need for related debt.

Funding Source	Amount
Foundations and Corporations	$4,076,200
Mass. Technology Collaborative	$ 520,000
NSTAR Energy Efficiency Rebate	$ 200,000
KeySpan Conservation Rebate	$ 26,628
Individual Support	$ 294,361
Other and In-Kind Support	$ 289,819
Total Funding Received	**$5,407,008**

Source: (12)

A new source of revenue for Artists For Humanity is the offering of their unique building for gallery events; AFH hopes to host three-four gallery events per month and rent their space as a function location. The environmentally-conscious theme, open interior space, and work of the organization's artists combine for a distinct venue. AFH believes that financial support for their programs will be easier to attract now that they are headquartered in a green building. (11)

10 LEED Certification

The LEED (Leadership in Energy and Environmental Design) Green Building Rating System® provides a national standard for high-performance, sustainable buildings. The LEED framework focuses on sustainable site use, environmentally-friendly building materials, energy efficiency, water conservation, and indoor air quality (www.usgbc.org/DisplayPage.aspx?CategoryID=19). Artists For Humanity is pursuing LEED certification and expects to qualify for the highest rating: LEED Platinum; a Silver rating is guaranteed and final confirmation is expected in the fall of 2005.

Pat Cornelius, the architect of the building, is assembling all the required documentation. Over-all, she is positive about LEED as a tool. However, during the EpiCenter certification process it was found that putting the documentation together is much more labor intensive than they anticipated and that some of the required documentation and associated calculations seem overly detailed. (16)


FSC certified wood was added to gain a LEED point.

One drawback of the LEED certification demonstrated with AFH's process is that applicants can be swayed to adding unnecessary features to receive a LEED point. For instance, rather than being rewarded for not using carpet or wood, AFH added some carpeting and some wood railings in order to quality for the recycled content carpet and the FSC certified wood LEED points.

As Mark Kelley put it:

> *In many sustainable projects, including this one, the U.S. Green Building Council's LEED rating system is used as a guide to choices in sustainability vectors. It's important to recognize that there are priorities embedded in that system and that those may not be appropriate for all projects, clients, climates, or building types. A scoping exercise, such as this one, allows reorientation of building design goals and LEED choices that are more fitting for the particular project.* (2)

See Appendix A for details on LEED points Artists For Humanity expects to qualify for.

11 Education and Outreach

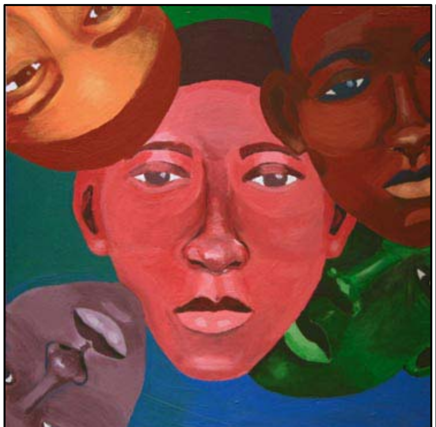
"If we can help people to see that it's not difficult to change, that would be a great thing." – Susan Rodgerson. (1)

Education is the core of the Artists for Humanity's mission. AFH works year-round to employ at-risk youth in the arts and teach the teen artists tools for self-sufficiency. The youth volunteer at AFH for 72 hours and are then paid to do art and are also given a commission on any sale of their work. "This is not charity," said Executive Director Susan Rodgerson, "The more you put out, the more you get back." (1)

According to Rodgerson, the EpiCenter is a key part of the AFH mission. Asked for the impetus to build green, she said, "I've always been interested in environmental issues." When it came time for AFH to build a new building, there was no question about constructing a building that was anything but green.

Artists, like green builders, “use whatever is available,” said Rodgerson, and creatively work within constraints to produce innovative, informative work. The sustainable mindset is a natural fit for artists, she said. Funders, however, were initially unable to see the connection between art education and green building. “We’re teaching kids,” she said. “Why wouldn’t we try to help them see ways that are more sustainable?” Rodgerson also told funders that sustainability – and the self-sufficiency ethic that they teach- is about “thinking logically.” In the end, supporters saw the art-environmentalism connection and helped her build both the EpiCenter and green building programs along with it. When it comes to environmentalism and AFH’s art-based empowerment work, “the big connection is teaching people how to create a good life for themselves.” (1)

11.1 Student Community



Princess Morris 2'X2' enamel on wood

Richard Torres 1'X1' enamel on wood

Deanna Hillery 4'X4' enamel on wood

Not surprisingly, Artists For Humanity teen artists were involved in each step of the EpiCenter design process. To begin with, staff architect and former founding AFH student Carlo Lewis played an integral role in connecting AFH with Arrowstreet. (11) In addition, current AFH teen artists were involved in design charettes and model lighting research, under the guidance of both Carlo and William Lam. (13) Teen artists from local universities Wentworth Institute of Technology and MIT also got involved by building an architectural model of the EpiCenter and performing a daylighting analysis.

11.2 Spiritus Solaris

“Spiritus Solaris” is an interactive environmental education program being developed by AFH and partially funded by MTC. Through this program, AFH will integrate “art and science, [and] introduce a model that provides the Boston community with a new awareness of the potential of renewable energy and sustainable buildings.” (14)

The program will teach building occupants and visitors about the EpiCenter’s green features through a permanent display in the building. The permanent exhibit, to be created by environmental artists Nick Rodrigues and Matt Althof, will display a model EpiCenter and its natural and urban surroundings, contextualizing the building in its larger environs. A tour that highlights the building’s green features will supplement the exhibit and AFH’s goal to teach community members about energy use and sustainable building practices that minimize environmental impact. The objective will be to introduce nature to members of an urban community and to prompt them to think about how they impact the environment with their activities. (4)

A complementary sustainable building curriculum will be created as part of Spiritus Solaris that can be used in any classroom. The curriculum will involve concepts of "urban ecology, climate change and social development, as well as site-specific study of the EpiCenter's environmental impacts and renewable technologies." (14) The curriculum is being developed by AFH youth with support from faculty and students of MIT and the Willauer School. The Willauer School is an Outward Bound style, experiential outdoor education school located on Boston's Thompson Island. (www.thompsonisland.org/willauer/)

The goal of this program is to have the EpiCenter be a resource that can be used by local schools, where classes can be brought in to learn first hand about renewable energy, sustainable building practices, and environmental responsibility. Currently, about three large tours are given of the EpiCenter per month. AFH will be investing in a staff person who will be dedicated to pursuing more groups and promoting a two-or-three day learning experience.

Claudia De Piante Vicin mixed media

Massiel Grullon 2'X2' enamel on wood

Elliana Coleman 2'X2' enamel on wood

12 Summary Results, Analysis, Reflections

AFH succeeded in building a new state of the art facility that uses only 25% of the energy that a conventional building of similar size would have used while at the same time sticking to tight budget constraints. The organization believes that building green is "economically feasible" and that the extra investments become more "viable after eight years." (15)

A post-occupancy review indicates that the PV system is meeting expectations and that daylighting is working surprisingly well. The overhead fans have been extremely effective in ensuring occupant comfort on warm days and the nighttime flushing process has kept the building thermal conditions comfortable except on especially hot days. (5) There is, however, some overheating in the office area, as a result of a light shelf overhang being eliminated for cost reasons and equipment being crowded in an area behind the south glass wall. Additional fans will be installed to improve the thermal conditions of this area. (7)

After comparing the data on the actual and predicted meteorological forecasts and energy consumption, Kelley observed that it is becoming less efficient to use meteorological trend data because of the fact that "typical" weather patterns are no longer appropriate, due to the changes being influenced by global climate change. This makes it difficult to determine what energy needs and savings opportunities will be in future years. (7)

Mark Kelley, the building engineer, offered the following ten observations and guideline principles to help ensure a successful building project:

1. *Prioritizing goals clarifies design and construction.*
2. *Describe the process you expect as well as the results you expect. Design intent is crucial.*
3. *LEED design charrette must happen after sustainable priorities are set.*
4. *Pay for quality that counts: planning, materials, skills, equipment, and durability.*
5. *Tradeoff envelope and systems improvements to save costs.*
6. *Handoffs are times of great peril. Extra communication is required whenever new personnel or trades arrive on the job.*
7. *Project management requires clear understanding of priorities, planning, and attention to detail.*
8. *Nurture jobsite culture – the system will self-organize benignly when workers understand goals.*
9. *Inspect frequently – shorten feedback loops.*
10. *Avoid adversarial process - Partnering works.* (2)

Norma Santiago 2'X2' enamel on wood

13 Contacts

Artists For Humanity	Susan Rodgerson	Boston, MA	617-737-2455
Arrowstreet, Inc.	Patricia Cornelison	Somerville, MA	617-623-5555
Building Science Engineering	Mark Kelley III, P.E.	Harvard, MA	978-456-6950
T.R. White	No longer in business		
Zade Co.	Mohamed Zade, Ph.D., P.E.	Boston, MA	617-338-4406

14 References

All paintings used in this report are by teen artists of Artists for Humanity. For more information and to purchase paintings go to www.afhboston.org

All pictures of the building were taken by Anja Kollmuss

(1) Personal communication, Susan Rodgerson, Director of Artists For Humanity April 14, 2005.

(2) Artists for Humanity Epicenter: A Successful Model for the Sustainable Design Process Mark E. Kelley III, PE, The Hickory Consortium; Pat Cornelison, Arrowstreet Inc. 2005 SOLAR WORLD CONGRESS.

(3) The Potential for Sustainability, Energy Conservation, and Power Production in the *Artists for Humanity EpiCenter: A Feasibility Study,* Artists for Humanity Building Science Engineering, Arrowstreet Inc. March 11, 2002.

(4) Interview, Elisha Long, former AFH LEED Coordinator/Environmental Educator, September 2, 2005.

(5) *"A Characterization of Building-Related Construction and Demolition Debris in the United States," U.S. EPA, 1998.*

(6) NSTAR Rebate Proposal, Submitted by Mark E. Kelley III, PE, The Hickory Consortium.

(7) Interview with Mark Kelley, Building Science Engineering, September 2, 2005.

(8) *The Elevator Revolution*, Environmental Building News, August 2004.

(9) Personal communication, Andrew Motta, Operations Director, Artists for Humanity, April 28, 2005.

(10) November 2, 2000 press release, American College of Allergy, Asthma & Immunology.

(11) AFH Final Report to MTC, 2004.

(12) Artists For Humanity EpiCenter Project Budget (nd).

(13) MIT student Manshi Low's report, Nov 9, 2004.

(14) Spiritus proposal.

(15) Interview with Andrew Motta, Operations Director, Artists for Humanity, August 31, 2005.

(16) Interview with Pat Cornelius, Architect, Arrowstreet Inc , June 13, 2005.