Palo Alto Heritage Center Energy Savings Analysis

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Abstract

Palo Alto Heritage Center Energy Savings Analysis, BRAD M. AVERY (Colorado State University, Fort Collins, CO 80523) DR. ANDY WALKER (Federal Energy Management Program, National Renewable Energy Laboratory, Golden, CO 80401).

The Palo Alto Heritage Center will be built near Brownsville Texas to commemorate the first battle of the U.S.-Mexican War. Due to several acts, initiatives, and Executive Orders, energy efficient design was a concern for this project. The Energy-10 software program was the primary tool used in the analysis. Energy-10 conducts an hour-by-hour annual analysis of twelve strategies to apply to a reference case building to generate a low-energy case building. Daylighting, glazing, shading, energy efficient lighting, insulation, air leakage, high efficiency HVAC, and HVAC control strategies were considered for this project. Specific roof and wall window modifications and wall construction modifications were also analyzed with Energy-10. Photovoltaic systems and natural ventilation are beyond the scope of Energy-10 and were analyzed separately. Results indicate that daylighting and high efficiency HVAC strategies offer the greatest annual energy cost savings, with both strategies saving about $2,000. With all energy efficient strategies and building modifications considered together, the low-energy building generated recognizes a 43% annual energy use savings over the reference case building with no energy saving strategies applied.

Category: Engineering

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Introduction

One hundred and fifty years ago a battle took place that would ultimately change the course of two nations. General Zachary Taylor engaged Mexican troops in the first battle of the Mexican-American war on May 8^{th}, 1846. Located about eight miles north of present-day Brownsville, Texas, the site is known as Palo Alto Battlefield. This battle and the two-year war that followed resulted in the loss of half of Mexico's territory to the United States.

The Palo Alto Battlefield National Historic Site was established in 1978 to "preserve and commemorate…an area of unique historical significance" (Department of the Interior, 1999). A 3,400-acre area was created with the purpose of historical and cultural education through the Palo Alto Battlefield National Historic Site Act of 1991. A temporary facility has helped to meet the goals of education and preservation, however the National Park Service (NPS) has decided that a permanent visitor's center will promote greater public interest and education of the history of the battlefield.

In designing and building the visitor's center, the NPS will be guided by:

> *Executive Order 13123: "Greening the Government Through Energy Efficient Management" - The preamble to this order states: "The Federal Government, as the Nation's largest energy consumer, shall significantly improve its energy management in order to save taxpayer dollars and reduce emissions that contribute to air pollution and global climate change"* (http://www.eren.doe.gov/femp/aboutfemp/exec13123.html, July 6, 2000).

and

> *Green Energy Parks Initiative - This initiative established greater collaboration between the Department of Energy (DOE) and the Department of the Interior (DOI). Through*

this initiative, the NPS will demonstrate the use of renewable and energy efficient systems and educate the public about these technologies.

The Federal Energy Management Program (FEMP) team at NREL provides assistance to federal and government agencies to save tax dollars and meet the goals and guidelines established by E.O. 13123 and the Energy Policy Act of 1992 (EPACT) among others. Andy Walker, the senior engineer at FEMP, has led the coordination effort between FEMP and the NPS to meet the renewable energy and energy efficiency goals of the NPS.

The visitor's center at Palo Alto Battlefield will be approximately 5,400 square feet in area and will have a welcome area, interpretive areas, a sales and office space, restrooms, space for mechanical and electrical systems, and a storage space. The interpretive areas will include an auditorium, outdoor exhibit spaces, indoor changing exhibits, and a media room.

The focus of my research this summer was to select, analyze, and evaluate appropriate renewable energy and energy efficient strategies to reduce building energy consumption while maintaining occupant comfort. The primary tool used in this analysis was the *Energy-10* software program.

Methods and Materials:

Energy-10 was the primary analysis tool used in the pre-design of the Palo Alto Battlefield Heritage Center. *Energy-10* is a software program that performs an annual hourly energy analysis with twelve different renewable or energy efficient options on an entire building. This tool is intended for residential or commercial buildings of 10,000 square feet or less. It should be noted that *Energy-10* is only a model or prediction of energy savings.

The initial data input for *Energy-10* was obtained from NPS documents and communications with David Vela and Ed Nieto of the NPS (personal communications, July 11 and 12, 2000). This data consisted of the building location, floor area, building usage, and the number of stories (Figure 1). The electrical service information was researched through Central Power and Light of Texas (http://www.aep.com/Tariffs/csw/CPL/B5.pdf, June 27, 2000). This data is a reasonable estimate of electrical service costs to the site. With these inputs, the *Energy-10* simulation was executed to generate base case and low-energy case structures. A variety of different energy efficient and renewable strategies were chosen individually as well as in combination. The results were ranked to determine which options yield the most cost-effective energy savings. Each strategy was further modified to increase savings and/or better meet the needs of the building, and this process was repeated several times.

In addition to the *Energy-10* analysis, other energy saving options were considered that cannot be modeled by *Energy-10*. The main two alternative options that were investigated were photovoltaics and natural ventilation. A quantitative analysis was not conducted for these strategies; instead simple building modifications and suggestions were made to promote opportunities for application of these strategies.

Results

The *Energy-10* analysis was conducted several times to obtain various sets of data. The data entered into *Energy-10* to build the reference case building for each simulation was kept the same (Table 1). After careful consideration of the twelve energy efficient strategies available to generate the low-energy case building, it was determined to include daylighting, glazing, shading, energy efficient lighting, insulation, air leakage control, high efficiency HVAC, and HVAC control strategies. With these eight options, the initial low-energy case was determined. Table 2 shows properties of the reference case building and the initial low-energy case building. Passive solar heating was not investigated since it is most effective in providing heating in cooler climates. The duct leakage option was not investigated since the ducts for the Palo Alto Heritage Center are internally located. The thermal mass option in *Energy-10* evaluates heat storage capacity added within the building, and again is not advantageous for the visitor's center due to the hot and humid climate. Finally, the economizer cycle was not considered for climate reasons.

The energy saving options listed above had a variety of configurations that impact the effectiveness of each option. The following configurations were used in the application of each energy saving strategy.

Daylighting

The daylighting strategy was conducted assuming that 50 foot-candles was adequate lighting for most public spaces. Continuous dimming was also applied to maximize the energy savings by maintaining a constant illumination level from light provided by daylighting and fluorescent fixtures.

Glazing

This strategy was simulated with double pane aluminum clad windows with a low-e glazing.

Shading

Shading recommendations are based on the latitude of the building, surrounding topography, vegetation, and building design. By default 40° latitude shading was simulated, although the latitude of the site is 26°. This default assumption should be conservative. Oversized shading geometries will block more direct beam sunlight annually, which is advantageous in the hot climate and weather of the region.

Energy Efficient Lighting

This strategy was set to simulate lighting equal to 75% of the annual energy use of the lighting in the reference case building.

Insulation

Insulation was simulated with 6” steel stud walls with 2” foam (R=19.2), foam core doors, a flat roof (R=38.0), and a slab on grade floor type with carpet.

Air Leakage Control

This strategy was applied by setting the effective leakage area to 0.0025 ft^2 per square foot of gross wall area.

High Efficiency HVAC

HVAC systems were configured with a heating system efficiency of 90%, a cooling system EER of 13.0, and fan efficiency of 25%.

HVAC Controls

The HVAC controls were configured to evaluate a heating setback and a cooling setup. The heating setback was set to 5° below the comfort setpoint of 72° F, and the cooling setup was set to 5° above the comfort setpoint of 76° F.

Each of the eight energy-saving options applied to the reference case building were simulated individually. This process was completed to evaluate the contribution toward energy savings offered by each particular option. The eight options were also simulated together to evaluate energy savings with all options applied. The values for total energy cost, total energy use, heating, cooling, and peak electric load from each of these simulations can be seen in Table 3. From this data it appears that energy savings from each individual option, when added together, is less than the energy savings found when all eight strategies are applied together. This is due to the synergistic effect of many of the specific options. The insulation strategy becomes even more effective at saving energy when air leakage is also considered. Likewise, daylighting, shading, and glazing are more effective when these options are evaluated together.

These individual strategies were then ranked to determine which were most effective (Figure 2). From this analysis, daylighting and a high efficiency HVAC system offer the greatest potential energy savings, with daylighting offering over $2,000 in annual energy cost savings, and high efficiency HVAC with over $1,800 in savings. Additionally, energy efficient lighting alone offers almost 1,000 dollars in annual energy cost savings.

After determining the effectiveness of these energy saving strategies, other building modifications were considered to further reduce energy consumption.

Roof Windows

The *Energy-10* daylighting simulation assumes that all roof windows are placed horizontally with a 0° tilt. This was modified to a 90° tilt for vertical arrangement of the windows and compared to the horizontal arrangement (Table 4). From this data, the vertical windows have a positive effect in reducing the annual energy use, the cooling load, and the peak electric load.

Wall Window Glazings

The reference case building in *Energy-10* is designed with double pane aluminum clad windows with a U-value of 0.70. With the glazing energy saving option applied, the low-energy building was designed with double pane aluminum clad windows with a low-e coating that have a U-value of 0.31. The low-energy case building windows were modified to include a spectrally selective glazing. The specific glazing investigated was quad low-e 88 that was placed on double pane aluminum clad windows. The quad low-e 88 glazing had a solar heat gain coefficient of 0.45 and visible transmittance of 0.62. This modification was compared to both the reference case and low-energy case building windows (Table 5). The table indicates that both the low-e glazing and the quad low-e 88 glazing reduce the annual energy cost, heating load, cooling load, and peak electric load. Annual energy cost is reduced by approximately $500 with the low-e glazing, and the quad low-e 88 saves about $300 more than the low-e glazing.

Wall Construction Modifications

The low-energy case walls were specified as six inch steel stud walls with a two-inch layer of extruded foam. An exterior thermal mass strategy was considered by adding a layer of concrete masonry units (cmu's) or concrete to the steel stud walls. Both cmu and concrete options were analyzed with *Enery-10* at thicknesses of two, four, six, and eight inches. Results showed that at each thickness concrete and cmu performance were almost identical. The analysis results for concrete are shown in Table 6 for each thickness of concrete using the six inch steel stud wall for reference. Although the eight-inch thickness performed the best overall, energy savings between the varying layers were marginal. From an energy perspective, the results seem inconclusive.

Final Results

Finally, each of the eight energy saving strategies were simulated with the roof and wall window modifications. The wall construction for the final analysis also included the two-inch concrete wall layer. These things, simulated together, created the final low-energy case building. Figures 3, 4, 5, and 6 depict Annual Energy Cost, Annual Energy Use, Monthly Electric Peaks, and Monthly Energy Use Averages. With the combined strategies and construction modifications, total energy cost was reduced by 43% as compared to the reference case building. Similarly, the cooling load was reduced by 62%, the heating load was eliminated, and the lighting load was reduced by 65%.

Discussion and Conclusions

Based on the *Energy-10* analysis, alternative options, National Park Service goals, and interpretive considerations, the following recommendations are made:

Daylighting

The use of a saw-tooth type roof monitor with the windows facing north is recommended. This should minimize passive solar gains and still allow for effective daylighting. With proper shading strategies, a clerestory roof monitor would be acceptable. The clerestory roof monitor has the added benefit of maintaining a flat roofline, which allows for an appearance that better aligns with cultural and historical influences of buildings in the region. Continuous dimming of interior lights should also be used to maximize energy savings. However, if personal control of lighting is an issue, stepped lighting is an acceptable alternative, but some energy savings will be sacrificed. Further benefits of these daylighting models include reduced glare since direct beam sunlight does not pass through the north facing windows or shaded south facing windows, and sharp contrasts in illumination is also minimized.

Glazing

The use of a spectrally selective glazing for the wall windows is recommend. The simulation incorporated a quad low-e 88 glazing with SHGC of 0.45 and visible transmittance of 0.62. However, any glazing with a SHGC of about 0.40 and visible transmittance of about 0.60 should be satisfactory. Windows that only receive diffuse sunlight (i.e. north facing windows) do not require a selective glazing since infrared wavelengths are not as prevalent. For such windows the only concern is blocking UV light. Proper shading can further reduce the number of windows that require a selective glazing.

Shading

A conservative shading geometry is recommended for the building. Porticos offer an easy way to incorporate overhangs over windows, and this feature is a common feature in the southwest. It is recommended that south facing windows should have a minimum overhang of 18 inches to provide for effective shading through a greater portion of the year.

Energy Efficient Lighting

Energy efficient lighting can save energy in the lighting load while significantly reducing the cooling load. In conjunction with daylighting, continuous dimming should be incorporated. Incandescent lamps should be avoided. Use of energy efficient T-8 or T-5 fluorescent fixtures with electronic ballasts should be considered. Task lighting can be achieved with compact fluorescent lights (CFL's). Bouncing light off of walls, ceilings, and other light colored surfaces can minimize workstation glare and provide more even and balanced illumination. LED exit signs should also be implemented, rather than incandescent or fluorescent signs.

Insulation

Wall construction should incorporate 6" steel studs with a 2" thick layer of foam. Additionally, a layer of concrete or block should be added to the wall construction as the outer layer. This recommendation is based on the goal of making the visitor's center blend with the surrounding climate and with traditional buildings of the region. Two inches of block or concrete is recommended from a resource conservation and cost perspective. Actual material selection of block or concrete should be determined by cost analysis as the performance of each are comparable.

Air Leakage Control

Consider designing an air retarder system (ARS) for the building to increase building envelope and insulation lifetimes. The ARS should address all joints, penetrations, and points of infiltration. Each should be properly sealed. Plastic film should be used to block infiltration through insulation.

High Efficiency HVAC

Cost of bringing utilities to the site is a concern. With this in mind, an electric system is recommended to eliminate the need of bringing natural gas to the site. A packaged terminal air conditioner with electric resistance baseboard heat is the recommended system. With any electric HVAC system heating system efficiency should be 100%. However, if an alternative system is used that requires natural gas, the heating system efficiency should be no less than 90%. The cooling system should have an EER of 13.0 or above.

HVAC Controls

A thermostat with programmable heating setbacks and cooling setups should be used. A heating setback of 5° F and cooling setup of 5° F are recommended to enable a greater range of temperatures and time at which the HVAC system is not operating.

Photovoltaics

This option was not feasible due to the relatively low utility costs. However, there are still opportunities to incorporate photovoltaics (PV) on the site. These PV units would provide energy for several applications, be visible to the public, and promote educational opportunities.

The Battlefield Overlook roof could be outfitted with a small prepackaged PV system on the roof. This system would provide enough power for any lights or speakers that may be included on the overlook. This would eliminate the need to bring electrical power from the visitor's center to the Battlefield Overlook and assist in the NPS goal of site preservation.

Safety lighting in the parking lot and areas surrounding the visitor's center offer a great opportunity to use photovoltaics. PV should also be considered for the parking lot or other areas that have potential evening uses. Also, any paths or walkways that have lighting considerations should incorporate photovoltaics. Using PV for these purposes can be unobtrusive while still having enough visibility to educate visitors about renewable energies and the NPS commitment to these sources of energy.

Natural Ventilation

Based on the wind data and comfort concerns from the National Park Service, natural ventilation should be implemented for the outdoor exhibit area (Figure 7). The impact and effectiveness of natural ventilation is influence largely by the placement and orientation of the outdoor exhibit area. A recommended change to the outdoor exhibit layout to maximize ventilation is detailed in Figure 8. Also, roof openings would add to ventilation benefits. These openings should face north to northwest to allow airflow. If the outdoor exhibits require protection from rain, overhangs should be considered. Wall apertures and openings can vary in size. However, to minimize the amount of dust, leaves, and other particles from entering the exhibit space, partial walls should be incorporated on the windward side of 2-3 feet in height. As detailed in the Development Concept Plan, seating could be built into this partial wall. It is recommended that these partial walls be implemented on all exterior sides of the exhibit space.

Acknowledgements

I would like to thank Andy Walker for all the wonderful support, advice, and assistance he has provided. Through his mentorship I have learned and understand more about sustainable buildings and energy-efficient buildings than I could ever have imagined. Also, thanks to Adie Curtner and Trina Brown for their advice and direction with the Energy-10 software, and to Ananda Hartzell for organizing the Energy-10 training session.

My appreciation also goes to Hugh Duffy and the staff of the National Park Service Denver Service Center for their enthusiasm and flexibility in working with me.

Many thanks to Robi Robichaud and John Sepich, who have served to focus my thoughts, assist at every step of the way, and their efforts and hard work to make this a true fun learning experience. Thanks also go to Bruce Hogue for his intriguing educational discussions, his humor, and his generosity in sharing his teaching experiences with me.

Finally, I thank the National Renewable Energy Laboratory for this opportunity to work and use their facilities here this summer, along with the National Science Foundation and the Department of Energy for their funding and support of the Pre-Service Teacher Program.

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Figures

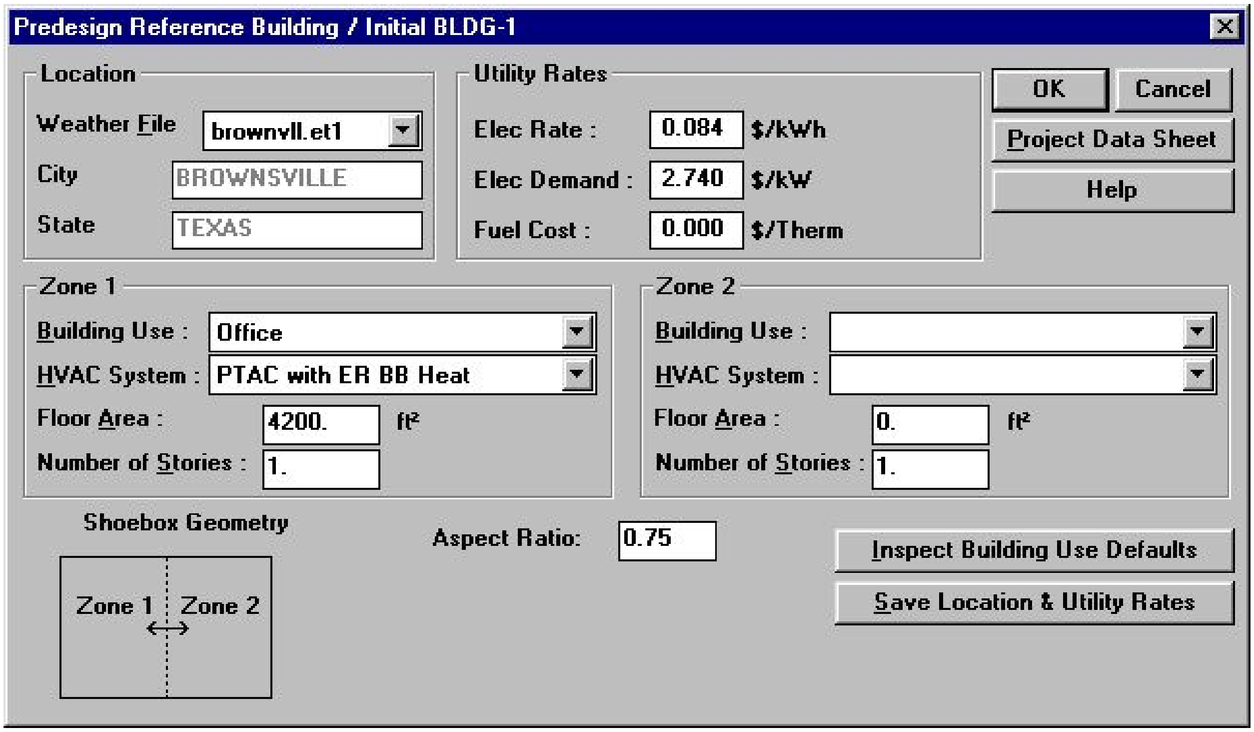

Figure 1: Data input window in *Energy-10*.

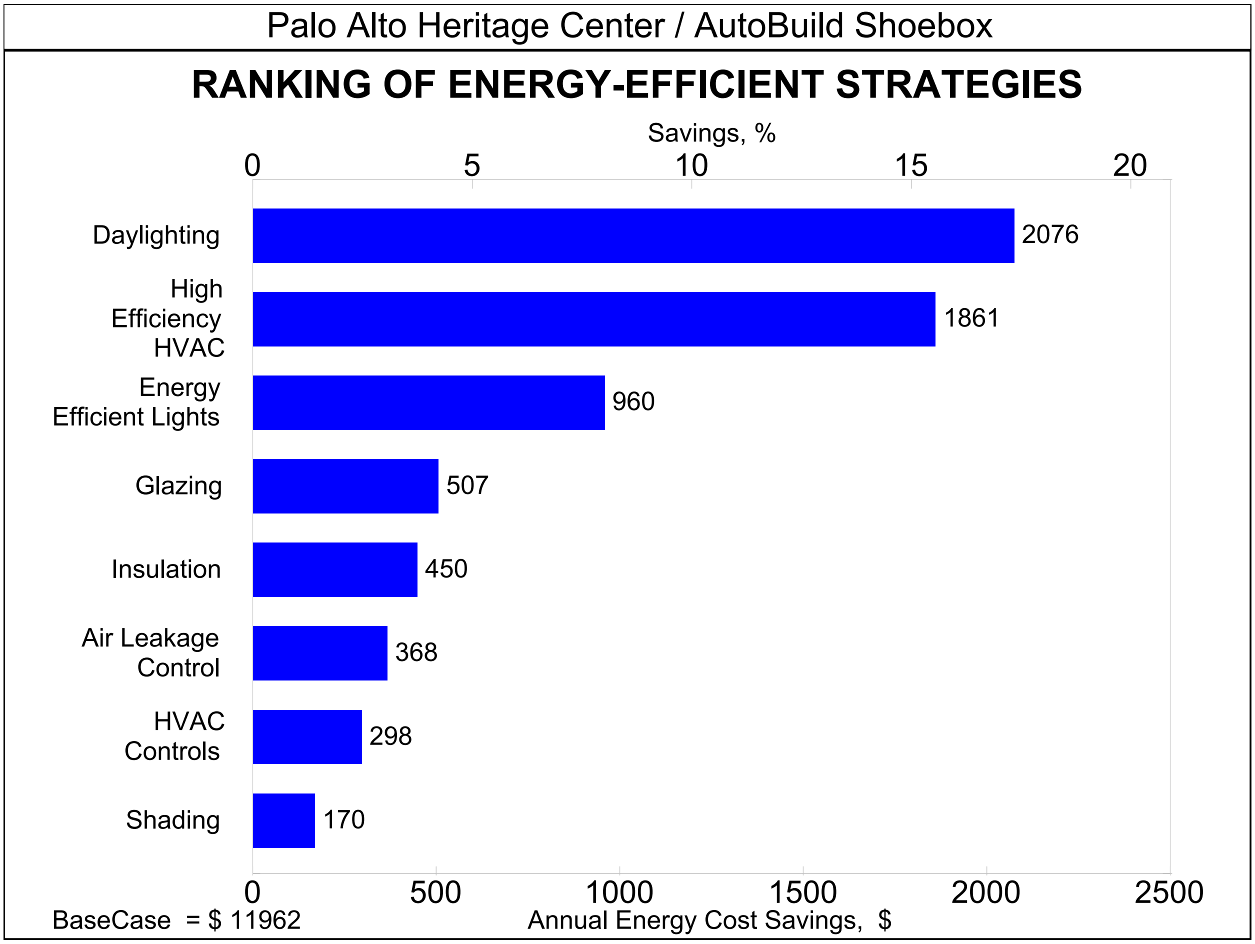

Figure 2: Rank of energy efficient strategies in *Energy-10*.

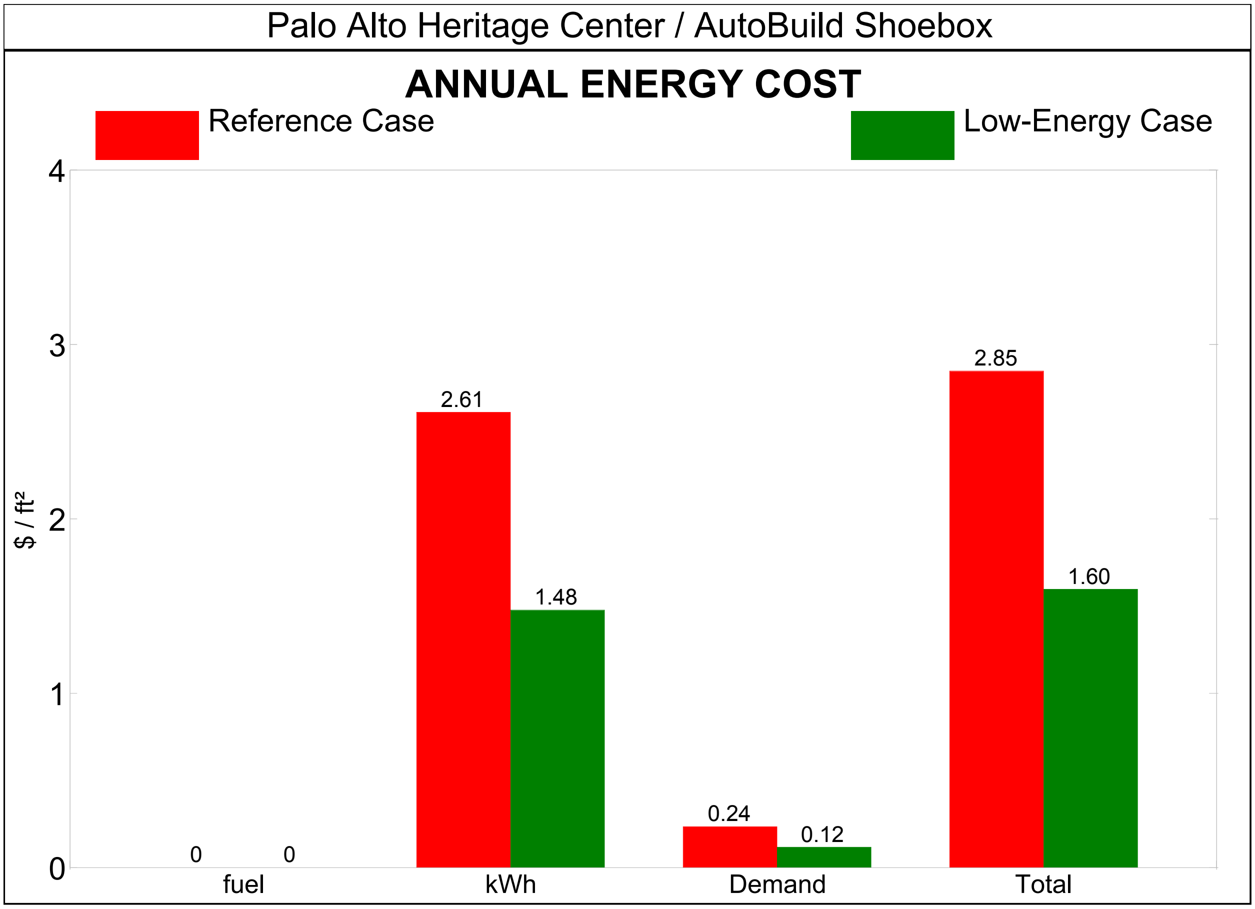

Figure 3: Comparison of annual energy cost of the reference case building to the low-energy case building in *Energy-10*.

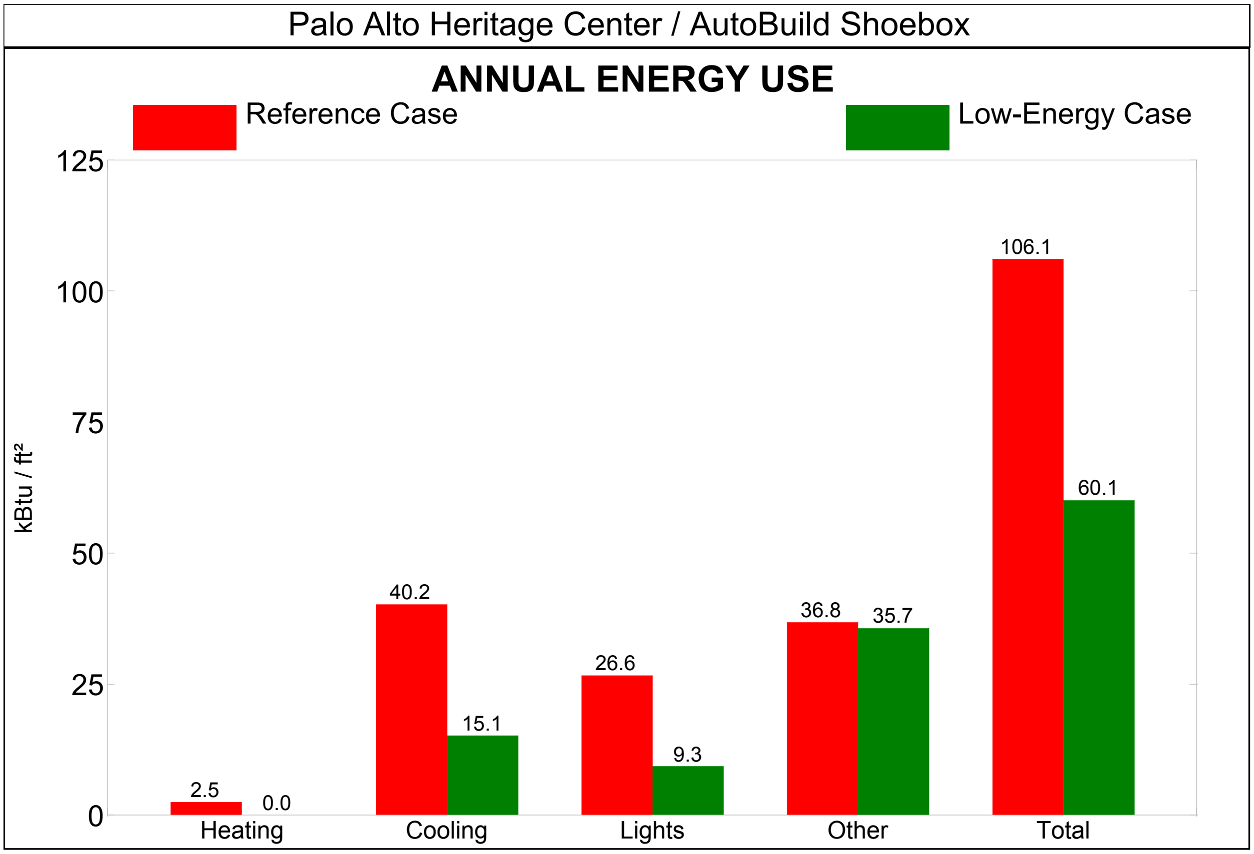

Figure 4: Comparison of annual energy use of the reference case building to the low-energy case building in *Energy-10*.

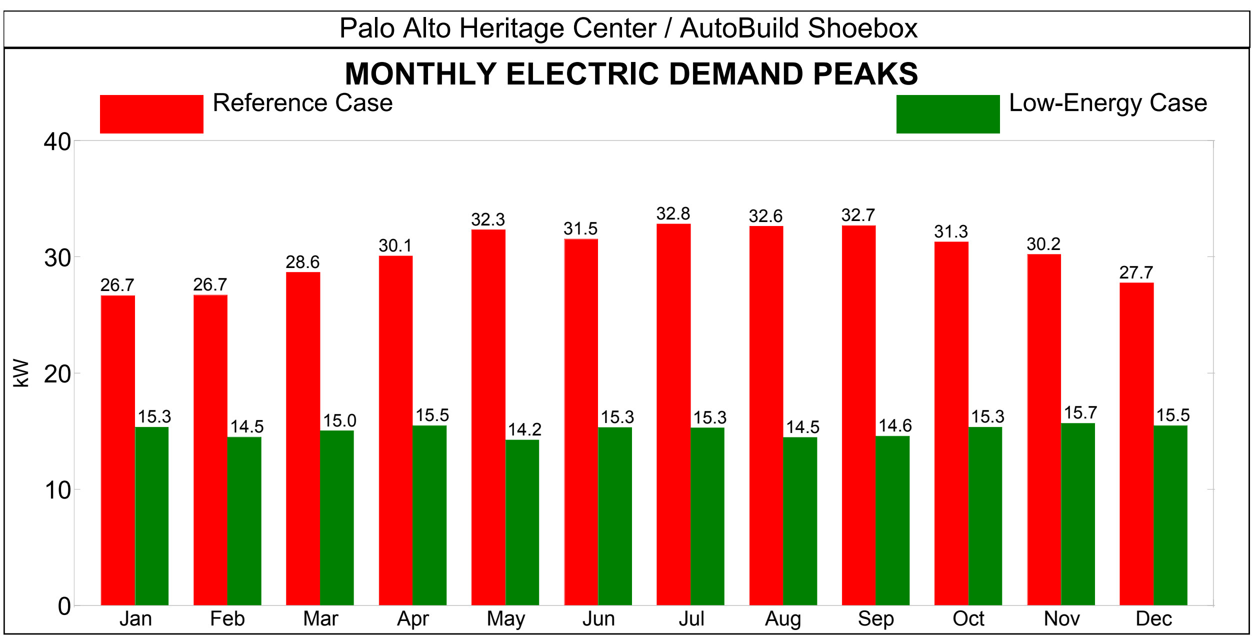

Figure 5: Comparison of monthly electric demand peaks of the reference case building to the low-energy case building in *Energy-10*.

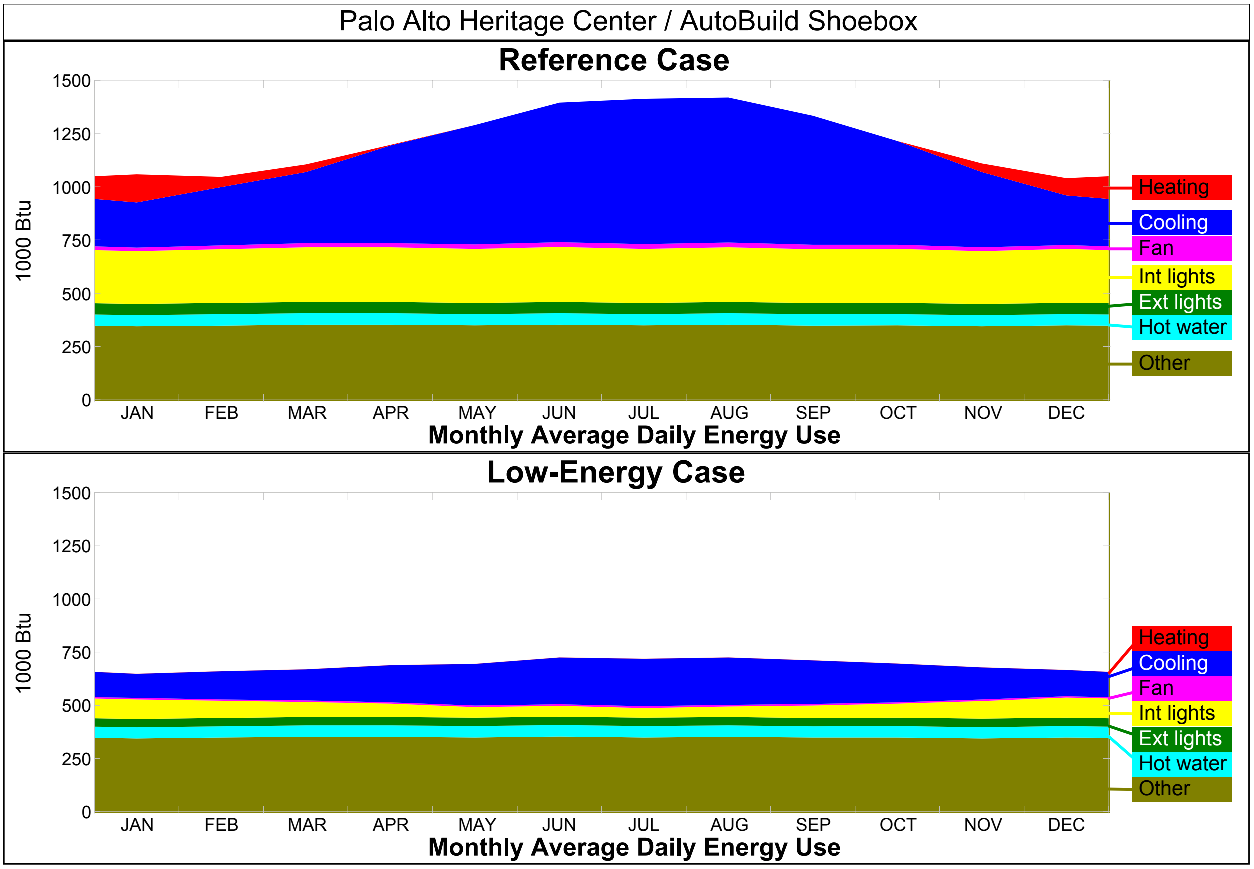

Figure 6: Comparison of monthly average daily energy use of the reference case building to the low-energy case building in *Energy-10*.

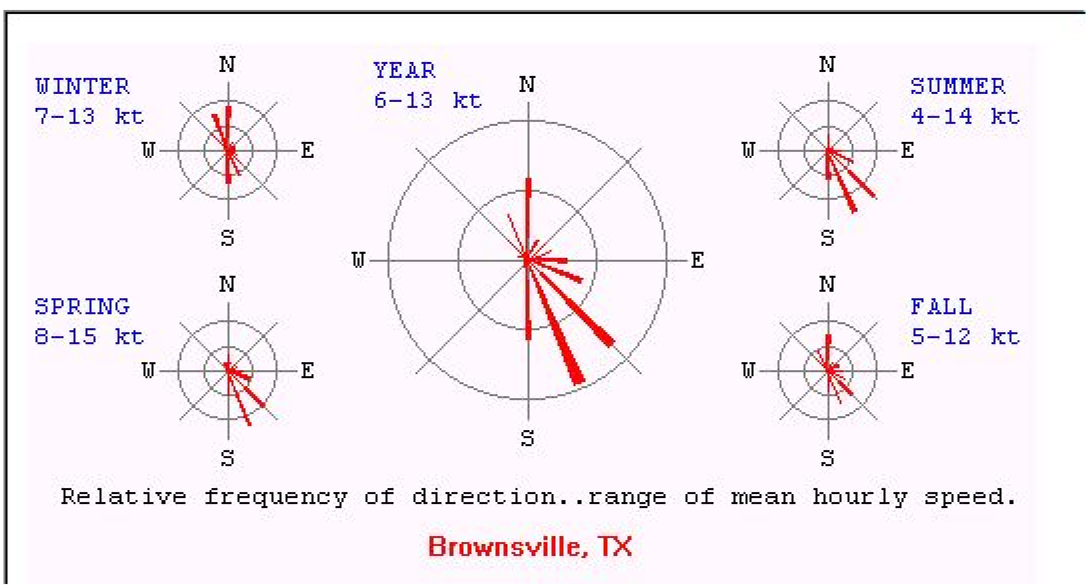

Figure 7: Seasonal and annual wind data for Brownville, Texas.

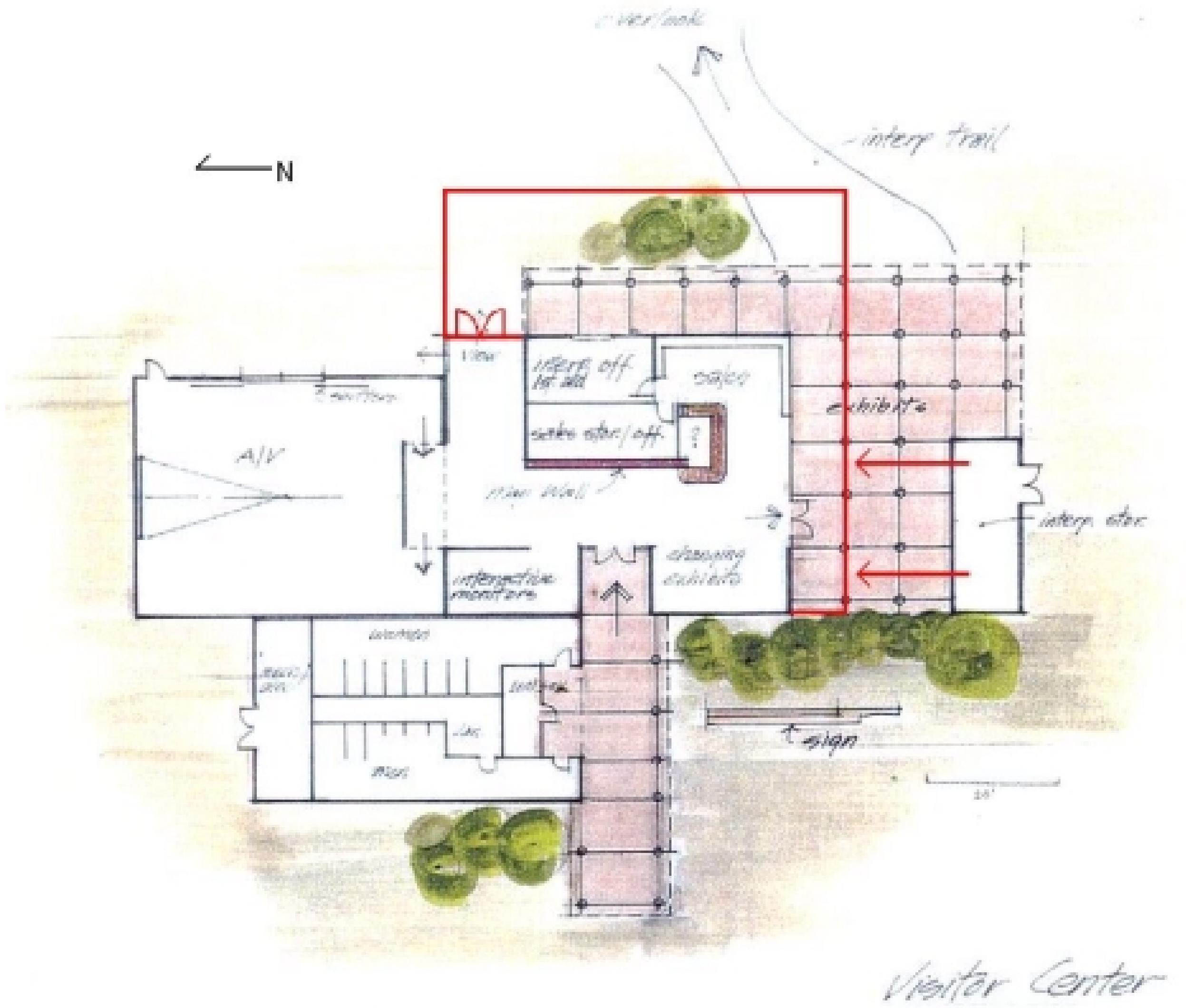

Figure 8: Recommended design modification to the outdoor exhibit space for more effective natural ventilation. This modification is based on the initial building design concept from the *Development Concept Plan for Visitor Facilities*.

Tables

Weather File:	Brownsville, Texas
Building Use:	Office
HVAC System:	Package Terminal Air Conditioner with Electronic Resistance Baseboard Heat (PTAC with ER BB Heat
Floor Area:	4200
Number of Stories:	1
Utility Information:	
Electric rate:	0.084 $/kWh
Electric demand:	2.74 $/kW
Fuel cost:	0.00 $/therm.
Aspect Ratio:	0.75
Workdays per week:	7
HVAC Control Schedule:	8am - 6pm
Duct Location:	Inside

Table 1: Input data for reference case building

Reference Case Building	**Low-Energy Case Building**
R-13 walls (4” steel stud)	R-19.2 walls (6” steel stud with 2” foam)
R-19.0 flat roof	R-38.0 flat roof
Reff=17.8 slab insulation	Reff=80.2 slab insulation
Aluminum double windows, U=0.70	Low-e aluminum w/ break, U=0.31
No window shading	40° latitude window shading
No skylights	Skylights at 0° tilt (flat)
Lighting load: 1.78 W/ft^2	Lighting load: 1.33 W/ft^2
HVAC: PTAC w/ ER BB heat	HVAC: PTAC w/ ER BB heat
Heating system efficiency: 100%	Heating system efficiency: 100%
Cooling system EER=8.1	Cooling system EER=13.0
No HVAC setback/setup	HVAC setback/setup=5° F
No economizer cycle	No economizer cycle
Effective leakage area: 452.9 in^2	Effective leakage area: 122.6 in^2
No thermal storage	No thermal storage

Table 2: Reference case and initial low-energy case building properties

EES	Total Energy Cost ($)	Total Electric (kWh)	Heating (kWh)	Cooling (kWh)	Peak Electric (kW)
None (reference)	11,962	130,582	3,046	49,478	32.8
Daylighting	9,886	108,151	3,393	45,784	26.5
Glazing	11,455	125,214	1,798	45,584	30.8
Shading	11,792	128,858	3,065	47,853	32.2
Energy efficient lights	11,002	120,021	3,294	46,960	30.6
Insulation	11,532	126,058	1,016	47,218	30.8
Air leak. Control	11,594	126,621	1,766	46,858	31.3
High efficiency HVAC	10,101	110,867	3,055	30,612	25.6
HVAC controls	11,664	126,956	2,285	46,706	33.1
Combined strategies	6,835	75,281	14	20,723	16.1

Table 3: Individual option and combined option data

EES	Total Energy Cost ($)	Total Electric (kWh)	Heating (kWh)	Cooling (kWh)	Peak Electric (kW)
None (reference)	11,962	130,582	3,046	49,478	32.8
Combined strategies	6,835	75,281	14	20,723	16.1
Combined strategies with roof windows at a 90° tilt	6,731	74,178	14	19,679	16

Table 4: Comparison of vertical roof window orientation to horizontal orientation

EES	Total Energy Cost ($)	Total Electric (kWh)	Heating (kWh)	Cooling (kWh)	Peak Electric (kW)
None (reference)	11,962	130,582	3,046	49,478	32.8
Low-e glazing	11,455	125,214	1,798	45,584	30.8
Quad low-e 88 glazing	11,182	122,347	1,454	43,180	29.8

Table 5: Comparison of quad low-e 88 glazing to low-e glazing and reference case building

EES	Total Energy Cost ($)	Total Electric (kWh)	Heating (kWh)	Cooling (kWh)	Peak Electric (kW)
None (reference)	11,962	130,582	3,046	49,478	32.8
Combined strategies with modified glazings 90° tilt of roof windows	6,712	74,011	2	18,675	15.7
and 6" steel stud walls					
2" concrete added	6,706	73,955	0	18,627	15.7
4" concrete added	6,703	73,935	0	18,609	15.7
6" concrete added	6,699	73,910	0	18,587	15.6
8" concrete added	6,698	73,904	0	18,580	15.6

Table 6: Comparison of concrete wall modifications with reference to the 6" steel stud wall

References

Allard, F. (Ed.). (1998). Natural Ventilation In Buildings: A Design Handbook. London: James & James Ltd.

Central Power & Light Company. (1999). Central Power & Light Company: Tariff for Electric Service. Corpus Christi, TX: Author. Retrieved June 27, 1999 from the World Wide Web: http://www.aep.com/Tariffs/csw/CPL/B5.pdf

Duffie, J., & Beckman, W. (1991). Solar Engineering of Thermal Processes (2nd ed.). New York: John Wiley & Sons, Inc.

Eiffert, P., & Kiss, G. (2000). Building-Integrated Photovoltaic Designs for Commercial and Institutional Structures: A Sourcebook for Architects. Golden, CO: National Renewable Energy Laboratory.

Executive Order 13123. (1999). Washington, DC: Federal Energy Management Program. Retrieved June 13, 2000 from the World Wide Web: http://www.eren.doe.gov/femp/aboutfemp/exec13123.html

Federal Energy Management Program. (1999) Green Energy Parks Overview. Washington, DC: Author. Retrieved June 22, 2000 from the World Wide Web: http://www.eren.doe.gov/femp/techassist/grenen_fact.html

Federal Energy Management Program. (1999). Greening Initiatives: Green Energy Parks. Washington, DC: Author. Retrieved June 22, 2000 from the World Wide Web: http://www.eren.doe.gov/femp/techassist/greenparks.html

Greening Federal Facilities Guide. (*Review Draft* 2000). Prepared under contract to the National Renewable Energy Laboratory by the Ensar Group for the Department of Energy's Federal Energy Management Program.

Harpers Ferry Center Division of Interpretive Planning. (1999). Long Range Interpretive Plan: Palo Alto Battlefield National Historic Site 1999. Harpers Ferry, WV: Author.

National Institute of Building Sciences. (2000). Whole Building Design Guide. Washington, DC: Author. Retrieved June 15, 2000 from the World Wide Web: http://www.wbdg.org/

National Oceanic and Atmospheric Administration. (2000). Climatology for Brownsville, Texas. Washington, DC: Author. Retrieved June 22, 2000 from the World Wide Web: http://www.srh.noaa.gov/bro/climate.htm

National Park Service Denver Service Center. (1998). Development Concept Plan For Visitor Facilities: Palo Alto Battlefield National Historic Site. Denver: Author.

National Renewable Energy Laboratory. (1999). The NREL FEMP Team: Who We Are. Golden, CO: Author. Retrieved July 10, 2000 from the World Wide Web: http://www.nrel.gov/femp/who.html

Tassou, S. & Lau, K. (1998). Low Energy Cooling Technologies - A Review. In S. Tassou (Ed.), Low-Energy Cooling Technologies For Buildings (pp. 1-22). London: Professional Engineering Publishing Ltd.