DOCUMENT RESUME

ED 428 506 EF 005 223

AUTHOR	Callahan, Michael P.; Parker, Danny S.
TITLE	Energy Efficient Florida Educational Facilities. Improvements to a Portable Classroom in a Volusia County School.
INSTITUTION	Florida Solar Energy Center, Cape Canaveral.
SPONS AGENCY	Florida State Dept. of Education, Tallahassee. Office of Educational Facilities.
REPORT NO	FSEC-CR-1008-98
PUB DATE	1998-06-00
NOTE	9p.
AVAILABLE FROM	Web site: http://www.fsec.ucf.edu/~bdac/pubs/CR1008
PUB TYPE	Guides - Non-Classroom (055) -- Reports - Descriptive (141)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	Air Conditioning; *Educational Facilities Improvement; Elementary Secondary Education; *Energy Audits; *Energy Conservation; Heating; Lighting; Public Schools; *Relocatable Facilities; *Research Projects; Roofing
IDENTIFIERS	*Florida

ABSTRACT

The Florida Department of Education is monitoring the energy use of two adjacent portable classrooms to compare their energy efficiency in a hot and humid climate and determine if they can be made more energy efficient either by retrofit or when the portables were constructed. This report provides the background of this research and describes the portable classroom's lighting, roofing, heating, ventilation, and air conditioning systems; and discusses results and conclusions. (GR)

On-line Publications

Energy Efficient Florida Educational Facilities
Improvements to a Portable Classroom in a Volusia County School

FSEC-CR-1008-98*
June 1998

Submitted by:

Michael P. Callahan
Danny S. Parker

Florida Solar Energy Center
1679 Clearlake Rd.
Cocoa, FL 32922-5703

Introduction

An ambitious project by the Florida Solar Energy Center (FSEC) and sponsored by the Florida Department of Education (FDOE) is monitoring the energy use of two adjacent portable classrooms to see how they might be made more energy efficient in a hot-humid climate. These classrooms have been monitored for one year to collect baseline data before the energy efficient measures are installed. These measures include an efficient lighting system, a new air conditioner, and a reflective white metal roof.

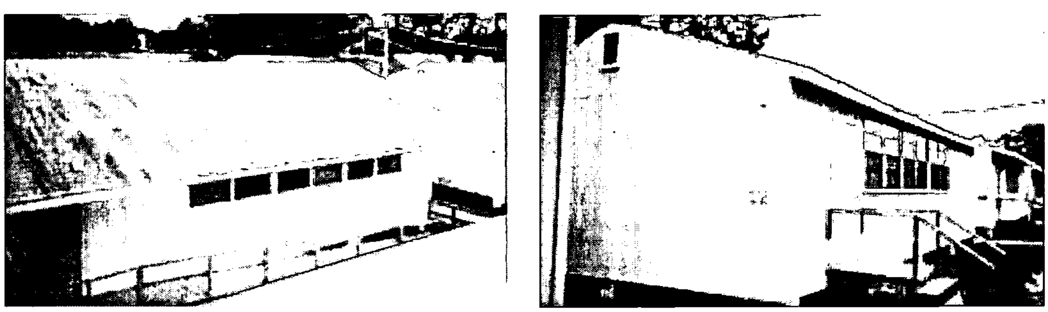

Figure 1. Photograph of the portables being monitored at Silver Sands Middle School. Portable 035 is on the right and portable 096 is on the left. Each has a conditioned space of 720 ft^2.

Objectives

The purpose of this study is to determine if portable classrooms can be made more energy efficient either by retrofit or at the time when new portables are constructed. We also want to determine which measures are the most effective and most affordable so that both energy savings and costs will be tracked. Retrofits include:

- Lighting: current lighting system to be replaced by T8 lamps with electronic ballasts
- Roof: current gray asphalt shingle roof to be replaced with a reflective white metal roof
- Ventilating and Air Conditioning: current 3-ton wall mount unit to be replace with 2½-ton
  Bard WH301-A wall mount model

Portable 035 was chosen for the initial retrofits since during the year of collecting baseline data, the HVAC has performed poorest of the two.

Background

An ever-expanding number of portable classrooms is a growing fact of life in the Florida school system. Where these relocatible classrooms were once thought to be temporary structures, it is now accepted that they are more or less permanent. One of the main problems of portable classrooms is that they are often poorly received by the community (Brown 1995). They are frequently judged as substandard educational facilities (Florida 1993) and have been called "eyesores" and "monotonous and uninspiring"(Educational Facilities Lab 1964). These perceptions have to do mainly with the portable's bland coloration and their non-permanent appearance (Brown 1995).

Florida schools, on average, have 9.9 portables with 836 ft^2 of floor area per portable (Callahan et al. 1997). In addition, studies show that each portable classroom uses approximately 30 kWh/day (Sherwin and Parker 1996) or 10,840 kWh per year (Callahan et al.1997). Portables account for 11.1 % of the energy budget for Florida public schools. Recent research shows that the energy use at Fellsmere Elementary is 360 kWh/day for 12 portables (Sherwin and Parker 1996).

The Florida Solar Energy Center, in conjunction with the Volusia County School Board and the Florida Department of Education, chose Silver Sands Middle School for the study. Silver Sands is located in Port Orange south of Daytona and has 39 portable classrooms.

Portables 035 and 096 have been chosen for the study. These portables are side by side and identical in dimensions and configuration. They are 36 ft. x 20 ft. in an east-west orientation with North and South facing windows. The windows are 4.1 ft. x 6.1-6.9 ft. with three on both the North and South side of the portables. Total glazed area is 162.6 ft^2 on each side of the portable.

Each portable was fully instrumented. Metering equipment consists of thermocouples that measure interior air temperatures and relative humidity, roof surface temperature, attic air temperature, and decking temperature. The portables are also wired to measure how long the doors are opened and provided with CO_2 sensors. The rooms are also configured to measure total portable kWh, air conditioning (AC) kWh, and lighting kWh. There is also a weather station at the site that measures wind speed, ambient temperature, relative humidity, and solar insolation over a 24 hour period. Instruments are scanned every ten seconds with integrated averages output to logger storage every 15-minutes. All this instrumentation is poled by a *Campbell CR10* data logger that is accessed by FSEC at night.

Lighting

Lighting represents about 13% of the total annual energy consumption for Florida schools (Sherwin and Parker 1996). This does not take into account the heat produced by lighting. Lights increase the sensible AC load by an average of 23% annually (Floyd et al. 1995). Schools typically have T12 lamps with magnetic ballasts in classrooms because they are the most inexpensive. However, it has been shown in previous studies (Sherwin and Parker 1996, Parker et al. 1996a, McIlvaine et al. 1994) that slim-line T8 lamps with electronic ballasts performed best in both commercial buildings and educational facilities. These T8 lamps combined with electronic ballasts consume less energy (122 W versus 155-180 W for the T12 lamps with magnetic ballasts), are brighter than T12s (109 decalux for T12s and 158 decalux for T8s), and run cooler (McIlvaine et al. 1994).

This is the concept behind retrofitting the lighting system in portable 035. The 24 fixtures in the with the old magnetic ballasts were replaced with 12 electronic ballasts. The F40CW T12 lamps were then replaced with F32 T8 lamps.

Roofs

The A-frame roofs currently in place consist of gray asphalt shingles over 3/4" plywood decking. One segment is 36' 3" x 11' 9" and the other is 36' 3" x 15' 9". This longer half provides an overhang for a handicap accessible entranceway on the South side of the building. The replacement roof is a reflective white metal roof. We decided to replace the roof because previous research has shown that roof colors significantly impacts space cooling energy use (Givoni 1976). In fact, a white roof has been shown to reduce cooling loads by approximately 13,000 kWh per year (10%) at Our Savior's School (Parker et al. 1996b). Asphalt shingles are known to have poor reflectivity. The reflectivity of gray asphalt shingles is 22%, black asphalt shingles is 5%, but for a white metal roof it is 67% (Anderson et al. 1991, Parker et al. 1993). A white reflective roof can decrease residential cooling requirements by an average of 20% (Parker et al. 1996b).

Heat, Ventilation and Air Conditioning (HVAC)

Both inefficient lighting and roof solar absorptance can significantly increase cooling loads. Generally, HVAC use makes up one-third of a school's energy budget. A poorly sized HVAC - or a poorly maintained system, can lead to major problems with indoor air quality, bacterial contaminants, viruses, mold, spores, and pollen (Brown 1995).

HVAC's are sometimes oversized by contractors in order to avoid future complaints (Vieira et al. 1996). The HVAC currently in place is a Crispaire AVP36HPA 3 ton wall mount unit. It has been replaced by a more efficient Bard WH301-A 2.5-ton wall mount unit. Bard manufacturing has donated the model for our research project.

Results and Discussion

Lighting retrofit

The portable classrooms had the traditional T12 lamps with magnetic ballasts in place. This type of lighting system puts out a great deal of heat and is not as bright as the T8 lamps with electronic ballasts which they were replaced with. The old system also had greater energy consumption than did the new system as seen in Figure 2.

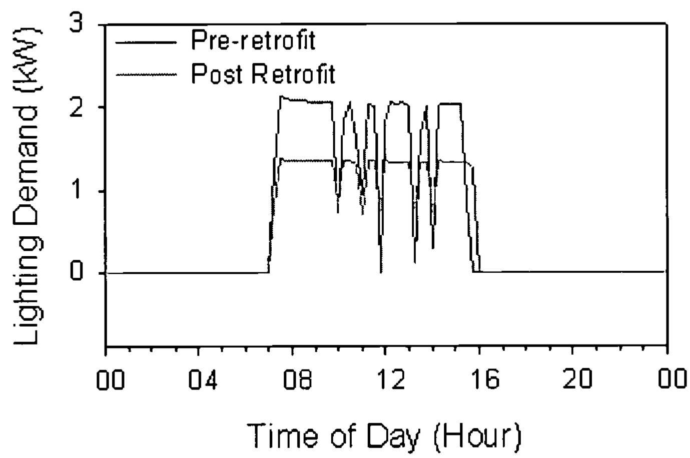

Figure 2. Graph of lighting demand over the course of a day for portable 035. Pre-retrofit average demand is 0.60 kW and post retrofit average demand is 0.45 kW.

The lighting energy comparison pre and post retrofit in Figure 3 highlights the energy savings. The average energy demand on May 20, 1998 prior to the retrofit is 0.60 kW while the average energy demand after the retrofit (May 27, 1998) is 0.45 kW. This represents a energy savings of 25%, which is higher than in previous studies (Sherwin and Parker 1996). This savings is considerable since the data shows that lighting energy for portable 035 is 26% for May 20 while on May 27 the energy use was only 19% of total portable energy use.

Figure 4 is an infrared thermograph of the lighting system at Silver Sands Middle School pre-retrofit. The darker colors represent the cooler areas while the lighter colors represent the hotter areas. It is very easy to see that the lighting fixtures heat up to over 93° F (white).

HVAC System

On June 17th the existing Cripsaire AVP36HPA wall unit was replaced with the new 2.5-ton system with an energy recovery ventilator. It would be premature to attempt to analyze data from the AC retrofit, due to the school year ending before the recent installation. With the end of the school year and the subsequent install, the AC has either been turned off altogether or the schedule has changed significantly. When school resumes in late August and the AC is once again run for most of the day, a savings analysis can be performed. Figures 5 and 6 examine preliminary data for this retrofit. This data has been gathered from two matched days with very similar outdoor temperatures.

It can be seen that the average temperature within the portable post retrofit is very similar to the pre-retrofit temperature, but that the total energy use by the AC system is 2.8 kWhs less (14%), even though the Bard unit is a 2.5-ton unit versus 3 tons for the old unit. Figure 6 also points out that through the hottest part of the day, the demand post retrofit was approximately 500 watts less than pre-retrofit.

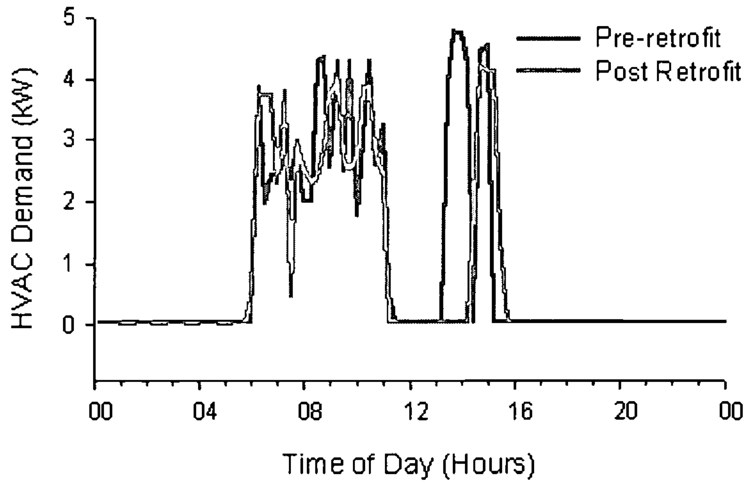

Figure 5. AC energy demand data for two matched days. Pre-retrofit total kWh = 22.4: post retrofit total kWh = 19.6

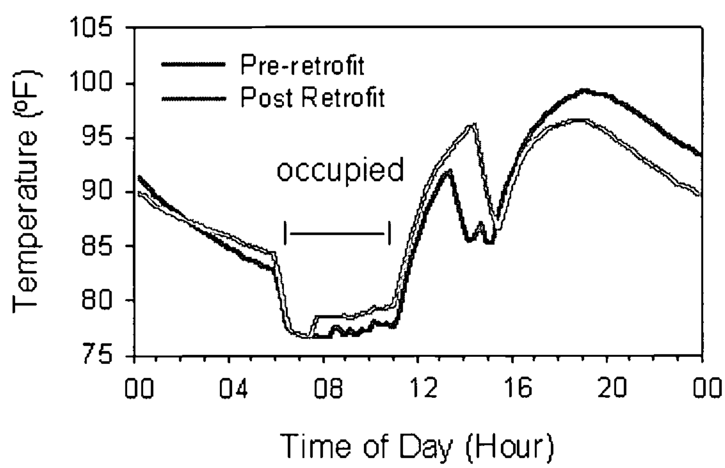

Figure 6. Interior air temperatuers for two matched days. Pre-retrofit average temperature =

88.09: post retrofit average temperature = 88.13

Air side problems of the old system can be observed in Figure 7. The infrared thermograph demonstrates leakage around the connecting of the cooling system supply duct to the conditioned space. The HVAC on portable 035 runs constantly (with a demand consistently over 5 kW per hour for 6-7 hours during the hottest part of the day) but does not effectively pull down the temperatures (75°F to over 80°F during the same time period). Part of this problem is that the portable loses cooling energy because the AC cools the exterior wall of the portable (blue to violet colors).

Roofing system

The old gray asphalt shingle roofing system is scheduled to be replaced by June 30, 1998 so no comparison can be made at this time. However, the current roofing system data is available for analysis.

Figure 8 demonstrates the temperatures associated with portable 035. The roof gets extremely hot reaching temperatures topping 130°F over the course of the day. Figure 9 is a graphical representation of the roof temperatures. While the ambient temperature averages 73.8°F, both the attic air and roof surface temperatures are quite a bit higher (86.02°F and 86.83°F on average respectively) and are much higher during the hottest part of the day (10:00 am - 4:00 pm). This is primarily due to high solar absorptance of the roof. This reduces the efficiency of the HVAC system because the ducts are in the attic and also get very hot. This, in turn, increases the interior temperatures even though the HVAC is continually running. When the roof is replaced with a reflective white metal roof, the differences in temperatures can be completely analyzed.

Schedule

Portable 035 will have all the retrofits installed withing a few weeks. This will allow portable 096 to serve as a control for comparison. Later, portable 096 will have the retrofits installed over time in order to fully observe the individual effects of the changes on energy usage.

- Lighting: the old lighting system (T12 lamps with magnetic ballasts) was replaced with the more efficient system (T8 lamps with electronic balllasts) on May 21, 1998.
- Roofing: the old asphalt shingle roof is scheduled to be replaced by the end of June.
- HVAC: the old HVAC system (Crispaire 3 ton unit) was replaced on June 17, 1998 with a Bard 2½ ton unit.

Conclusions

The Silver Sands Middle School portable classroom project has been underway for approximately one year. We have collected a year of baseline data concerning energy use, weather data, and roof system temperatures for portables 035 and 096. We are in the process of retrofitting portable 035 with more energy efficient measures than are currently in place. The old T12 lamp magnetic ballast lighting system has been replaced with a T8 electronic ballast lighting system and has yielded an energy savings of approximately 25%. The old Crispaire AVP36HPA 3-ton wall unit has been replaced with a more efficient Bard

WH301-A2 2.5-ton wall unit. However, due to the recent replacement no data analysis is available at this time. In addition, the new reflective white metal roof is scheduled to be retrofitted towards the end of June. Results of this work will be reported in Phase VI of our contract with FDOE.

References

Anderson, R. W., D. W. Yarbrough, R. S. Graves, and R. L. Wendt (1991). "Preliminary assessment of radiation control coatings for buildings. Insulation Materials: Testing and Applications, 2d vol., ASTM STP 1116, R. S. Graves and D. C. Wysocki, eds. Philadelphia: American Society for Testing and Materials.

Callahan, M. P., D. S. Parker, W. L. Dutton, and J. E. R. McIlvaine (1997). "Energy Efficiency for Florida Educational Facilities: The 1996 Energy Survey of Florida Schools". FSEC-CR-951-97, Florida Solar Energy Center Cocoa, FL.

Educational Facilities Laboratories (1964). Educational School Facilities. New York: Author (ERIC Document Reproduction Service No. ED 066-846).

The Florida Center of Community Design and Research. (1993, November 16). "The use of relocatible classrooms in the public school districts of Florida." (A research report for the Florida Department of Education, Office of Educational Facilities). Tampa: University of South Florida.

Floyd, D., D. Parker, J. Sherwin, and J. E. R. McIlvaine (1995). "Energy Efficiency Technology Demonstration Project for Florida Educational Facilities: Occupancy Sensor". FSEC-CR-867-95, Florida Solar Energy Center Cocoa, FL.

Givoni, B. (1976). Man, Climate and Architecture. London: Applied Science Publishers Ltd.

McIlvaine, J. E. R., M. Mallette, D. Parker, P. Lapujade, D. Floyd, L. Schrum, and T. Stedman (1994). "Energy Efficiency Design for Florida Educational Facilities". Prepared for the Florida Department of Education, Florida Solar Energy Center Cocoa, FL.

Parker, D. S., J. E. R. McIlvaine, S.F. Barkaszi, and D. J. Beal (1993). "Laboratory Testing of the Reflectance Properties of Roofing Materials". FSEC-CR-670-93, Florida Solar Energy Center, Cape Canaveral, FL.

Parker, D. S., S. F. Barkaszi, Jr, S. Chandra, D. J. Beal (1995). "Measured Cooling Energy Savings from Reflective Roofing Systems in Florida: Field and Laboratory Research Results". FSEC-PF-293-95, Florida Solar Energy Center, Cocoa, FL.

Parker, D. S., L. Schrum, J. K. Sonne, T. C. Stedman (1996a). "Side-by-Side Testing of Commercial Office Lighting Systems: Two-Lamp Fluorescent Fixtures". FSEC-PF-301-96, Florida Solar Energy Center Cocoa, FL.

Parker, D. S., J. R. Sherwin, J. K. Sonne, S. F. Barkaszi, Jr. (1996b). "Demonstration of Cooling Savings From Light Colored Roof Surfacing in Florida Commercial Buildings: Our Savior's School". FSEC-CR-904-96, Florida Solar Energy Center Cocoa, FL.

Rasmussen, E., K. Rasmussen, J. Stanard, S. Bernhard, G. Z. Brown, J. Briscoe, J. Kline, P. Kumar, and Z. Wang (1995). "Design and Evaluation of Energy Efficient Modular Classroom Structures". Modern Building Systems, Inc, Aumsville, OR and University of Oregon, Eugene. OR.

Sherwin, J. R. and D. S. Parker (1996). "FLASTAR: Florida Alliance for Saving Taxes and Energy Resources". FSEC-CR-916-96, Florida Solar Energy Center Cocoa, FL.

Vieira, R. K., D. S. Parker, J. F. Klongerbo, J. K. Sonne, J. E. Cummings (1996). "How Contractors Really Size Air Conditioning Systems". FSEC-PF-289-96, Florida Solar Energy Center, Cocoa, FL.

* Submitted to:

Suzanne Marshall
Florida Department of Education
Office of Educational Facilities
325 W. Gaines St., Rm. 1054
Tallahassee, FL 32399

On-line Publications

NOTICE

REPRODUCTION BASIS

☐ This document is covered by a signed "Reproduction Release (Blanket)" form (on file within the ERIC system), encompassing all or classes of documents from its source organization and, therefore, does not require a "Specific Document" Release form.

☒ This document is Federally-funded, or carries its own permission to reproduce, or is otherwise in the public domain and, therefore, may be reproduced by ERIC without a signed Reproduction Release form (either "Specific Document" or "Blanket").

This document is in the public domain, according to Suzanne Marshall of the Florida Department of Education. Confirmed by telephone in consultation with Michael P. Callahan of the Florida Solar Energy Center, 4 May 1999.