ABSTRACT

According to the Hartford Institute there are about 350,000 churches in the United States (US). Churches generally operate fewer hours per week than commercial or industrial facilities. Congregations are generally small with a median size of 75 with annual budgets of $90,000. About 90% of all American congregations are 350 or less, but 50% of all church participants attend churches larger than 350 attendees. In light of recent increases in energy costs many churches in the US consume significant portions of their operating budgets for lighting, heating and cooling.

Graduate students in the Master of Construction Management program at Western Carolina University in North Carolina performed energy audits of churches during the spring semester of 2013. Eighteen churches were audited. Average energy bills amounted to nearly $20,000 per year per church. Recurring energy wasting issues were noted and categorized.

A list of common, low cost energy conserving strategies was formulated based upon the recurring themes of the audits performed. Inefficient incandescent lighting was still used in twelve of the churches surveyed. Weather stripping and caulking issues were noted in nine churches. Motion sensors for lighting control were recommended for nine churches. Programmable thermostats were recommended for ten churches.

INTRODUCTION

Churches buildings are unique challenges for engineers and architects who design these structures. About half of all church goers attend churches with congregations larger than 350 members. These churches comprise only 10% of the total number of churches (Hartford Institute 2012). This portion of organized religion includes the mega-churches with 2000 or more weekly attendees. Stained glass windows, baptismal fountains, baseball fields and green spaces, specially designed sound systems, and video screens may be found in mega-churches. Design configurations and standards for these larger structures are readily available for review for any congregation which has the cash to build them. Construction costs in the hundreds of millions of dollars (Jabusch,2010) have been reported. These larger churches and mega-churches are generally well staffed and operated. The other 90% of churches with congregations smaller than 350 parishioners must optimize their operations to compete with the mega-churches. Energy consumption expenses are
often a primary cost for many of these churches. The primary objective of this study was to determine the common issues related to energy costs for smaller congregations.

Building a new, energy efficient, sustainable church is logistically easy to do with the oversight of competent engineers and architects, but older, smaller existing churches are often at a disadvantage when in operational competition with newer, better funded congregations. Graduate students in the Building Information Modeling (BIM) class at Western Carolina University in Cullowhee, North Carolina performed energy audits of eighteen churches during the spring semester of 2013. The findings of the audits were reviewed to determine common themes. Lighting, ventilation, and building integrity were identified as the primary categories of consideration related to energy consumption.

LITERATURE REVIEW

There are numerous articles written about energy usage in churches (London Diocese, United States Environmental Protection Agency (USEPA), and the National Religious Partnership for the Environment (NRPE)). These articles provide guidelines for church leaders in various sized churches, different denominations and a variety of weather conditions. There is also literature which provides guidance for church lighting, ventilation loads and church specific energy loads.

Lighting in churches is often used ornamentally and for creating a mood enhancing environment (Lit-up Anglican 2008). Lighting may also be a significant portion of the power bill, especially for small churches. Incandescent lighting fixtures used in conjunction with dimmers as well as ornamental exterior lighting are commonly used to create traditional church environments conducive to worship. Eliminating ornamental lighting, except for special occasions and replacing incandescent lamps with fluorescent lamps (USEPA 2012) are often recommended to reduce power bills. Simpler building designs with natural lighting are cited for mega-church design (Bratton 2012). The cost per square foot for construction may be cheaper and the trend to meeting contemporary social, economic and environmental considerations (Dapto Anglican 2012) may be enhanced.

Church and sanctuary ventilation requirements are generally similar to the requirements for schools and auditoriums. The American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) Standard 62 provides the necessary ventilation rates (ASHRAE 2004). Providing a comfortable environment for parishioners which is energy efficient and quiet can be a challenge for church administrators. Arnold describes retrofitting old church units with more efficient, cheaper to operate systems in an older church (Arnold 2012). The split type, mini-systems he discussed would be acceptable for smaller church classroom applications. Thermostat and computer controls are another area discussed which can save energy and costs (Networked thermostats 2009). Controlling thermostat settings and using computer controls can provide cooling, heating and ventilation when needed. Many churches must operate ventilation units continually (versus as-needed) due to staffing issues and utilization of older technology resulting in increased operating costs.

There is an apparent trend in the literature for traditional churches to address contemporary social, environmental and economic needs (Dapto Anglican 2012).
Church complexes are described as campuses (Bratton, 2012). Youth programs and an emphasis on green programs are discussed in the literature (Daniels, 2012). In short, the diversity of churches’ focus is daunting. Sports fields and courts, baptismal pools, musical equipment, commercial sized kitchens, and stained glass windows are a few of the components required in the modern church to be competitive in an ever increasingly crowded field. Often, church administrators do not know they are impacting their energy bills until after the components are used in practice.

METHODOLOGY

Graduate students in the Master of Construction Management program at Western Carolina University in North Carolina performed energy audits of churches during the spring semester of 2013. Eighteen churches were audited. These churches were primarily located on the eastern coast of the United States, but California, Washington, Michigan, and Nevada were represented. One audit, eliminated from the study was a Muslim mosque located in the Middle East. This house of worship was administered by the state, and energy bills were not available, so comparisons with the other churches in the study were not practicable. One Seventh Day Adventists church and two Catholic churches were included in the study, but the predominant faith represented in the study were protestant churches. The instructions provided to the students were:

1) Look at a church. It may be the church you attend or another public place of worship. It does not matter what the religious affiliation of the institution is, as you will not be concerned with any theological issues. You may need to contact an officer of the church to obtain the necessary information;

2) Write a paper which includes an Introduction, Body, Conclusion and References. Refer to the "Research Paper Instructions" on the Home Page of this course for details regarding page number requirements, font size, and so forth.

In the Introduction, include a description of the structure or structures on the church property (wood, brick, etc.), their oldest and newest ages; the number of members and attendees of the church; the number of church employees; the types of lighting fixtures used; the annual energy costs from the power bills; and the hours of operation. In the body, find at least five sources of information on church construction and/or energy usage no older than 12 years old (Year 2000). Discuss the information you found on church construction and energy usage. The library website provides a search engine (Academic Search) to find recent articles. Include an Excel chart of the monthly energy bills (in dollars and Kw-Hrs) for at least twelve months. Discuss the chart. You might describe the air conditioning units, including their serial and model numbers and whether they are an outside or inside unit. I can help you if you have any HVAC questions. In the Conclusion, discuss recommendations you may (or may not) have for improved energy consumption in the lighting systems or HVAC systems. In a "References" page, list the five or more sources you used above. The information you obtain may be incorporated into a scholarly article that researches energy usage in churches, so make certain that the material you submit is accurate and supportable. If you feel that information obtained from a church should be kept confidential, please make a note of that in your paper or contact me with your concerns. Keep in mind, we do not expect you to be an expert on church construction
or energy usage. Check the research paper instructions on the Home Page. HOW you write will hold more weight than WHAT you write.

This study was intended to answer the following questions: 1) How much money do churches spend annually on energy?; 2) Do churches use fluorescent and compact fluorescent lighting fixtures?; 3) Are heating and cooling costs for churches significant?; 4) Are church buildings well maintained for energy conservation?

Recurring energy issues from each of the students’ reports were noted and categorized. An Excel spreadsheet was generated to assist the authors in identifying and summarizing the recurring themes.

RESULTS

Average energy bills amounted to nearly $20,000 per year per church ranging from $2200 per year to over $50,000 per year. An accurate cost per attendee was not possible from the data collected in this study. Larger churches appeared to use more energy, but may in fact be more energy efficient per attending member in terms of BTUs per person. A minimal electricity bill of $2200 per year appears to be an accurate estimate of energy costs for the smallest protestant churches in the southeast United States, but any detailed conclusions about energy usage are not possible based upon the data collected. Inefficient incandescent lighting was still used in twelve of the churches surveyed. Only one church in the sample was noted as using T-5 fluorescent lamps, five using T-8 lamps and nine using T-12 lamps. Motion sensors for lighting control were recommended for nine churches. Dimmer switches were used in conjunction with incandescent lamps in several local churches where inquiries were made, but this issue was not documented in this study.

The average age of the oldest buildings at each location in the sample was 78 years. Twelve of the 18 churches sampled were noted as needing improvements in their air conditioning systems. Only four of the twelve were noted as using heat pumps which are efficient sources for heating and cooling in the southeast US. Students were tasked with concentrating on electricity bills and generally did not collect other energy source costs, but propane bills were documented to be as high as $63,000 per year in a large North Carolina church, and less than $1000 in a small Michigan church. Programmable thermostats were recommended for ten churches. Heating and cooling costs in churches are significant based upon the electricity bills provided for the study.

Weather stripping and caulking issues were noted in nine churches, especially where large ornamental, stained glass windows were present. Activity buildings were noted at seven church locations in the sample. There appears to be an issue with maintenance in some churches and energy costs for most churches but a universal pattern of poor maintenance was not noted. The authors informally questioned two local church administrators at churches included in the study and two not included, and in all four cases, power expenses were thought to be exceeded only by personnel and staffing costs. A summary table of the research findings are shown below.


<table>
<thead>
<tr>
<th>Questions</th>
<th>Findings</th>
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<tbody>
<tr>
<td>How much money do churches spend annually on energy?</td>
<td>The average energy cost of the churches in this study was $20,000 annually. Cost per capita member was not computed.</td>
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<tr>
<td>Do churches use fluorescent and compact fluorescent lighting fixtures?</td>
<td>Twelve of the eighteen churches used incandescent lamps. Ten churches used T-12 fluorescent lamps. Four used T-8 lamps, and one used T-5 lamps. Motion sensors were recommended for nine churches. Incandescent lamps were used in conjunction with dimmer switches.</td>
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<tr>
<td>Are heating and cooling costs for churches significant?</td>
<td>In twelve of the eighteen churches, cooling was deficient during the warmest months of the year. Programmable thermostats were recommended in ten churches. Heating fuels costs were not separately available from most of the church energy bills. The highest propane bill was $63,000 per year.</td>
</tr>
<tr>
<td>Are church buildings well maintained for energy conservation?</td>
<td>Weather stripping and caulking costs were noted in nine churches.</td>
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**CONCLUSIONS**

A list of common, low cost energy conserving strategies was formulated based upon the recurring themes of the audits performed. The reports indicated an average $2,470 per year could be saved on electricity bills through low cost, no cost system modifications which included: 1) Church leaders should eliminate incandescent lamps in their churches; 2) Windows and doors should be regularly checked to ensure they are sealed; 3) Heat pumps could be installed as a primary cooling and heating source for churches in the southern United States; and 4) Activity buildings and non-worship buildings should be closely monitored to control energy costs.

The use of incandescent lamps was widespread among the churches surveyed. Incandescent bulbs can use as much as five times the energy of fluorescent lamps. High output lamps and fixtures were used in four churches in the sample, mostly in parking lots and activity buildings. Even for these applications, fluorescent lamps could provide adequate light more cheaply.

Two of the churches in the sample were noted to have a large number, twelve or more, stained glass windows in their sanctuaries. In both churches, daylight was visible in most of the joints in most of the windows, indicating deteriorated caulking. One church had covered their stained glass windows with custom made storm windows. While this type of expenditure is not justifiable based upon energy savings, attendees will be more comfortable when the ventilation system is well designed, and doors and windows do not leak conditioned air.
This study will provide church administrators a starting point when considering how to reduce energy bills and realize a cost savings. Additional future church energy studies may be done with construction management graduate students in a more focused manner. Different denominations have different energy use considerations, for instance, due to the number of occupied hours and the time of day of facility use. Churches located in the northern U.S. generally need more heating than churches in the southern U.S., and the reverse is true of air conditioning. A focused study of one denomination and one geographic area will provide better energy savings feedback to church officers.

REFERENCES