DECISION MODEL FOR HIRING ENERGY SPECIALISTS BASED ON NIGHT SETBACK SAVINGS IN EXISTING MEDICAL OUTPATIENT BUILDINGS

By

KRISTIN GRAY

A THESIS PRESENTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE IN BUILDING CONSTRUCTION

UNIVERSITY OF FLORIDA

2010

To my dear parents, Karen and Thomas Gray; my sisters, Kara Noreika and Kaitlin Hecht; and my friends. Without my family's positive support and love this would not have been possible. Without my friend's encouragement and humor I would not have made it through the day-to-day completion of this process.

ACKNOWLEDGMENTS

I would like to thank everyone who helped me complete my thesis. First, I would like to thank my committee chairman, Dr. Charles Kibert for his continuing support throughout my college career and for the opportunity to become involved in sustainable construction. I would also like to thank my cochairman, Dr. Jim Sullivan for his guidance and positive encouragement throughout this process. Without his guidance on the smallest of issues this would not have been possible. And finally thank you to my members Dr. Paul Oppenheim, his sharp eye and knowledge helped smooth the process, and Sanjyot Bhusari, who took the time out of his workday to answer the simplest of questions.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Abstract of Thesis Presented to the Graduate School
of the University of Florida in Partial Fulfillment of the
Requirements for the Master of Science in Building Construction

DECISION MODEL FOR HIRING ENERGY SPECIALISTS BASED ON NIGHT SETBACK SAVINGS IN EXISTING MEDICAL OUTPATIENT BUILDINGS

By

Kristin Gray

August 2010

Chair: Charles Kibert
Cochair: James Sullivan
Major: Building Construction

Health Care Campuses consume a vast amount of energy. While hospitals are the typical concern for owners, outpatient facilities consume a good amount of energy as well. Building automation systems allow for energy savings strategies to be implemented. This research will focus on the application of a building automation system energy savings strategy, night setback, to an outpatient medical facility. The savings exhibited from this application on one building are extrapolated to other outpatient buildings. These savings are leveraged to provide the amount of energy savings needed to justify hiring an energy specialist that can save up to 40% on total campus energy.

This research provides a decision model for owners wanting to save energy on health care campuses that have little information or knowledge regarding building automation for heating, ventilation, and air conditioning systems. Using a simple calculator requiring minimal input, the owner can determine how many months it will take to payback any initial investment to implement night setback as well as the number of hours this strategy can sustain when applied to one or multiple buildings.

CHAPTER 1
INTRODUCTION

Introduction

Health care facilities are one of the most complicated buildings to plan and construct. There are many obstacles faced including, matching the importance of patient care with the highest level of technology at an affordable cost. Building Automation Systems (BAS) have become the forefront with the ability to monitor the building performance remotely and minimize disturbances to patient care. As the construction industry continues to embrace high-performance building, BAS is becoming a major concern for their projects. If not properly planned and implemented construction managers can be delayed, owners can lose out on energy savings, and more work can be created for maintenance staff.

Problem Statement

With high-performance building increasing in demand the use of building automation systems (BAS) has grown. The rapid rate of growth has not allotted for optimal implementation of the systems in buildings, especially for large campuses. One of the benefits of a high-performance building with a BAS is energy savings. Currently, institutions are facing difficulties with properly implementing energy efficient technologies in their buildings due to staff members being overwhelmed with constant maintenance issues. Many owners and operators want to optimize their energy use but are unsure as to what modifications or adjustments they should make to their building systems; lighting, HVAC, and equipment, and what savings can be exhibited. Using the Shands Florida Surgical Centers method for night setback and applying it to other similar existing outpatient facilities, the amount of energy savings from implementation can justify hiring an energy specialist.

Research Objectives

The objective of this research is to create a decision model and method for owners to decide whether they can or should hire an energy specialist with little information. Using the night setback strategy as a basis for energy savings to be applied to supporting an energy specialist's salary.   A worksheet for cursory calculations and an owner decision model is to be created.

Significance of the Study

Currently, there is insufficient knowledge as to the energy and money saving possibilities in system monitoring through building automation. This study analyzes the Shands Florida Surgical Center to present the energy savings due to implementation of night setback energy savings strategy.

Limitations of the Study

The limitation exhibited in this study is a lack of detailed information regarding the building design and equipment for the case study building, the Florida Surgical Center. In addition the application of these savings to other buildings is a rough estimate and lacks concise numbers to be fully relied upon.

CHAPTER 2
LITERATURE REVIEW

Introduction

Health care facilities are increasing their demands for improved patient care. A large portion of the difficulties faced in providing high quality patient care is the ability of the heating, ventilation, and air conditioning systems (HVAC) to provide consistent and quality supply. The most recent trend is increased controls for HVAC systems and incorporating them into full building automation systems (BAS) that allow the documentation and control of the entire facility. The request for high-performance buildings by many owners has increased the use of BAS. The HVAC system is monitored by various devices to ensure that the equipment is performing at the desired level and then detects potential equipment failure. This is important in ensuring the quality patient care desired as these silent alarms allow for equipment to be fixed prior to breakdown, eliminating the lag time to order parts and repair.

Currently owners do not utilize these controls to optimize energy. Energy consumption is a growing issue and health care campuses consume a vast quantity of energy. This issue needs to be applied to existing buildings not just new buildings. But some existing buildings do not have controls and will have to install them. In any case it all starts with the design and construction process and in this analysis and with further exploration it will be determined which part of the process will be ideal for making these decisions.

This chapter discusses the guidelines that determine the building and HVAC system design, high performance building, energy, building automation systems, the construction design process, and facility operations.

Guidelines

Heating, Ventilation, and Air Conditioning (HVAC) systems have a wide variety of guidelines for specified system uses. For example one priority of hospitals is to have good indoor air quality due to the volatile nature of the patients. There are numerous guidelines to ensure quality in HVAC systems, these details can be found in the following paragraphs. A list of all the guidelines that should be considered when designing a cost-effective system will be created.

American Society Heating Refrigerating and Air-Conditioning Engineers Standard

The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) is an international organization of over fifty thousand individuals and was started in 1894. Their mission is to advance the arts and sciences of HVAC to serve humanity while promoting a sustainable world through research, standards writing, publishing, and continuing education. Their focus is in the area of HVAC systems and they have developed standards required by many LEED Credits to be followed. These standards include ANSI/ASHRAE standard 52.2-1999, ASHRAE standard 55-2004, ASHRAE standard 62.1-2004, and ANSI/ASHRAE/IESNA 90.1-2004. In addition, ASHRAE Energy Audit (ASHRAE 2010).

ASHRAE standard 52.2-1999

This ASHRAE standard, “Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size”, measures air filter efficiency to determine how well the filter restricts airborne particles. Particles typically range in size from 0.3 to 10 microns in diameter. These sizes are then categorized into twelve ranges that help to determine a filter’s MERV. MERV is a numerical method of rating filters based on minimum particle size efficiency (ASHRAE 1999).

ASHRAE standard 55-2004

This standard, “Thermal Comfort Conditions for Human Occupancy”, should be followed to meet a minimum of 80% of the total occupants comfort level. The requirements are as follows (ASHRAE 2004):

- Humidity levels should be able to maintain a humidity ratio at or below 0.012, which corresponds to a water vapor pressure of 1.910 kPA (0.277 psi) at standard pressure or a dew-point temperature of 16.8^{o} C (62.2^{o} F).
- The upper reference point of air speed is 40 feet per minute (fpm) it may be used to offset an increase in the air temperature and the mean radiant temperature, but not by more than 5.4^{o}F above the values for the comfort zone without elevated air speed. This means that the required air speed may not be higher than 160 fpm.

ASHRAE standard 62.1-2007

The ASHRAE Standard 62.1-2007, “Ventilation for Acceptable IAQ” provides acceptable ventilation rates and indoor air quality to occupants to minimize health risks. More specifically it provides allowable ventilation based on occupancy. Pollutant emissions from materials and elements inside the building, such as paints and flooring, are also taken into consideration. Table 2-1 provides the minimum cubic feet per minute per person and maximum density per 1000 square feet that is recommended for spaces (ASHRAE 2004).

Table 2-1. Minimum ventilation rate for maximum person density

Spaces	Minimum cfm/person	Maximum person density/1000 ft^{s}
Nonsmoking		
Offices	20	7
Lobbies	15	30
Smoking Lounges	60	70
Classrooms	15	50
Laboratories	20	30

These values will determine the size of the HVAC system and the amount of air that will have to be distributed to the specified spaces.

ASHRAE standard 90.1-2004

ANSI/ASHRAE/IESNA 90.1-2004 “Energy Standard for Buildings Except Low-Rise Residential Buildings” is unique in that it was formulated under the American National Standards Institute (ANSI) consensus process and the Illuminating Engineering Society of North America (IESNA) decided to be a joint sponsor of the standard. Minimum requirements were established for energy-efficient design of buildings. The design must address the building envelope, HVAC, service water hearing, power, lighting, and other equipment (ASHRAE 2008). Section 6: HVAC is of interest for this study and only the topics that are directly related to existing buildings and controls will be expanded upon.

Section 6 with regards to ASHRAE 90.1-2004 states that:

- Section 6.1.1.2 Additions to Existing Buildings – this section states that if an addition is done section 6.2 must be followed for new equipment. If the existing equipment is going to be used then that section does not have to be followed.

- Section 6.1.1.3 Alternations to Heating, Ventilation, and Air Conditioning in Existing Building – New equipment should comply with minimum efficiency requirements applicable to that equipment. Alterations to existing systems shall not decrease the economizers’ capability unless the system complies with 6.51. Compliance is not required for equipment not being replaced that modifications do not increase annual energy consumption, make sure replacements to equipment parts match up, a refrigerant change, equipment relocation, or for ducts and pipes that have insufficient space to meet these requirements.

- Section 6.4.1 - must include minimum efficiency requirements, 6.4.2 - load calculation requirements; 6.4.3 - controls requirements (Appendix A); 6.4.4 - HVAC System Construction and Insulation requirements; and 6.4.5 - completion requirements.

- The minimum system component efficiency requirements listed in Table 6.8.1A-G must be met.

- Section 6.5 provides a prescriptive compliance option. Prescriptive provisions are included for air and water economizers (6.5.1); simultaneous heating and cooling limitations (6.5.2); air system design and control including fan power limitation and variable speed drive control (6.5.3); hydronic system design and control including variable flow pumping (6.5.4); heat rejection equipment (6.5.5); energy recovery from exhaust air and service water heating systems (6.5.6); kitchen and fume exhaust hoods (6.5.7); radiant heating systems (6.5.8); and hot gas bypass limitations (6.5.9).

ANSI/ASHRAE/ASHE standard 170-2008

This standard, “Ventilation for Health Care Facilities”, provides design and alteration standards for ventilation in a health care facility space. The purpose being to reduce infection of patients, health care workers, and visitors from normal respiration of particles in the air. When making adjustments to HVAC equipment in an existing building it must meet the requirements for systems and equipment. If there are alterations to spaces, filter and space ventilation requirements should be followed. The filter requirements for most rooms are MERV 7 for filter bank 1 and MERV 14 for Filter bank 2 the exception being the protective environment rooms requiring bank 2 to be 17(HEPA) and for an administrative out outpatient spaces do not require a second bank filter. Space ventilation and design requirements are also listed. For example, class B and C operating rooms must have airflow of 25 to 35 cfm/ft^2, positive pressure, minimum outdoor ach of 4, minimum total ach of 20, relative humidity between 30 and 60%, and the design temperature should be between 68 and 75 degrees Fahrenheit (ASHRAE 2008).

ANSI/ASHRAE standard 135-2008

This standard, “BACnet A Data Communication Protocol for Building Automation and Control Networks”, was developed to improve the building automation industry. ASHRAE got a committee together as the Standing Standard Project Committee number 135 and created the BACnet protocol for building automation. This will be discussed in further detail under the Building Automation section.

ASHRAE energy audit

The ASHRAE Energy Audit is a way for commercial facilities to analyze their current energy use and the auditor provides suggestions for low cost options or capital investment options. There are three levels to the energy audit and they are as follows (ASHRAE 2010):

- Preliminary Energy Use Analysis – this first critical step is to analyze the facility's historical energy use, benchmarking the building using the EPA's Energy Star Portfolio Manager, and performing a utility rate analysis to pinpoint any cost savings opportunities.
- Level I – Walk Through Analysis: This level focuses on low cost to no cost energy conservation measures. It also provides a list of high energy saving measures.
- Level II – Energy Survey and Analysis: This level provides a more detailed building survey and energy analysis. Details will be provided on what options can be done and the implementation and operating costs with potential savings. It is mostly in regards to operations and maintenance procedures.
- Level III – Detailed Analysis of Capital-Intensive Modifications: This is another expansion on Level II which takes the analysis further and provides more details on the energy analysis. The typical suggestions for this level require more capital costs and may be installing new systems instead of making modifications to existing systems.

Sheet Metal and Air Conditioning Contractors' National Association Standard

The Sheet Metal and Air Conditioning Contractor's National Association Standard is headquartered outside Washington, D.C. is an international association of union contractors. Currently there are approximately 1,944 members in 98 chapters throughout the United States, Canada, Australia, and Brazil. They produce voluntary technical standards and manuals that address all facets of the sheet metal industry. These standards cover everything from duct construction and installation to air pollution control (SMACNA 2010).

SMACNA plan. The SMACNA IAQ Guide for during construction states that during construction these guidelines must be followed:

- HVAC Protection: All ductwork should be protected with a plastic cover over duct opening, use MERV 8 filters during construction, and clean the ducts. This is to protect the ductwork from debris and contaminants.
- Source Control: Avoid using harmful or toxic materials.
- Pathway Disruption: When working with materials that contain Volatile Organic Compounds (VOCs) either ventilate with outside air or seal off area to prevent spread.
- Housekeeping: Prevent and remove any dust or debris from the site, keep site clean, clean spills, and remove standing water.

The SMACNA guide is recommended for use in LEED projects. To reach these goals the SMACNA standard employs the following guidelines (SMACNA 1995): ventilation guidelines of ASHRAE 62-1999 should be followed, building surfaces and mechanical equipment should be kept in a sanitary state, separate potentially contaminated areas from occupied spaces, control major contamination sources, minimize hazards to occupants when construction, operating, and maintaining the project, and finally provide an IAQ plan that occupants accept.

United States Environmental Protection Agency Standard

The United States Environmental Protection Agency (USEPA) was formed in the brink of a U.S. energy crisis in December 1970. Their goal was to protect human health and to safeguard the natural environment including air, water and land. They planned to consolidate into one agency a combination of federal research, monitoring, and standard setting and enforcement activities to ensure proper protection of our environment. For almost 40 years now the USEPA has been working toward a cleaner, healthier environment for America (USEPA 2010).

Energy star. The Energy Star program was a joint venture between the USEPA and the US Department of Energy (DOE). Their goal was to help America save money while protecting our environment through energy efficient products and practices. In 2009 it was reported that enough energy was saved to reduce utility bills by nearly $17 billion for all of the US.

Figure 2-1 provides an outline of the Energy Star process for a healthcare facility. The Energy Star Challenge is a way to spark owners to set the goal of improving energy

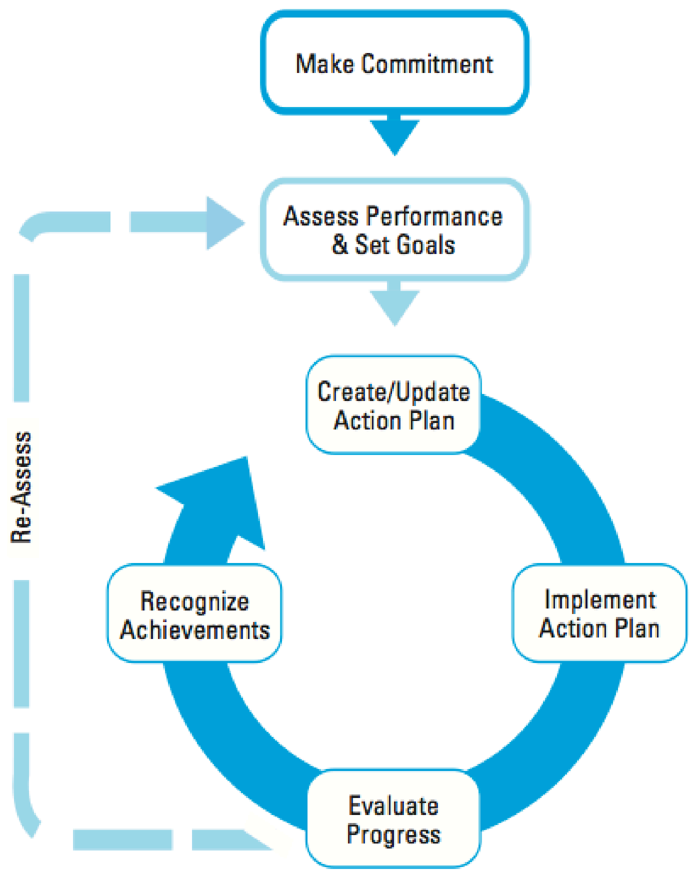


Figure 2-1. Energy Star guidelines (Source: USEPA)

usage by 10% as a starting benchmark. To do that they must assess current building performance, create an action plan, implement the plan, and evaluate the progress. Evaluating progress is important to the whole process as it encourages the owners to keep energy data from different aspects of the hospital throughout the years. This allows for trends to be noted and further adjustments made to increase energy savings over time.

Energy savings can not only benefit the owners pocket but for the hospital as a whole Energy Star (2009) reports that each dollar a healthcare facility saves is the equivalent of $20 of revenue earned. Utilizing Energy Stars portfolio manager allows for owners to see what their energy rating is from 1 to 100. A facility can be given the Energy Star label if it performs at the top 25% of performance ratings nationally.

Efficiency Valuation Organization (EVO)

Currently, the Efficiency Valuation Organization (EVO) is the only non-profit organization in the word that is solely dedicated to creating measurement and verification tools to promote efficiency. It began in 1994 when members of the US Department of Energy and Lawrence Berkeley National Laboratory worked together to establish an international consensus on methods to determine energy/water efficiency savings. The original publication in 1996 was named the North American Energy Measurement and Verification protocol (NEMVP) and was later updated in 1997 and renamed to the International Performance Measurement and Verification Protocol (IPMVP). The most recent edition was published in 2001 (EVO 2010).

International Performance Measurement and Verification Protocol (IPMVP). Volume III, Concepts and Practices for Energy Savings in New Construction was developed by EVO to provide succinct descriptions of the best practices techniques for verifying the energy performance of new construction projects. EVO specifies a list of benefits or “motivations” for using the International Performance Measurement and Verification Protocol (IPMVP) Volume III and they are as follows (EVO 2007):

- **Increase energy savings** - Accurate determination of savings gives facility owners and manager valuable feedback on the operation of their facility, allowing them to adjust facility management to deliver higher levels of energy savings, greater persistence of savings and reduced variability of savings.

- **Operations and Maintenance Troubleshooting –** M&V provides performance feedback, which can facilitate operations and maintenance troubleshooting. This is particularly valuable during the first year or two of operation of a new building.

- **Performance Contracting –** Although performance-contracting activity in new construction has been limited to date, in principle there is no reason why performance contract models cannot be adapted to new construction. While M&V is a key aspect of performance contracting in and of itself, greater experience with M&V in new construction in all contexts will provide a basis for increased knowledge of building performance and greater confidence in savings projections. This in turn will lead to lower perceived risk and greater acceptance of performance contracting in new construction.

- **Encourage better project engineering –** M&V is the major validation vehicle for energy efficient design strategies at the component and at the whole building level.

- **Help demonstrate and capture the value of reduced emissions from energy efficiency and renewable energy investments –** In addition to energy cost and resource consumption, emissions reduction is emerging as a new and important "currency" in the assessment of energy saving and environmental initiatives. New construction M&V provides a basis for determining emissions reductions and improvements in air quality associated with reduced energy consumption.

- **Help national and industry organizations promote and achieve resource efficiency and environmental objectives –** The IPMVP is being widely adopted by national and regional government agencies and by industry trade organizations to help increase investment in energy efficiency and achieve environmental and health benefits in a retrofit context. Similar benefits can be realized through M&V in new construction.

Measurement and Verification allows for energy savings in new construction to be determined by comparing the measured baseline energy to the post construction energy use.

Energy Savings = Projected Baseline Energy Use – Post-Construction Energy Use

While the Florida Surgical Center was a new project it was also a design-build project, meaning many of the HVAC features were not installed or properly programmed. For the purpose of the changes made to this project the equation that will be used to determine energy savings is:

Energy Savings = Baseline Energy Use – Post-Retrofit Energy Use Adjustments

To utilize this standard a M&V plan must be created and it must follow these specified requirements (EVO 2007):

- Documentation design intent of energy performance strategies.
- M&V objectives and description of the project context e.g. performance contract, incentive-based design fees, etc.
- Technical identification of the boundaries of savings determination e.g. piece of equipment, system, or whole building. The nature of any energy effects beyond the boundaries may be described and their possible impacts estimated.
- Clear statement describing M&V period. Documentation and specification of the baseline including a listing of all important assumptions and supporting rationale
- References to relevant sections of any energy efficiency standard or guide used in setting the baseline.
- Specification of the set of conditions used for weather adjustments, including the period and/or weather data used, and any assumptions or interpolations made in the case of missing or incomplete data.
- Expected overall M&V accuracy and anticipated areas of error susceptibility and magnitude of the sensitivity.
- Description of Quality Assurance procedures.
- Specification for reporting format of the results.
- Specification of the information and data that will be available for third party verification, if required.
- Budget and resources for the entire M&V program, including long-term costs, broken out into major categories.

According to Volume I of this plan Option B will be used to determine the changes made to a retrofit, which uses the formula previously listed.

ANSI/TIA/EIA – 862

This ANSI/TIA/EIA standard, “Building Automation Cabling Standard for Commercial Buildings” provides details on planning and installation of a structured system for BAS applications used in new and existing commercial buildings and campuses. It provides performance, topology, and technical criteria on different cabling systems to be able to connect BAS equipment (Knisley 2003).

Engineering Equipment Manufacturers and Users Association Publication 191

The EEMUA is a non-profit organization that helps companies that own or operate industrial facilities. They do this by providing best practices for various aspects of the industry, which helps to improve the environment, safety, and operating performance of industrial facilities while keeping costs low.

Their Publication 191 “Alarm Systems – A guide to Design, Management and Procurement” provides recommendations for more efficient alarm management. It stresses that the most important characteristic of a good alarm system design is the operator response. Some principles that should be followed include: focus operator attention on the most important alarms, there should be clear and understandable alarm messages, provide recommended corrective action with a space for comments for future alarms, lock all alarms from a field device, and finally analyze the alarm system to identify any problem alarms or to determine where more training is needed (Goble et al. 2007).

In Table 2-2 standards relating to high performance building and HVAC systems are compiled and categorized by areas they cover.

Building Codes

A building code is defined as “a set of standards established and enforced by local

Table 2-2. List of guidelines for high performance building and HVAC

Standard	Ventilation	Indoor Air Quality	System Control	Comfort	Energy Efficiency	Measurement & Verification	Health Care Specific
ASHRAE 52.2-1999	X	X					
ASHRAE 55-2004				X			
ASHRAE 62.1-2007	X	X					
ANSI/ASHRAEIESNA 90.1-2004	X	X	X	X	X		
ANSI/ASHRAE Standard 135-2008			X				
ASHRAE/ASHE 170-2008	X						X
ASHRAE Energy Audit					X		
SMACNA Plan		X					
ENERGY STAR					X		X
IPMVP					X	X	
ANSI/TIA/EIA - 862			X				
EEMUA Publication 191			X				

government for the structural safety of buildings” (Webster’s 2010). Building Codes in the United States date back to the early 1900s with the sudden urge for a standard for constructing buildings. In 1915, after code enforcement officials met to discuss the issue, the Building Officials and Code Administrators (BOCA) International, Inc. was formed. The organization represented code officials from eastern and mid-western portions of the United States. Soon after two more organizations were formed; the International Conference of Building Officials (ICBO) in 1922 and represented the western states and the Southern Building Code Congress International (SBCCI) in 1941 and represented the southern states (Alachua County Growth Management 2010).

International code council

The three organizations, BOCA, ICBO, and SBCCI, came together to form the International Code Council (ICC) in 1994. The non-profit organization was “dedicated to developing a single set of comprehensive and coordinated national model construction codes". These codes no longer had regional limitations but were codes that could and should be followed by all of the United States (ICC 2010). Now there are almost 13 different International Codes produced by the ICC.

Florida building code

Many years later, the State of Florida mandated building codes during one of the construction booms in the 1970s. It was required that all municipalities and counties adopted and enforced one of the four model codes. These were the state minimum codes. In the 1990s a series of natural disasters occurred, including Hurricane Andrew in 1991, which proved that the building codes were not being strictly enforced throughout the sate. In response to this situation, the Florida Building Commission developed a single statewide-unified code. On March 1, 2002 the Florida Building Code (FBC) became effective and superseded all local codes. It is the only code now to be followed in the state of Florida (Alachua County Growth Management 2010).

Energy efficiency

The FBC now has regulations for energy efficiency and is directly related to HVAC systems. Section 13-407.AB.2 Controls explicitly states the requirements for Florida commercial building compliance methods. This portion of the code states the regulations for HVAC controls such as: zone, temperature, humidity, off-hour controls and many more, which can be seen in Appendix A (Florida Building Code 2004).

University of Florida Building Requirements

The University of Florida (UF) has known building requirements not only for aesthetic purposes but also for functional purposes. For example they have their own Building Automation System Guide Specification to ensure that all buildings can properly communicate with the EBMS. While Shands is affiliated with UF they do not follow their building codes. Shands specifications are typically job specific and comply with AIA.

American Institute of Architects Specifications

The American Institute of Architects (AIA) provides specification outlines for architects to use when determining different specifications for project use. These are the specifications that contractors follow in the building process as part of the contract documents. These are the same specifications that Shands follows for their buildings and are also project specific.

American Hospital Association

The American Hospital Association (AHA) was founded in 1898 that provides education for leaders in healthcare and is a premier resource for information on issues and trends in health care. AHA has grown into an association of over 5,000 hospitals and 37,000 individuals. The association aims to ensure that the perspectives and needs of their members are heard and addressed in national health policy legislative and judicial matters. For a hospital to become a member of this association any institution that is classified as a hospital and is accredited as a hospital by the Joint Commission on Accreditation of Healthcare Organizations or is certified as a provide of acute services. Instead of certification or accreditations an institution that is licensed as a hospital by the appropriate state agency may be registered as a hospital by meeting the following:

- There shall be at least six inpatient beds that are continuously available for patient care who are nonrelated and stay on average in excess of 24 hours per admission
- It shall be clean, uncrowded, safe, and built and maintained with health in mind.

- It must have an identifiable governing authority morally and legally in charge of hospital conduct.
- There must be a chief executive who is responsible for the operation of the hospital in accordance with the established policy.
- An organized medical staff or fully licensed physicians that must provide patient services independently in the hospital. The staff should be accountable and provide proper medical care to patients.
- Admission must be done by a member of the medical staff and evaluated or by non-physicians but they should find prompt medical attention for them.
- Nurse services are continuous
- Complete records of all patients should be kept and available for reference
- There shall be a pharmacy with a registered pharmacist
- Patients should receive food services to meet their nutritional needs.

If all of these requirements are met then the hospital will fall into one of four different classifications: general, special, rehabilitation and chronic disease, and psychiatric (AHA 2010).

American Society for Healthcare Engineering

The American Society for Healthcare Engineer (ASHE) is an advocacy association looking out for the needs and ideas of professionals in healthcare engineering. While they work similarly to AHA they also work with other industry members to gather information on new issues. More recently they are conducting an energy survey regarding hospitals and outpatient facilities to determine their energy use and hope to devise ways to save energy in the future (ASHE.org 2010).

Agency for Health Care Administration

The Agency for Health Care Administration (AHCA) was created by Chapter 20 of the Florida Statute as head health policy and planning entity for the state. AHCA is responsible for $18 billion in Medicaid for over 2.7 million Floridians, licensing of over 41,000 health care facilities, and for health care data. Besides some of their design criteria for existing buildings AHCA perform a survey with their engineers on the HVAC systems. They look at the following three areas air handing unit preventative maintenance, moisture issues, and condensation in occupied spaces.

Air Handling Unit Preventative Maintenance (PM) addresses whether the PM plan is documented with logs for equipment cleaning and filter exchange. It also addresses when staff performs cleaning are their proper safety procedures and are they documented and practiced.

Moisture Issues in Air Handling Units addresses whether there is overflowing or leaking water in the drain pans and if so they should be maintained for drainage. Determine if there is any bio-film in drain pans or on other wet surface, if so they should be physically removed and disinfected with the unit off. PM plan should be updated to fix the issue. Finally, it addresses if there are seriously damp porous materials on filters and that the staff should replace and document that the cause was eliminated.

Condensation in Occupied Spaces covers issues with condensation and dampness. When the system is in cooling mode are there signs of condensation or dampness on the surface of outside walls if so observe overcooling, negative pressure, and impermeable wall coverings. Or is there condensation and dampness on the chilled water pipes or surfaces like supply air vent louvers if so observe poorly insulated chilled water pipes and supply air directed on overcooled surfaces. Finally in heating mode can condensation or dampness be seen on outside walls, if so observe poor insulation, thermal bridges, and ventilation to perimeter areas.

These surveys are done to ensure that systems are running properly as the health of the HVAC system is important to the health of the patients. Any issues exhibited will have to be fixed whether through additional parts, insulation, or program changes (AHCA 2010).

High Performance Building

High-performance building, or green building, is a growing industry that requires numerous standards to ensure that the building performs to the specified level. These standards are in addition to traditional codes. A common name for these standards is rating systems. Currently, there are quite a few different rating systems including, but not limited to: Green Star, BREEAM, Green Globes, GGHC and LEED. The following paragraphs will discuss Green Globes, GGHC and LEED in further detail. While the Florida Surgical Center did not use any of the rating systems for certification they were used for a basis of design.

Green Globes

Green Globes is a rating system that started in Canada and is based off of the Building Research Establishment Environmental Assessment Method (BREEAM), which dealt with existing buildings. It was published in 1996 by Canada's Standards Association and is now available in the United States. In the U.S. the Green Building Initiative (GBI) owns and operates their Green Globes. It has a similar rating system to LEED but the differences are that there is verification by a third party, owners can compare buildings in their portfolio, and most importantly it supports integrated design. The Florida Surgical Center (FSC) did not take this approach as patient care is their priority not certification levels.

Green Guide for Hospitals

The American Society of Healthcare Engineering (ASHE) began the health care "sustainable design tools with the *Green Healthcare Construction Guidance Statement"* in January 2002. An independent steering committee started to develop the *Green Guide for Health Care* early in 2003 and finished version 1.0 in December for public comment. Since then adjustments have been made and the last version released was Version 2.2 in January 2007 making it a full-fledged registration and certification program, it is no longer in the pilot stages (Frumpkin 2007).

The USGBC's LEED structure was borrowed for the use of the Green Guide. They took the basic structure that is well recognized and adjusted it to fit the needs of health care facilities. Due to the sensitive nature of hospitals they have significantly different requirements in their building codes than any other building type. Which is why this Green Guide has changed the face of sustainable construction in the health care industry. This was still a fairly new rating system when FSC was designed.

Leadership in Energy and Environmental Design (USGBC)

The United States Green Building Council (USGBC) was started in 1993 by David Gottfriend, Rick Fedrizzi, and Mike Italiano. They had a vision of changing the relationship between the construction industry and living systems. This non-profit organization then created the rating system Leadership in Energy and Environmental Design (LEED) in 1998. The USGBC is committee-based, member-driven, and consensus-focused. It started as a simple rating system with the intent to "foster greater economic vitality and environmental health at lower costs". The USGBC does this by bridging the "ideological gaps between industry segments" and by developing "balanced policies that benefit the entire industry" (USGBC 2009). Now it is internationally recognized and has grown to 79 chapters, over 31,000 registered and certified buildings, and over 62,000 LEED Accredited Professionals.

Leadership in Energy and Environmental Design – New Construction (NC)

In October 2005, the USGBC released LEED version 2.2 for New Construction. Throughout the previous years there have been numerous changes to the criteria but the biggest change came in 2009 with the release of LEED v3. For the purpose of this study LEED v2.2 will be referenced for their high-performance standards. This rating system has total possible points of 69. Certified is 26-32 points, Silver is 33-38 points, Gold is 39-51, and Platinum is 52-69 points. Since then they have developed a new version called LEED v3 2009.

New health care facilities that wished to participate in this rating system had to follow LEED New Construction (NC) standards. The timing of the project registration and start determine which version can be used. For any project to pursue this rating system it must be able to meet all seven of the prerequisites dictated by LEED. If these are met then the project can continue with the LEED process. LEED has specific categories for Energy and Atmosphere as well as Indoor Environmental Quality, which are pertinent to the buildings HVAC performance. The criteria listed under these two categories can be used as a basis of design for a high-performance building.

In addition, “BAS technologies can be applied to approximately 40% of the criteria” (Herrmann 2005). The use of a building automation system when following a high-performance building standard has not been directly addressed. “BAS can be an effective tool in obtaining LEED points and allowing the owner/operator to better maintain the facility”. While New Construction design standards are important this study will focus on existing buildings.

Leadership in Energy and Environmental Design – Existing Buildings (EB)

LEED for Existing Buildings (EB) recently came out with a new version, LEED 2009 for Existing Buildings: Operations and Maintenance that was launched in April of 2009. This rating system can be used as a basis for changes from an existing building to a high-performance building. The intent of this process is to "promote high-performance, healthful, durable, affordable, and environmentally sound practices in existing buildings". This rating system requires that changes be made to most of the building floor area but for the purpose of this study the focus will be on the ideology of Energy and Atmosphere and Indoor Environmental Quality (USGBC 2009).

Energy and Atmosphere

Energy and Atmosphere is an important topic as it addresses the significance of energy efficiency. To determine what currently exists in the building and to ensure proper strategies are maintained for the future the current sequence of operations should be documented. Then a building operating plan should be created that addresses: occupancy schedule, equipment run-time schedule, design set points for all HVAC equipment, and lighting levels. Then a preventative maintenance plan should be created to ensure the system runs properly. Finally, an energy audit should be conducted that meets the requirements of the ASHRAE LEVEL I walk-through assessment.

Commissioning

There are three parts to the commissioning process for an existing building. They are described as follows:

- **Investigation and Analysis** – This can be done by either developing an appropriate commissioning plan, analyze the plan, document the breakdown of energy use, list problems that affect occupants comfort levels and provide solutions, and provide cost-effective energy savings and document the cost-benefit analysis of each. Or an ASHRAE Level II, Energy Survey and Analysis, Energy Audit, document the break down to energy use, perform a savings and cost analysis, and provide cost-effective energy savings and document the cost-benefit analysis of each.

- **Implementation** – Implement no or low cost operational improvements, provide training for maintenance staff making them aware of high-performance building operations, demonstrate financial costs and benefits of measure that have been implemented, and update the building operation plan to reflect changes made to occupancy schedule, equipment run-time schedule, design set points and lighting levels.

- **Ongoing Commissioning** – implement an ongoing commissioning program, create a written plan for the overall commissioning cycle for the building, complete at least half the scope of work in the first commissioning cycle, and update the building operating plan as necessary.

The commissioning practices for an existing building is a bit different than for new construction in that the current building issues need to be addressed. Then a plan must be created and finally implemented. This is a good process for keeping proper documentation of the process for application to future buildings.

Performance measurement

In order to measure performance for a building there must first be a building automation system (BAS) for the building that monitors and controls major building systems. The system then must be used to acquire energy data that will help to identify opportunities for energy savings. To do this a breakdown of energy usage in the building must be documented through energy bills or metering. Based on this breakdown employ system-level metering covering at least 40 or 80% of the total expected annual energy consumption. It should also address one to two of the large energy consumption categories and be covered by 80%. This provides initial energy issues and the savings created by system-level metering.

Energy performance

To ensure a minimum energy performance is met the use of the Energy Star Rating system, previously discussed, can be used. A minimum performance rating of 69 must be met and energy meters must be certified and data collected for 12 months. To optimize energy performance for a project a minimum performance rating of 71 must be met. Additional credit can be given for each point above the performance rating of this high-performance building.

Comparison to LEED NC

LEED NC addresses enhanced refrigerant management, onsite and offsite renewable energy and will not be further discussed as LEED EB addresses these issues similarly. The topics discussed under this category displays the differences from LEED NC. Also LEED EB addresses Emissions Reduction Reporting that is not addressed in LEED NC. Indentifying building performance parameters that reduce energy use and emissions, track and record emissions reduction, and report emission reductions using a third-party voluntary reporting program like Energy Star can do this.

Indoor Environmental Quality

This category is important for ensuring quality air, especially in health care facilities. As a building ages often the indoor environmental quality degrades. This is addressed through indoor air quality, occupant comfort, and green cleaning.

Indoor air quality

Projects should attempt to meet ASHRAE Standard 62.1-2007 but if this is not possible because of the physical constraints of the existing ventilation system the system should then supply at least 10 cubic feet per minute of outdoor air per person under normal operating conditions. An HVAC system maintenance program should be implemented and the building exhaust systems should be tested and maintained. The following are more detailed methods to improving indoor air quality, also known as Best Management Practices (BMP).

Indoor Air Quality Management Program should be developed and implemented on a continual basis an IAQ management program based on the EPA Indoor Air Quality Building Education and Assessment Model (I-BEAM).

Outdoor Air Delivery Monitoring required the installation of monitoring systems that provide feedback on ventilation performance to ensure that minimum outdoor flow rates are maintained. In addition, an outdoor airflow measurement device that ensures it is within 15% of design minimum and at least 80% of the buildings total outdoor intake flow. The device must be monitored by the control system that provides data in intervals no longer than 15 minutes for at least six months.

Increased Ventilation of outdoor air ventilation rates for all units serving occupied spaces by at least 30% above minimum ASHRAE Standard 62.1-2007 requirements.

Reduce Particulates in Air Distribution, this is similar to LEED NC in that a MERV of 13 or greater filter for all outside air intakes and inside air recirculation returns should be in place. But there should also be a determined schedule for maintenance.

Indoor Air Quality Management for Facility Alterations and Additions, this is also similar to LEED NC due to the implementation of SMACNA IAQ Guidelines but it is for Occupied Buildings Under Construction.

Many of the criteria listed for an existing building that wants to become a high-performance building is similar to LEED NC with minute differences.

Occupant comfort

As with LEED NC occupant comfort is of great concern, which is also important for patient care.   There are four different strategies that can be used to approach occupant comfort; one or all can be used.

- Occupant Survey – Create and implement an occupant survey and complaint response system regarding thermal comfort, acoustics, IAQ, lighting, and any other issues that may arise. It should be representative sample of at least 30% of total occupants. Results should then be documented and corrective actions should be taken. At least 1 occupant survey should be conducted during the performance period.
- Controllability of Systems: Lighting – A minimum of 50% of building occupants should have the ability to adjust lighting to fit their needs. It should be 50% of individuals and 50% of multi-occupant space.
- Thermal Comfort Monitoring – Monitoring systems should be in place to ensure continuous tracking and optimization of systems as well as to ensure ongoing building performance as described in ASHRAE Standard 55-2004. The building must also have continuous monitoring of air temperature and humidity of occupied spaces at an interval of 15 minutes or less, periodic testing of air speed and radiant temperatures, alarmed for conditions that require system adjustment or repair including a list of the sensors, zone set-points and limit values that would trigger an alarm, and finally procedures that allow for prompt adjustments or repairs in response to identified problems.
- Daylight and Views – While daylight is an option it does not have nearly as many proven benefits as views do for patient care. Daylight has four possible paths that can be taken these are demonstrate that 50% or more of regularly occupied spaces achieves 25 foot-candles through a computer simulation, use a combination of sidelight and/or top lighting to achieve at least 50% of regularly occupied spaces with proper daylighting, demonstrate through records using a 10 foot grid that indoor light measurements meet the minimum daylight illumination of 25 foot-candles, or finally a combination of any of the above listed methods. The other option is to focus on views where there must be a direct line of sight to outside between 30 inches and 90 inches above finished floor for 45% of building occupants in regularly occupied areas.

These options for LEED EB have slightly different variations on LEED NC; the most notable is the smaller percent requirements. This is in part due to the inability to significantly change the design of the building, like building orientation, which makes meeting the more stringent requirements of LEED NC impossible.

Green cleaning

This is a growing concern for many building owners and occupants following these guidelines will "reduce the exposure of building occupants and maintenance personnel to potentially hazardous chemical, biological and particulate contaminants, which adversely affect air quality, human health, building finishes, building systems, and the environment" (USGBC 2009). There are six strategies that can help improve indoor air quality while minimizing damage to the HVAC system. They are as follows:

- High Performance Cleaning Program – During the performance period a high-performance cleaning program, supported by a green cleaning policy that addresses: a staffing plan, proper training, chemical concentrates with proper dilution system, sustainable cleaning materials like paper products, sustainable hard floor and carpet care, and use cleaning equipment.
- Custodial Effectiveness Assessment – An audit should be conducted in accordance with APPA Leadership in Educational Facilities' (APPA) "Custodial Staffing Guidelines " to determine the appearance level of the facility that must score a 3 or less.
- Purchase of Sustainable Cleaning Products and Materials – Sustainable purchasing should be implemented for cleaning materials and products and 30% of he total annual purchases of products must be sustainable.
- Sustainable Cleaning Equipment – A program should be implemented for the use of janitorial equipment that reduces building contaminants and minimizes environmental impact.
- Indoor Chemical and Pollutant Source Control – Much like LEED NC a permanent entryway system of at least 10 feet long must be installed to capture dirt and particulates from entering the building. In addition containment drains should be installed for the appropriate disposal of hazardous liquid wastes where chemical concentration mixing occurs.
- Indoor Integrated Pest Management – An indoor integrated pest management (IPM) plan should be developed, implemented and maintained for the facility.

While cleaning materials and general maintenance is not directly related to the HVAC system the ability to reduce particulates in the air allows for air filters to last longer. This saves money by changing filters less often.

Indoor environmental quality is important for patient care but also for the HVAC system. If some of these high-performance design strategies are implemented the design of the HVAC system can be drastically altered.

Energy

The United States consists of 309.4 million people only 4.5% of the total world population yet the U.S. consumes the most energy (EIA 2010). In comparison to other countries the United States is quite the energy hog. In oil consumption alone we are the greatest consumer in the world at a rate of 19.5 millions of barrels per day. China is the closest country in oil consumption with 7.8 millions of barrels per day. When it comes to total energy use the world used 483.6 quadrillion British Thermal Units (BTUs) in 2007. The United States guzzled 101.55 quadrillion BTUs, 20.6% of the world energy consumption. The continent of Europe consumed less than the U.S. at 85.59 quadrillion BTUs. The closest energy consuming country is China who, in 2007, consumed 77.8 quadrillion BTUs (EIA 2010).

Energy in the United States is used at an alarming rate. In 2006, a total of 99.5 quadrillion BTUs was used over all primary industries. The building industry, combining commercial and residential, consumed 38.9% of the total energy consumption which is approximately 38.72 quadrillion BTUs. The building industry consumes close to half the energy consumption. Figure 2-2 demonstrates the overall energy consumption by area (EIA 2010).

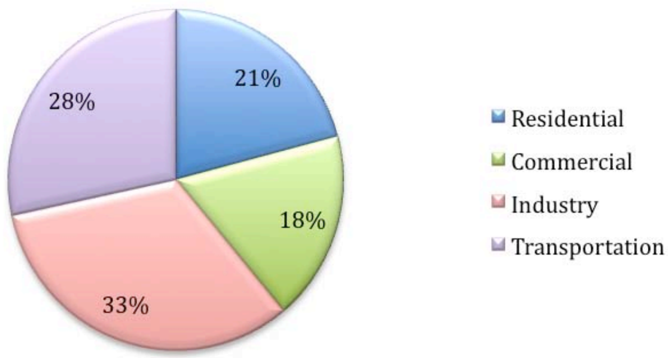


Figure 2-2. Primary energy consumption 2006

South Atlantic

The Census dictates the various regions in the United States. The South Atlantic region consists of Delaware, Washington D.C., Maryland, Virginia, West Virginia, North Carolina, South Carolina, Georgia, and Florida. This South Atlantic region of the United States consumed 17.57 quadrillion BTUs of energy, 17.3% of the total U.S. consumption (EIA 2010). The southeast generally has warmer temperatures during the summer and milder winters. While this provides savings in energy usage for heating there is a grave increase for summer months.

Florida

Florida has 18.5 million people and is the fourth highest populated state. Florida alone consumed 4.60 quadrillion BTUs of energy, 52.78% of which came from the building industry, both residential and commercial. Florida is a unique state with a wide expanse of strip malls, assisted living, and health care facilities.

Northern Florida experiences temperatures that are a bit more moderate compared to south Florida. Specifically Gainesville, FL has an average yearly high of 79^{o} Fahrenheit (F) and an average low of 57^{o} F (countrystudies.us 2008). But during the summer months the averages high can reach 90^{o} F, which takes a great deal of energy to cool.

Health Care in the United States

The Department of Energy (2009) describes that “hospitals are among the nations most complex and energy-intensive facilities”. Hospitals alone use 836 trillion BTUs of energy annually and about 8% of all building type consumption. In 2003 it placed fourth on the list of energy consumption by building type with Office being first at 19%, then Mercantile at 18%, and Education at 11% of the total. The DOE also reports that hospitals have 2.5 times the energy intensity and carbon dioxide emissions of commercial office buildings, producing more than 30 pounds of CO2 emissions per square foot. Energy consumption is an important issue to tackle as U.S. hospitals spend over $5 billion annually on energy. This equals 1% to 3% of typical hospitals operating budget or an estimated 15% of profits.

In 2003 the DOE reported that inpatient facilities used 438.8 thousand BTUs per square foot and outpatient used 205.9 thousand BTUs per square foot. As a whole Health Care uses 345.9 thousand BTUs per square foot ranking second to food sales and service. While healthcare facilities use 8% of total energy consumption they only make up 4% of the total floor space when compared to all other building types. Figure 2-3 provides a better understanding of the distribution of energy use among health care building systems. Space heating is the largest area of energy consumption with lighting and water heating close behind.

The type of healthcare facility can also play a role in the energy consumption for example hospitals will remain open twenty four hours a day, seven days a week while a

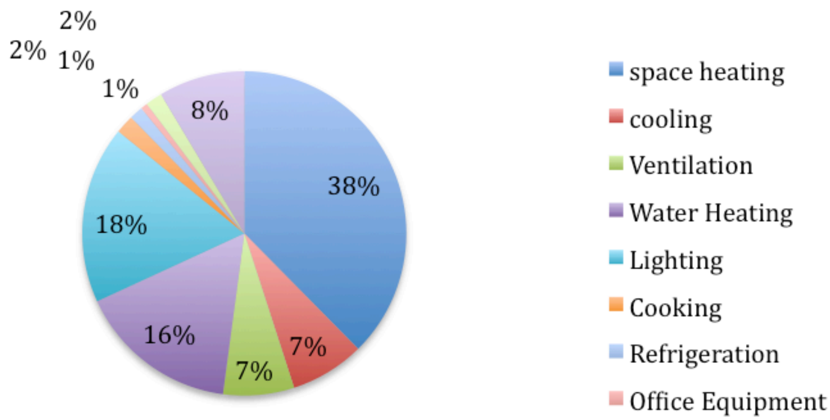


Figure 2-3. Health care energy use distribution

surgical center or outpatient clinic has typical office hours. This major difference plays a large role in energy consumption. While inpatient facilities are much larger there are fewer but outpatient facilities are much smaller but there are many. When considering energy consumption in health care inpatient facilities (hospitals) are often thought of but outpatient facilities consume quite a bit of energy as well. Scotland addresses these issues and can be seen under World Wide Strategies.

Inpatient

An inpatient is a patient who requires an overnight stay in a hospital. The stay is required because the treatment given requires monitoring or they need constant medical care (Websters 2010). These types of facilities are typically hospitals that are open 24 hours a day 7 days a week.

Outpatient

An outpatient is a patient who is not hospitalized but is cared for at a doctor's office, clinic, or day surgery center. Basically these patients do not need overnight care or monitoring because the services they received do not require monitoring or the treatment can be continued at home (Websters 2010).

Health Care in Florida

Florida has a large aging community that requires extensive use of health care facilities. Table 2-3 provides a total list of hospitals in Florida.

When comparing hospitals in Florida to other states Florida has the third most hospitals and the second highest revenue, second to California (AHD 2010). When it comes to health care clinics, which are outpatient facilities, there are quite a few in Florida.

Table 2-3. Number of hospitals in Florida by type

	Hospitals	Beds	Beds per 1,000 Pop.
Total Hospitals	297	66,048	3.5
Community	211	55,130	2.9
Investor Owned	84	18,198	1.0
Not-for-Profit	96	27,422	1.4
Public	31	9,510	0.0
Children	12	1,994	0.1
Rural	26	1,241	0.1
Teaching	7	5,562	0.3
Trauma	22	12,994	0.7
LTAC	23	1,358	0.1
Psychiatric	32	4,737	0.2
Rehabilitation	15	1,062	0.1
Federal	12	3,389	0.2
Specialty	4	372	0.0
Hospitals with Emergency Departments		209	
Number of Closures Since 1995			
Community	24		
Psychiatric	25		

According to AHCA facility locator Florida has close to 2,000 health care clinics. That includes only the ones registered and listed on the AHCA website.

Florida's commercial building sector consumes 23.67% of all the energy in the state. Health care facilities typically consume 10% of the energy for all commercial building types energy. Therefore, health care facilities in Florida consume .1111 quadrillion BTUs of energy a year. That is a significant amount and means that there is more room for savings (EIA 2010).

Shands HealthCare. Shands HealthCare is located in Gainesville, Florida with a few buildings outside of Gainesville. Shands is a not-for-profit organization and Table 2-4 shows the type and number of facilities.

The Hospitals are split into two academic, three community hospitals in Live Oak, Lake City, and Starke, and two specialty hospitals. The newest medical center is the Shands Cancer Center (Shands 2010).

Table 2-4. Shands facilities type and quantity

Facility Type	Number of Facilities
Hospital	7
Home Health Agencies	2
Out Patient Practices	80+

Potential Savings

The potential for savings in the health care industry is vast. Few health care centers or health care campuses are addressing this issue with full force. There are a few that have addressed these needs and their methods will be explored in the United States and throughout the world.

United States Energy Saving Strategies

Energy efficiency in hospitals is a growing concern as it is one place to reduce costs for facilities. Practice Greenhealth, Arlington, Virginia conducted a survey showing that hospitals are capturing low hanging fruit. Sixty of the 550 members were surveyed about their hospitals and more than 93% said they currently had energy efficient efforts underway. This study confirms the importance of energy efficiency in hospitals.

While there are many ways to implement energy saving strategies one that can reap the most benefits is forming an energy management team. A hospital in Florida's climatic zone, according to the census zone 5, employed this strategy. Shriner's Hospital for Children in Houston, Texas created a team made up of an energy manager, four engineers, a laborer, a biotech professional, and a secretary. They implemented this team and strategy in 1997 and have since reduced their hospital utility costs by 40%. They also participated in the ENERGY STAR program in 2002 they started low but with a few operations and maintenance changes and two technology upgrades they improved their rating to 75 within a coupe of years. Their upgrades include:

Lighting improvements done included installing LED exit signs that use 1/10 the ampacity of a standard sign. They also installed occupancy sensors in public areas and mechanical timers in non-public areas to keep the lights off when not in use. They also replaced T-12 lamps with T-8 lamps and electronic ballasts.

Fan Systems were added as they balanced the air and water systems throughout the hospital, decreasing kWh by 68,900 in nine months, and installed energy efficient motors and variable frequency drives.

The HVAC system was upgraded to new energy efficient motors and two new chilled water pumps. A split-HVAC system was installed for one section so that when rooms are not fully occupied the smaller system will run (1.5 ton) instead of the larger system (87.6 ton). Through an energy management system the units operate one at a time to optimize performance.

The energy manager has documented all of these changes and with their dramatic reduction in energy use they experienced a gross reduction of 24% savings in energy consumption that went to their bottom line. In addition in 2007, the Shriner's Children's Hospitals won the 2007 ENERGY STAR award. In the report on this award the hospital director estimates that over the past ten years the total energy savings is $1.2 million. With smaller adjustments Shriner's claims to be able to exhibited great savings and brought their energy rating up from 88 to 91 in a years time. Some of their small adjustment strategies are unique and may not apply to all facilities but are noteworthy (ASHE 2007).

Laundry room issues – the steam table in the laundry room consumed 2.5 tons of steam an hour causing the air conditioner to deliver 2.5 tons of maximum cooling an hour and still couldn't keep up leaving the room at 80 degrees. They switched their focus from fixing the air conditioner to fixing the steam. They installed an electrical-actuated steam valve with a mechanical timer that cost $85 total to install. What it does is shut off the table two hours after use. The total savings in the first year was $8,000 in steam and $16,000 in chilled water costs for a total of $24,000. Now they receive complaints of the room being too cold.

Dryer Heat – Also in the laundry room heat was leaking out of the lint traps making that area of the dryer as hot as 140 degrees. They installed one inch of air conditioning duct board to the lint door and reduced the heat to about 85 degrees. Insulation was also extended beyond steam lines to traps and valves, which keep 85% to 90% of the heat inside the line.

World Wide Energy Savings Strategies

Many countries have addressed the issue of energy usage and have since made changes to maximize energy efficiency. In Scotland they have achieved a reduction of 2% per year in energy consumption since 2000 (Murray et al. 2008). With the success of their hospitals now they are tackling the outpatient services sector, which in Scotland represent 55% of the total number of healthcare facilities and account for 29% of total

Table 2-5. Energy conservation measures and savings

ECM	Extend of implementation	Energy savings (%)	
		Thermal	Electrical
#1: Thermal insulation of external walls (exposed facades) for buildings without or inadequate insulation	All pre-1980 buildings that have no wall insulation	34–40%	4%
#2: Thermal insulation of roofs (exposed side) for buildings without or inadequate roof insulation	All pre-1980 buildings that have no roof insulation	5–8%	2%
#3: Installation of double glazing	All pre-1980 buildings with central heating, and 70% of 1981–2001 buildings	15–28%	
#4: Maintenance of central heating installations	All existing installations need annual maintenance in accordance to national regulation	11%	
#5: Replacement of inefficient boilers with energy efficient oil burners	For all buildings with old central heating installations	17%	
#6: Replacement of inefficient boilers with energy efficient natural gas burners	Only 15% of buildings with old central heating systems, which are located in climatic zones B and C, where natural gas is available.	21%	
#7: Installation of temperature balance controls for central space heating	All buildings without temperature balance control, in accordance to national regulations	5%	
#8: Installation of space thermostats	All buildings without space thermostats	5%	
#9: Installation of external shading	Only 60% of the AC buildings, constructed before 2001		10–20%
#10: Installation of ceiling fans	Only 50% of the AC buildings; fans cover 60% of the total floor area		60%
#11: Mechanical night ventilation	Not Applied		
#12: Installation of solar collectors for sanitary hot water (SHW) production	Only 50% of the buildings without solar collectors		55–70%
#13: Installation of energy efficient lamps	All buildings without energy efficient lamps		60%
#14: Installation of Building Management System (BMS)	Only 10% of pre-1980 AC buildings, 30% of 1981–2001 AC buildings, and 50% of 2002–2010 AC buildings.	20%	30%

floor area. The key to making these changes is creating proper benchmarks that are achievable.

In Greece they face similar issues with energy use in many of their buildings. They have very few health care facilities but they consume the highest amount of energy and have the largest floor area. They addressed many issues that had not previously been addressed to increase their energy savings in many of their buildings including health care facilities. Figure 2-5 provides a list of Energy Conservation Measures (ECM) and the savings they provided to their different buildings.

The savings exhibited by the Energy Conservation Strategies (ECM) are based on the timeline of buildings they were implemented on. The areas that have the potential for the biggest savings are installing energy efficient lighting, solar collectors for sanitary hot water, ceiling fans, and a Building Management System (BMS). With the implementation of these strategies Greece has the potential to reduce thermal energy demand by 19-188 GWh and electrical energy demand by 16-174 TWh (Gaglia et al. 2007).

Building Automation Systems

Automatic control of systems dates back centuries ago but it wasn't until 1920s that automation became prominent in the HVAC industry. At that time "several instrument companies began making complete boiler control systems". Since then building automation controls (BAS) has grown drastically with the increased availability of computers since the 1950s (Stuart 1996). Now BAS has grown into a massive industry that requires integrated knowledge of mechanical engineers, architects, construction teams, installers, and programmers. Now it not only addresses HVAC but many other systems that compose a building including: lighting, energy management systems, building façade systems, and security monitoring and alarm control system. This section will discuss the intricacies of BAS including different managing systems, languages used to communicate, controls wiring, equipment used, the different controls systems, and strategies to optimize the BAS.

Building Automation and Control System Types

The International Organization for Standardization (ISO) calls Building Automation and Control Systems (BACS) an umbrella term for all aspects of building automation. There are many management systems that refer to specific functional aspects of the

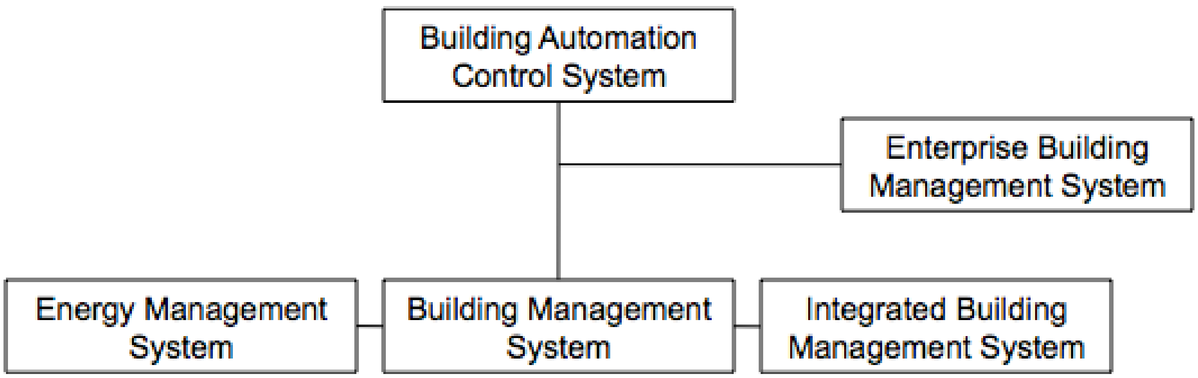


Figure 2-4. Building automation control system relationships

BAS but are all related to the optimization and integration of building systems. These terms are: Enterprise Building Management System, Energy Management System, Building Management System, and Integrated Building Management System. Figure 2-4 shows the relationship between these management systems.

Enterprise building management system

Enterprise Building Management System (EBMS) also acts as the umbrella to the BAS, which enables it to include “maintenance management, energy information, enterprise-resource management, human-resources planning, and asset-management”

(Tatum 2009). It is a similar term to BACS as it is all encompassing but it really only encompasses the different systems not necessarily all of the management terms that will be discussed.

At the University of North Carolina at Chapel Hill they have implemented this system, which “enables campus-wide demand management from a single suite of integrated applications and services, regardless of the existing control system installed into each building” (Bhusari et al. 2007). It has been said “the marriage of BAS and enterprise systems is made possible by Web technology – essentially extensible Markup Language (XML) and web services (WS)”. What this does is allow communication between the different frameworks, which was not possible before. “Using BACnet/IP, a device like the facility manager’s laptop can now connect anywhere in the enterprise and get BAS data from throughout the enterprise”. This technology enables a person to leave the country and check on the facility operations on their laptop at any point in time. Shand’s Health Care centers use an EBMS and are able to with use of BACnet (Tatum 2009). This will be further explored in the following sections.

Energy management system

In the 1970s there was the oil price shock that triggered a strong interest in energy savings potential of automated systems. This expands the thought of automation for comfort to automation for energy optimization. As a result, the term Energy Management System (EMS) emerged. This management system highlights automation functionality related to power-saving operation like optimum start and stop control (Kastner et al. 2005).

Building management system

Building Management Systems (BMS) brought new meaning to building management with the capabilities of accumulating historical operational data. This allows for operational and maintenance staff to review trend logs to improve control strategies. It can also aid in the assessment of cost of operation and schedule of maintenance (Kastner et al. 2005).

Integrated building management system

The term Integrated Building Management System (IBMS) is similar to BMS but it incorporates other demand control aspects like lighting systems. It also recognizes the importance of HVAC and that it is the domain with regard to control and presentation (Kastner et al. 2005).

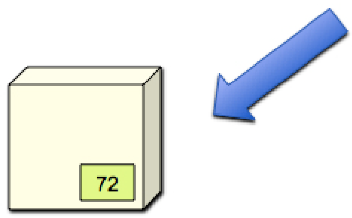
Building Automation Control Networks (BACnet)

Since June of 1987 the data communication protocol for Building Automation and Control Networks (BACnet) has been under continuous development. The first meeting of Standard Project Committee (SPC) 135P took place at the ASHRAE Annual Meeting in Nashville, Tennessee. The development of this protocol was not because there was no other way to interconnect products made by different manufacturers but because it was not easy to do. In the end the building owners tend to feel as though they are trapped into using products from a single manufacturer. It was first published in 1995 was updated in 2001 and 2004. The most recent release was in 2008 as ANSI/ASHRAE Standard 135-2008.

Some of the benefits exhibited are: single operator workstation for all systems, competitive system expansion, owners are no longer locked-in, and interoperability.

BACnet applications include: HVAC control, fire detection and alarm, lighting control, security, “smart” elevators, and utility company interface.

The way BACnet operates is there are a series of objects, which is a collection of information related to a particular function that can be uniquely identified and accessed. All objects provide a set of properties, which are used to retrieve information from the object or to give commands to the object. Figure 2-5 shows a temperature sensor as an object and its attached properties.



Object Name	Space Temp
Object Type	Analog Input
Present Value	72.3
Status Flags	Normal, Out-of-Service
High Limit	78.0
Low Limit	68.0

Figure 2-5. Temperature sensor properties

Input devices

There are different attributes that an object can have for example there can be an analog or digital input. An input device is a device that indicates building conditions to a controller. When creating the different set points for a control system they can be one of the two values. An analog input is one that can set upper and lower limits that the control must stay between and if it goes outside those values and alarm is sent to the maintenance staff. This device senses a variable such as temperature, pressure, or humidity and can provide the maintenance staff with a readout of the variable on their computer (Gosse 2007).

On the other hand, a digital (binary) input is a point that is either working properly or in alarm, for example a filter point could go into alarm when it is deemed dirty. They produce the ON or OFF signal that shows whether the device is in the right predefined range. These are less expensive but also provide little information. Examples of these devices include thermostats, humidistat's, differential pressure switches, flow switches, light level switches, accumulators, current sensing relays, timed override initiators, and specialized digital inputs (Gosse 2007). BACnet defines 23 standard object types in detail but there can easily be thousands more.

Output devices

A building automation system can also have output devices that change the state of a controlled device in response to a command from the BAS controller. There are also two types of output devices, analog and digital. Analog outputs produce signals between values such as 0 volts direct current (VDC) to 5 VDC or 0VDC to 10 VDC. They provide proportional control of damper and valve actuators and variable frequency drives. They are also directly connected to motor-driven valves and damper actuators to move them open or closed.

Similar to digital input, digital output is a device that accepts on and off signal. A BAS controller CPU evaluates the information received as inputs. The controller then sends a command causing a change of state at a controlled device. Most commonly used in BAS are triacs, which require an external power supply. A triac is a "solid-state switching device used to switch alternating current". Digital output devices include incremental outputs, pulse width modulated outputs, and relays (Gossee 2007).

BACnet can be summarized as objects and services model, a network layer protocol, and a selection of various network transport technologies. Additional benefits include: No charge for it's use, maintained by ASHRAE committee that represent all sectors of industry, designed specifically for building control, can be implemented in devices of any size, can be readily enhanced, and most importantly is not tied to present technologies.

Local area network

Determining which Local Area Network (LAN) to use was the next step in the BACnet process. A LAN is "a system for linking private telecommunications equipment, as in a building or cluster of buildings" (Webster's 2010).

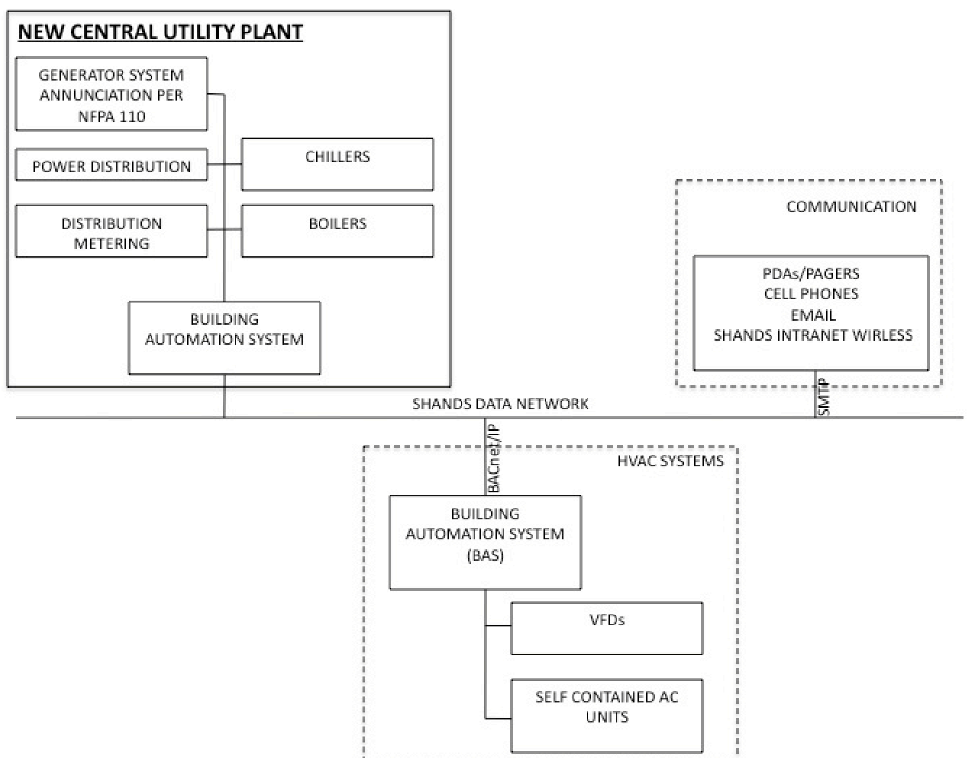


Figure 2-6. Shands Cancer Center portion of EBMS

There are many different types of LANs with the most familiar being Ethernet. When designing BACnet a LAN has to be selected. Six LAN types were selected as options and they include: Ethernet, ARCNET, Master-Slave/Token-Passing (MS/TP), Point to Point (PTP), Echelon's LonTalk, BACnet/IP, and "Virtual LANs".

Figure 2-6 shows a portion of the Shands Cancer Centers EBMS this all ties into the overall Shands EMBS. The BACnet/IP is used to communicate with the HVAC systems. This is all connected to all systems but the basic HVAC is shown for demonstration purposes.

Wire Types

To connect the controls to the building automation system there are many different voltages for wire: low, medium, high, and in some cases ultra high. While all levels of voltages are used on a construction project the most important is low voltage for controls.

Low voltage. Low voltage is a growing concern for building automation and control, as it is a newer field for electricians and HVAC installers to handle. Quite often there is a crossover between the two when it is not specifically stated in the scope of work. In 2008 the National Low Voltage Contractors Association (NLVCA) was established to encompass "all low voltage trades under a single umbrella". The benefit of this organization is that it enables builders to search for low voltage contractor in their area (NLVCA 2010).

For the purpose of HVAC controls the specialty license that would be searched for is ES – Specialty Contractor, Certified Limited Energy Systems Specialty (Low Voltage). To obtain that license an exam must be taken which has two parts: a business section which is 50 questions and two and half hours and a technical/safety section which is 100 test questions and 5 hours. An ES 069 Certified Limited Energy System Specialty is a certified license that labels you as a statewide contractor, specific specialties, and limited energy. A certified electrician can also perform the same duties but is less specialized.

When trying to define low voltage there are numerous definitions and the same goes for the other levels. It greatly depends on the wiring use. For the purpose of this study the NEC Systems level is what is used. Table 2-6 describes the different available definitions.

Table 2-6. Voltage definitions

Standard	Use	Level	Voltage
NEC	Equipment	0-600	Standard
		601-2000	Low Industrial
		2001-35,000	Medium Industrial
		35,001 & up	High Industrial
NEC	Systems	0-49	Low Distribution
		50-1000	Medium Distribution
		1000 & up	High Distribution
IEEE	Transmission	0-600	Low
		601-69,000	Medium
		69,001-230,000	High
		230,001-800,000	Extra High
		800,000 & up	Ultra High

Control Systems

Building automation control systems can also be described as intelligent building systems. Wong (2008) describes the different types of systems that can be connected to the BAS, they are as follows: Vertical transportation system, energy management system, building façade system, security monitoring and access control system, digital addressable lighting control system, and HVAC system. The EMS system was already addressed as a type of BACS management system. The combination of these control systems can improve work efficiency, enhance cost effectiveness, increase user comfort, and improve environmental sustainability. In addition there are other systems that are not directly related to the BAS and they are: internal layout system, hydraulic and drainage system, telecom and data system, and addressable fire detection and alarm systems. For the purposes of this study the systems that should be connected to the BAS are addressed. Wong also presents the critical selection criteria when choosing these different system types.

Vertical transportation system

Vertical transportation systems are the elevators in buildings. These should be connected to the BAS as they can be connected to security monitoring or emergency services. As in case of an emergency, like a fire, there should be the ability to stop the elevators from being used. When utilizing these systems criteria that should be addressed include: energy consumption, operating and maintenance costs, acceleration and deceleration, vibration level, automatic and remote control/monitoring, and service life. Elevators can be monitored through the BAS and when the elevator stops in between floors or has other issues they can be immediately addressed (Wong et al. 2008).

Building façade system

Most building façade systems focus on window coatings and coverings. There are other types like active window systems that use electronic window coverings or louvers to adjust to the sun levels. Some incorporate photovoltaic thin films and others have reflective coatings to reduce heat absorption through the windows. While there are still manual ways to incorporate building façade systems, employees participating in manual blind opening and closing throughout the day, they are not nearly as efficient or effective as motorized shades. To incorporate a motorized system building owners should consider the following selection criteria: operating and maintenance costs, response change in temperature and sunlight, service life, and automatic and remote control/monitoring (Wong et al. 2008).

Security monitoring and access control system

This type of system is important for the safety of building occupants and to limit access in a building to employees only or select personnel. Currently, Radio Frequency Identification (RFID) systems are commonly used for building or room access. An RFID system enables data to be transmitted y a portable device, called a tag, that is read by an RFID reader and processed according to the needs of the application. In addition, technology there is general security that requires motion sensors, glass break sensors, and water sensors. This is important for the overall safety of the building occupants. Incorporating this into the BAS provides full-monitoring capabilities remotely and at a central location. The selection criteria to consider for this system is: service life, time for public announcement, time for informing building management, time for total egress, initial costs, and operation and maintenance costs (Wong et al. 2008).

Digital addressable lighting control system

Lighting systems encompass two areas: artificial lighting and daylighting. Artificial lighting has the ability to be turned on and off through motion sensors. There are also self timers or timers incorporated into the BAS. Utilizing the BAS to control the lighting can save quite a bit of energy. With daylighting, building façade systems like motorized shades can be incorporated as well. The building exterior can work with the sun to reflect not only away from the building for heat load issues but also into the building for vast amounts of natural light (Kastner et al. 2005). It is important when selecting these systems that owners address the following: automatic and remote control/monitoring, permanent lighting average power density, average efficacy, operating and maintenance cost, service life, and ease of control (Wong et al. 2008).

HVAC system

HVAC system monitoring is important as not all areas or rooms require the exact same temperatures, airflows, relative humidity, etc. The level of complexity for an HVAC system is related to the controls implemented and programmed. The HVAC system is key to providing occupant comfort. Thermal comfort relies not only on air temperature but also airflow, humidity, and radiant temperature (Kastner et al. 2005). When selecting a system and the amount of control that it needs, owners must consider: service life, amount of fresh air, acoustic comfort, indoor air quality, total energy consumption, initial costs, and finally operating and maintenance costs (Wong et al. 2008). These can mostly be addressed through the controls themselves.

HVAC System Intricacies

In a BAS there are a number of set points, or points, that are either programmed to collect data or have an instrument to adjust different aspects of the building systems. There are numerous instruments that can be utilized to monitor and control the system. Although there are many different aspects to the controls system, as previously discussed, this section will focus on HVAC and all related instruments. The reason for this is HVAC heating and cooling make up 45% of all energy use in health care facilities, the largest chunk. This also means the potential for the greatest savings. To fully understand the controls that are involved in HVAC some of the system components must be better understood. While there are many types of cooling and heating systems, the ones that Shands typically uses will be the focus.

Chilled water system

A chilled water system contains refrigerant that expands through the thermal exchange valve (TXV), removes heat from the chilled water medium, it is then circulated through a facility and into the air stream through a chilled water coil. In this system the chilled water system refrigerant needs to be compressed from a low to a high temperature. The high-pressure gas in the compressor with the heat removed in the condenser. Typically in Florida the systems are water cooled, as they are more efficient. Centrifugal chillers with VFDs range from 100-3,000 tons and have an integrated part load value (IPLV) of .35-.6 kWh/ton hr (R.S. Means 2006).

Heat recovery units

To remove moisture from the ambient air, while still cooling the ventilated air by passing all incoming air over a desiccant coated wheel, a heat wheel or enthalpy wheel is used. As the wheel rotates the desiccant migrates from the incoming air to exhaust air and moisture is exhausted outside. This process removes up to 85% of moisture and heat from exhaust air and transfers that heat to the intake are in the winter. These systems are common in high performance buildings as they reduce humidity levels as to mitigate any dust mite or mold growth. The recovered heat reduces the energy required to heat or cool the ventilated air (R.S. Means 2006).

HVAC Control System Devices

HVAC controls provide the greatest opportunity for energy savings as 52% of all energy consumption in health care facility comes from space heating, cooling, and ventilation. HVAC systems have minimum controls requirements to run the HVAC system; it is the extra control devices that provide the energy efficiency possibilities. For existing buildings devices may have to be replaced because they are too old or are not compatible with newer systems. For those two reasons it is important to understand what the controls are. The remainder of this section will discuss the different devices.

Controller

The most important aspect of the HVAC monitoring system is the controller as it is a hub for all the hardware to communicate to the needed instrument such as the chiller. There are three levels of controllers. The highest being the building level, then air handlers, and the lowest being room level. The following are descriptions of each:

- Building Controller – The building level controller talks to all the controllers in the buildings and logic is passed back and forth between them. The building controller will schedule the rest of the units, has more server space, and more power to run a large building automation system. Software systems are implemented at this level.

- Advanced Application Controller – This controller occurs as the air handler unit level. At this level the controller reads input and outputs from the humidity sensors, temperature sensors, and any other devices. The function of this controller is to receive input from a device that will cause the control to make an output to the system, which will adjust as needed. This is a little less advanced than the building but has the ability for customization and requires programming logic. An example of this can be seen visually in Figure 2-7. A temperature sensor reads 61°F when the temperature set point is 60°F. This sends a message (input) to the controller, which then sends a message (output) to the valve to modulate open to cool the room more.

- Application Specific – This is at the room level and it typically is a variable air volume (VAV) box. Often there is little to no programming needed as it all comes as a package with VAVs today.

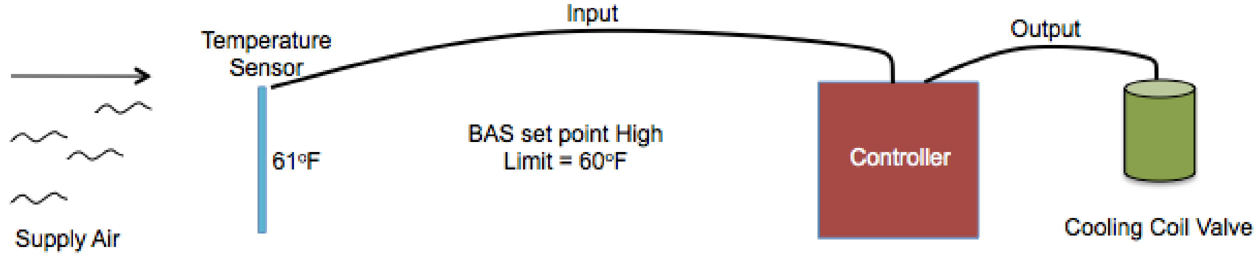


Figure 2-7. Advanced application controller

These levels can be seen visually in Figure 2-8. The server is important for data storage as the controllers can only handle a certain amount of data holding. Once the controller reaches its maximum load it puts all that information onto the server instead of deleting it. This is important from a future energy savings standpoint as that data can be trended and analyzed from year to year, month-to-month to help find more ways to lessen the energy load.

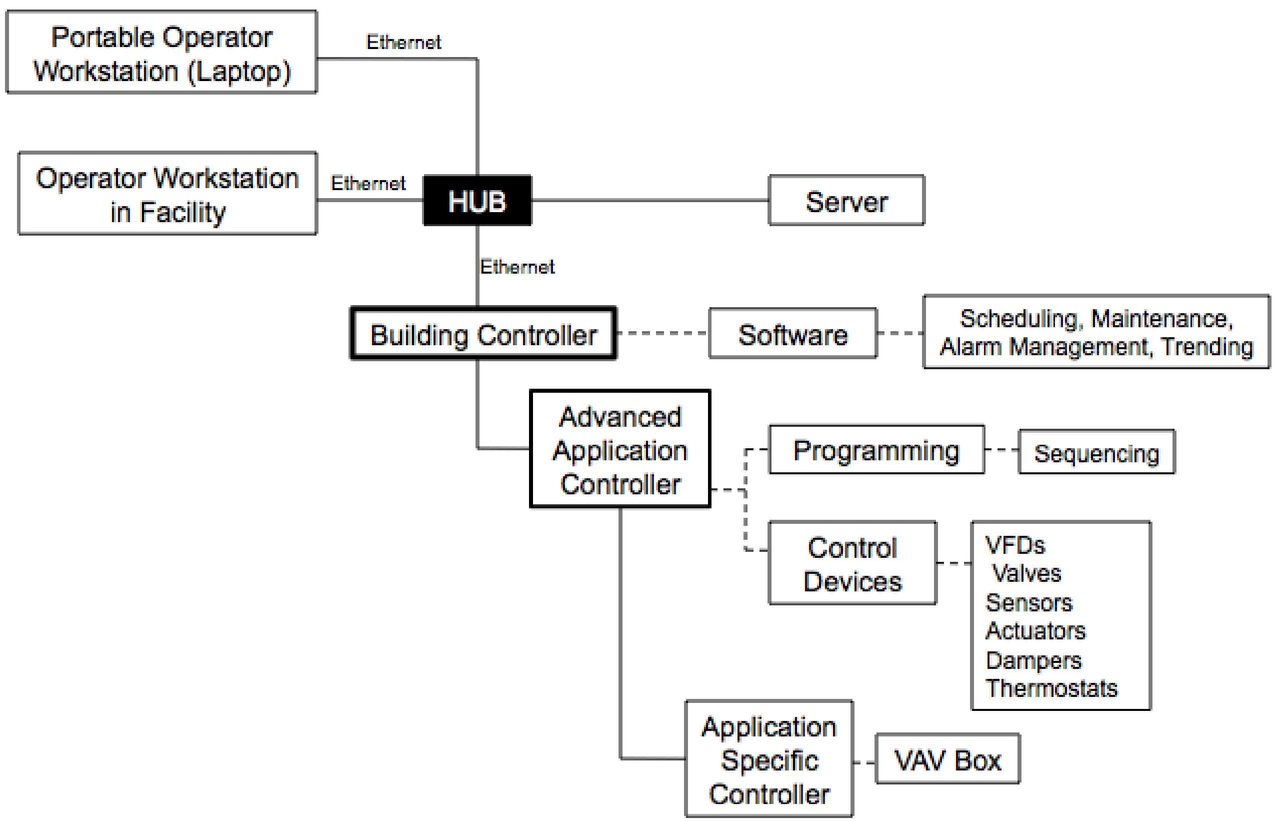


Figure 2-8. General layout of BAS system and controls

The hardware involved with the controller is the inputs and outputs. The Shands Cancer Center's extensive use of controls provides a summarizing list of all hardware options for an HVAC system at the advanced application controller level. These can be seen in Table 2-7.

Software, which is at the building controller level, is where the user interface is found. Software in this case is applications with which the building systems run. It provides the programming to actually schedule, do alarm management, trend the data,

Table 2-7. Hardware in Shands Cancer Center for HVAC system

Hardware		Point Type			Alarm Condition		
Point Description	Units	Analog	Digital	Integrated Set point Value	High limit	Low Limit	Alarm Delay (min)
1/3 coil valve output	% open	x					5
Cooling coil valve output	% open	x					5
Economizer damper output	% open	x					
Minimum outside air damper output	% open	x					
Preheat coil valve output	% open	x					5
Return air control fan damper output	% open	x					
Return VFD speed command	% speed	x					
Supply fan VFD speed command	% speed	x					
Outside air humidity	%rh	x			65	35	5
Return humidity	%rh	x			65	35	5
Return air flow	Cfm	x				0	1
Supply airflow	Cfm	x				0	1
Cooling coil temperature	Deg f	x			65	45	5
Mixed air temperature	Deg f	x			80	45	5
Preheat temperature	Deg f	x			55	40	5
Return air temperature	Deg f	x			80	65	5
Return chilled water temperature	Deg f	x			70	50	5
Return heating hot water temperature	Deg f	x			180	100	5
Space temperature	Deg f	x			80	68	5
Supply air temperature	Deg f	x			60	45	5
Cooling coil differential pressure	Inwg	x			1		
Preheat coil differential pressure	Inwg	x			1		
Return air static pressure sensor	Inwg	x			-1	-3	2
Supply air static pressure sensor	Inwg	x			4	1	2
Return fan vibration transmitter	Ips	x			0.15		1
Final filter status	Clean/dirty		x				5
Pre-filter status	Clean/dirty		x				5
Exhaust fan low static alarm status	Normal/alarm		x				1
Hood exhaust fan fire shutdown relay	Normal/alarm		x				
Low limit alarm status	Normal/alarm		x				1
Outside air fan high static alarm status	Normal/alarm		x				1
Pamdemic	Normal/alarm		x				
Return fan high static alarm status	Normal/alarm		x				1
Return fan low static alarm status	Normal/alarm		x				1
Supply fan high static alarm status	Normal/alarm		x				1
Supply fan low static alarm status	Normal/alarm		x				1
Decontamination exhaust fans	On/off		x				
Hood exhaust fan status	On/off		x				
UV light status	On/off		x				5
Economizer damper status	Open/closed		x				

Table 2-7. Continued

Minimum outside air damper status	Open/closed	x	
Outside air isolation damper output	Open/closed	x	
Outside air isolation damper status	Open/closed	x	
Relief air damper output	Open/closed	x	
Relief air fan damper status	Open/closed	x	
Return air control fan damper status	Open/closed	x	
Supply air isolation damper output	Open/closed	x	
Supply air isolation damper status	Open/closed	x	
Return duct smoke detector status	Normal/alarm	x	x
Return fan fire shutdown relay	Normal/alarm	x	x
Supply duct smoke detector status	Normal/alarm	x	x
Supply fan fire shutdown relay	Normal/alarm	x	x

and whatever other capabilities are needed. In the instance of the Shands Cancer center they applied some extra software to the VFD. A list of al the software possible can be found in Table 2-8.

Variable Air Volume Box

A variable air volume (VAV) box, or system, adjusts the amount of air that enters a room to maintain the desired temperature throughout the year. When the temperature in the room is too cold the damper motor will close the damper to reduce airflow to the space. There are two types of VAV boxes, pressure dependent and independent. Pressure independent is more common as it allows for the boxes to maintain closer room control. They also come with a reheat coil used to reheat the air when needed after reducing the cooling load (Levenhagen et al. 1993). VAVs also have the ability to provide multizone level control with a single duct. This works by each zone having a thermostat in each space that controls its zone damper to reduce the air to that space as needed (Haines et al. 2003).

Variable frequency drives

Variable Frequency Drives (VFDs) and Variable Speed Drives (VSDs) are terms

Table 2-8. Software in Shands Cancer Center HVAC system

Software		Point Type				Alarm Condition		
Point Description	Units	Analog	Digital	Integrated	Set point Value	High limit	Low Limit	Alarm Delay (min)
Outside air humidity	%rh	X						
Cooling coil setpoint	Deg f	X			52			
Mixed air setpoint	Deg f	X			50			
Outside air temperature	Deg f	X						
Supply fan VFD speed feedback	Hertz	X		X				
AHU runtime	Hours	X						
Exhaust runtime	Hours	X						
Hood exhaust fan runtime	Hours	X						
UV lights runtime	Hours	X				8000		60
Exhaust static pressure setpoint	Inwg	X			2			
Return static pressure setpoint	Inwg	X			2			
Supply static pressure setpoint	Inwg	X			2			
Exhaust VFD automatic status	Alarm/normal		X	X				
Return VFD automatic status	Alarm/normal		X	X				
Supply VFD automatic status	Alarm/normal		X	X				
Exhaust fan VFD speed feedback	Hertz			X				
Return fan VFD speed feedback	Hertz			X				
Exhaust VFD alarm	Normal/alarm		X	X				
Exhaust VFD bypass	Normal/alarm		X	X				
Return VFD alarm	Normal/alarm		X	X				
Return VFD bypass	Normal/alarm		X	X				
Supply VFD alarm	Normal/alarm		X	X				
Supply VFD bypass	Normal/alarm		X	X				
Exhaust fan start	On/off		X	X				1
Exhaust fan status	On/off		X	X				1
Hood exhaust fan stat	On/off		X					1
Hood exhaust fan status	On/off		X					1
Return fan start	On/off		X	X				1
Return fan status	On/off		X	X				1
Supply fan start	On/off		X	X				1
Supply fan status	On/off		X	X				1
System start up	On/off		X					

often used interchangeably and have varying definitions. Joliet Technologies (2010), a manufacturer of project designed VFDs and VSDs, describes the differences. A VFD refers to Alternating Current (AC) drives only and a VSD refers to either AC or Direct Current (DC) Drives. A VFD varies the speed of an AC motor by varying the frequency to the motor, while a VSD when referring to DC motors varies the speed by varying the voltage to the motor.

On the other hand, the Carrier Corporation (2005) describes a VFD as a device that uses power electronics to vary the frequency of input power to the motor, thereby controlling motor speed. A VSD is described as a more generic term that applies to devices that control the speed of either the motor or the equipment driven by the motor (fan, pump, compressor, etc) and can either be electronic or mechanical.

For the purpose of this study VFDs will be discussed in further detail. Carrier (2005) goes on to discuss how VFDs are now commonly applied to air handlers, pumps, chillers and tower fans. There are three parts to a VFD, the rectifier, dc bus, and inverter

The rectifier is used to convert incoming ac power into dc power. The term "6 pulse" is used to describe a VFD that has 6 rectifiers the same goes for 12, 18, and 24 pulse. A VFD using transistors in the rectifier section is said to have an active front end. The power that flows through the rectifiers is then stored on the dc bus. The dc bus contains capacitors to accept power from the rectifier, store it, and later deliver that power through the inverter system.   The final section is the inverter, which contains transistors that deliver power to the motor. An Insulated Gate Bipolar Transistor (IGBT) is a common in VFDs because it has the ability to switch on and off several thousand times per second and precisely control the power delivered to the motor. This is done with a method known as pulse width modulation (PWM) to simulate a current sine wave at the desired frequency to the motor. The motor speed (rpm) is dependent upon frequency this can be exhibited in the following equation:

Speed (rpm) = frequency (hertz) x 120 / number of poles

One of the biggest issues faced in the past was operational noise which has since been corrected as drivers today operate at higher frequencies making noise above the audible range. Piper (2009) provides three factors that work together to improve operating efficiency with VFDs and they are as follows:

- Buildings operate at less than full load. Building systems are sized for peak load conditions, which often occur only 1% to 5% of the annual operating hours. This means that pump and fan motors are using more energy than necessary 95% to 99% of their operating hours.
- Designing for peak load oversize's the system for most operating hours. This condition is further compounded by the practice of over sizing the system design to allow for underestimated and unexpected loads. In addition future loads might result from changes in how the building space is used.
- Motor energy use is a function of speed and the most commonly used motor in HVAC systems is the three-phase induction motor. The power drawn by the motor varies with the cube of the motor's speed. This means that if the motor can be slowed by 25% of its normal operating speed, its energy use is reduced by nearly 60%. If it can be reduced by 50% the energy use is reduced by nearly 90%.

The savings that can be achieved is accomplished by converting 60 cycle line current to direct current, then to an output that varies in voltage and frequency based on the load placed on the system. As system load decreases the VFD reduces the motor operating speed making the flow rate meet the systems needs but does not exceed load requirements. The largest benefit from a VFD is energy savings and an additional benefit is less wear and tear on the motors. The applications that provide the most energy savings are those that require variable speed operation. Some of the applications are:

- The flow rate produced by pumps serving the HVAC system can be matched to the building load by using a VFD to vary the flow rate.

- Similarly a system that requires constant pressure can be maintained regardless of the flow rate, such as domestic hot and cold water system, using a VFD controlled pressure set point.
- There is also the opportunity to help control variable air volume boxes more efficiently than traditional methods.

While a VFD can provide numerous benefits owners, operators, and installers should be cautioned that if not properly wired, by either wire type or length, sparks can be created in the bearings eroding their surface among other potential hazards.

The cost of a VFD ranges depending on the number of points required by the owner.

Actuator

An actuator is defined “as a mechanical device for moving or controlling something” (Websters 2010). Actuators are typical pneumatic but can also be electronic, the difference being that pneumatic are used with transducers and electronic are straight electric-operated valves and damper motors (Levenhagen et al. 1993). A pneumatic actuator is a piston and spring in a cylinder. It is used to open and close dampers (Haines et al. 2003).

Dampers

Dampers are used in HVAC systems to control the airflow and maintain certain temperatures and/or pressures. There are two arrangements available for dampers, parallel blade and opposed blade (Haines et al. 2003). Levenhagen (1993) makes the argument that both have useful purpose depending on the desired needs. Parallel blade dampers tend to bend the air for the first few degrees of rotation when they go from open to close, basically they do little controlling in the first 20-30% of movement. The best use for these dampers is when trying to mix air streams. On the other hand, opposed blade dampers are usually used where better control of the air streams are needed and where it is important to prevent large amounts of stratification in the ductwork.

Sensors

There are four different types of sensors for a controls system: temperature, humidity, pressure, carbon dioxide, and network sensors. These sensors are used as analog input devices. The following are descriptions of the various sensors (Haines et al. 2003).

- Temperature Sensor – Modern day temperature sensors are known as resistance temperature detectors (RTD), in which resistance varies with temperature. These can be wired into the control network to determine the thermostat temperature and adjust the air temperature based on the temperature sensor reading. A set of limits can also be implemented as high and low temperatures to ensure air does not get too warm or too cold.

- Humidity Sensor – To control the humidity in a space the amount of water vapor must be controlled. When the relative humidity at the desired temperature set point is too high, dehumidification is needed to reduce the amount of water vapor in the air. When it is too low, humidification is used to increase the amount of water vapor in the air. For best operating efficiency a nonlinear controller with a neutral band should be used. It can control the range of levels at 30-50% relative humidity. It can also control humidification through the relative humidity control valve, and dehumidification through the temperature control valve. Dehumidification is done by cooling through a chilled water valve, which is controlled by humidity or temperature.

- Pressure Sensors - There are four different kinds of pressure sensors, or controllers: static, high, low, and differential. Static pressure controllers are quite common with the use of modern day VAV systems and can be located at the box or just above the space. It is also very difficult to use, as it requires a reference point as well as the static point being measured. Picking the correct reference point is difficult, as improper placement can give inaccurate readings. Differential pressure controllers are used to maintain the same differential pressure between the supply fan and the return fan in a VAV system or it can be across a pump (Levenhagen et al. 1993).

- Carbon Dioxide Sensors – These can be installed in all rooms or at a minimum in entryways to buildings to reduce the amount of CO_2 in a building from the outdoor environment. There are duct probe and wall mounted versions. They can be used in conjunction with Demand Control Ventilation (DCV) strategies to reduce energy savings by 10-70%. In addition they can provide better indoor air quality through the same DCV strategies (Johnson Controls 2010).

- Network Sensors - These sensors combine humidity and temperature sensors and have the ability to connect with BACnet easily and work with different zones (delta controls 2010).

Relays

A relay, as defined by Merriam Webster's dictionary (2010), is an electromagnetic device for remote or automatic control that is actuated by variation in conditions of an electric circuit and that operates in turn other devices (as switches) in the same or a different circuit. Haines (2003) describes a relay as a device that takes a signal from a controller, changes it in some way, and relays it to another controller or actuator. There are different types of relays such as power, electrical, and latching. These relays have an unlimited variety of contact configurations to meet many different needs, they include: single pole single throw (SPST), single pole double throw (SPDT), double pole double throw (DPDT), three pole single throw (3PST) and so on (Levenhagen et al. 1993).

They function with the use of a magnetic coil that creates a magnetic field, when energized, that pulls on a plunger, thus making the movement that controls the action of some contacts to do the switching. There are different types of relays including time delay, which are available with a delayed start or stop (Levenhagen et al. 1993). Averaging relays receive signals from thermostats or sensors and are used for reset purposes, if there are many thermostats, averaging their signals will regulate the temperature of the air delivered to the spaces in which all the thermostats are located (Edwards 1980). The final relay is a discriminator relay that will accept many input signals, up to twenty, and pass on the highest or lowest of the inputs. Some will even output both the highest and the lowest; these are widely used in multiple zone HVAC systems for energy conservation (Haines et al. 2003).

Thermostats

Thermostats are combination controllers and sensors. They are digital temperature-sensing input devices but can come in many forms (Gosse 2007). They can be network digital (BACnet MS/TP), network resource files, zone control systems, programmable digital standalone, non-programmable digital standalone, modular room controls, and electric. Thermostats can be used to control the temperature in a room or zone. Adjusting the thermostat to the desired temperature will trigger the HVAC system to respond in the appropriate manner.

Valves

Valves are typically used for steam, hot water, and chilled water where the flowing temperature transfer media require regulation for temperature control. These valves can modulate coil capacity by throttling flow (Edwards 1980). There are a few different types of valves and they are as follows (Haines et al. 2006):

- Two-position valve – These valves are selected for a pressure drop of 0% to 20% of the piping system pressure differential which leaves the other 80% to 90% for the heat exchanger and its piping connections.
- Modulating valve – This is adjusted by the control system to control the controlled variable. If the valve is designed with a linear characteristic then the flow rate will vary directly with lift for a constant pressure drop across the valve. The benefit of a linear valve is they work well for proportional control of team flow. This is because the heat output of a steam heat exchanger is directly proportional to the steam flow rate. Finally, there is the equal percentage valve that has a plug shaped so that when there is a change in valve position it produces a corresponding percentage change in flow.
- Three-Way Valves – these are typically used to provide a roughly constant flow rate through the piping system while varying the flow rate through the heat exchanger. A heat exchanger in this case can be many things including a chiller,

a condenser, a heater, a cooling tower, and a heat exchange coil. There are two types of three way valves, mixing and diverting.

These valves all function with a valve operator that can be pneumatic, electric, or have electronic motors. It is important to select the proper valve for the right function such a for steam or water flow.

HVAC programming

Programming for HVAC provides many opportunities for energy savings. It is probably the most important aspect of the BAS system. All the devices are great but if they are not fully utilized there are many missed energy savings opportunities. Programming includes scheduling of the different devices but typically in DDC controls it is a method of logic. The logic can be applied in many different ways to get the desired results. The language that is used for programming, BACnet, was previously discussed.

HVAC Control Strategy – Night Setback

Night setback has been employed in previous projects mostly in the 1970s and 1980s when energy was a national issue. While energy costs keep fluctuating the concern is coming back for many reasons. In the past night setback entailed programming the building automation system to increase the temperature at night for cooling days and decrease the temperature at night for heating days, usually by 5 to 10 degrees F. The savings exhibited in these different studies show very low savings. An overview of these studies and their findings can be found in Table 2-9.

The most of the studies were from the early nineties and were for housing or apartments (army barracks). Those types of buildings use little to no outside air as the

Table 2-9. Night setback savings percentage by building type

Facility Name	Type	Setback Values	Estimated Savings	Actual Savings	Source
FSC	Outpatient	10 Deg F	10%	30%	Case Study
Goppingen Army Barracks	Housing		7%		Purucker 1991
Not Available	Housing		11-14%		Purucker 1991
Not Available	Housing		4%		Purucker 1991
Heidelberg	Housing		16%		Purucker 1991
Fort Devon	Office	15 Deg F	14-25%	19.20%	Szydlowski 1992
	Office		2% for every degree setback		Cypress EnviroSystems

theory is that through doors opening and closing enough fresh air will be circulated through the home. While some office buildings exhibited potential savings they were wood constructed and only showed savings for heating night setback.

When to Install BAS

A building automation system is quite complex with numerous devices and extensive programming that can be time consuming. If not properly planned into the design it can raise more issues further down the line in construction and throughout operation. This section will discuss the planning process and different construction management techniques.

Planning Processes

Every project has a specific process it follows and it only varies with project types. In this case the project will be your typical design-build. This process entails three different stages including schematic design, design development, and construction drawings. While the process may vary slightly depending on the construction management techniques the following process is similar throughout.

Schematic design

During this stage the "designer develops the conceptual design, the scale, and the relationship of building components" (Bisharat 2004). In this portion of the construction process it is "normal for the architect to have the lead role in both the design and the management of the design at the conceptual and schematic design stages" (Baldwin 1999 – construction management). Since this stage is further along in the process making changes is more frequent and tend to have a greater overall impact on the design. Although this is a difficult stage to make changes in it is better than later in the process where areas of the project could be complete.

Design development

This stage is imperative to determining a solid design that meets the needs of the owner, code requirements, and performs the basic functions needed. There are various documents that are derived from this phase including "fully developed floor plans, detailed exterior and interior elevations, wall sections, reflected ceiling plans, critical details, specifications, and partially developed mechanical, electrical, plumbing, and fire system drawings" (Bisharat 2004). The budget will be altered and refined to show the changes made in the drawings. This is the optimal time for the major subcontractors to collaborate and be integrated in the design process. The mechanical engineers must work with the design team and owner to get a better understanding of their needs. System monitoring is a detailed aspect of the design and requires an integrated approach to reach the owners needs or goals in a cost effective manner.

Construction drawings

In the construction drawing phase designers develop "drawings and specifications that are actually used to construct the project, as well as the documents used in bidding" (Bisharat 2004). Every firm provides different documents depending on the type of project delivery method. Typically they will provide documents that will allow for projects to be competitively bid on, general and supplementary conditions, specifications and other miscellaneous documents. Making changes after this phase is difficult and time consuming. Essential key design decisions including HVAC system elements should be well planned prior to this process.

Construction Management Techniques

There are different types of construction management techniques. Some relate only to the construction management team and others are all encompassing from the beginning, like design-build. This section will briefly discuss the different construction management techniques.

Traditional delivery method

In this delivery method the design and general contractor (GC) have separate contracts with the owner. The GC is not hired until the design is complete. Therefore, GC has no participation in the design of the building and the sole responsibility is to build according to the construction documents. They must also create a cost estimate, a schedule, and manage the project (Schaufelberger et al. 2002).

Agency construction management

In this delivery method the owner has three separate contracts, they have one with: designer, general contractor, and construction manager. The construction manager acts as the owner's agent. His responsibility is to coordinate design and construction issues with the GC and designer. The construction manager is typically hired first and then the designer. The general contractor typically is not hired until the design is complete. With this method there is the opportunity for integration of the two parties but that would require the GC being hired during the design (Schaufelberger et al. 2002).

Construction manager at risk

In this delivery method the owner has a contract with the designer and construction manager/general contractor separately. This is also known as the construction manager or general contractor method. The designer is hired first and the GC is hired soon after, early in the design development phase. The GC then can provide services like constructability analysis, cost estimating, and value engineering. Then the GC constructs the building once the design is complete or in some cases construction can be fast-tracked where construction starts after each phase of drawings is complete. For example once the groundwork and/or demolition drawings are complete construction may commence on those areas (Schaufelberger et al. 2002).

Design-build

In this scenario the owner has a contract with a general contractor or designer to complete the design and construct the building. This can be done through one firm that has both a construction management team and a design staff (architects and engineers). Or a joint venture can be done with a design firm or vice versa. The fast track method is used often in design build. The Florida Surgical Center at Shands used design build with fast track (Schaufelberger et al. 2002).

Integrated design

Integrated design is important for the proper implementation and timely installation of building controls. They should not be an after thought as the farther into the process that this important feature becomes the more difficult and timely it is to implement, which ultimately means more money. This form of design encompasses all building stakeholders, architects, engineers, construction managers, the facility and maintenance staff, and any other important figures for the project. Their input is used in the design of the facility. This is a highly used approach when it comes to high performance buildings. In the design phase the following items should be considered (Figure 2-9):

Figure 2-9. Integrated design considerations

- Accessibility – elements within the building should be addressed to meet the needs of disabled people. Following Americans with Disabilities Act (ADA) rules will typically suffice unless there is a need for additional requirements for the type of facility.

- Aesthetics – the way in which the building appears physically in terms of elements and spaces should be integrated in the design.

- Cost-effective – select appropriate building materials that have low life cycle costs to help with budgeting control.

- Functional/Operational – this addresses many facets of a building including the special needs, system performance requirements, durability, and efficient maintenance ability.

- Historic Preservation – If the project is in a historic district or is a historical building thought should be put into the design to develop strategies that match one of the four approaches: preservation, restoration, rehabilitation, or reconstruction.

- Productivity – occupant well being is very important and should be addressed including their physical and psychological comfort. This involves air distribution, lighting, workspaces, system, and technology.

- Security/Safety – Building occupants should feel safe with protection from man-made and natural hazards.

- Sustainability – the environmental performance of the building elements and strategies should be planned and developed.

For a project to be able to address all of these there must be integration in the team. This is why a design charrette, a focused and collaborative brainstorming session held at the beginning of the project, should be done (Prowler 2010).

Facilities Operations

Facilities operations and maintenance covers a broad spectrum of services required to assure that buildings will perform the functions for which they were designed and constructed. The DOE Federal Energy Management Plan (FEMP) Operations and Maintenance Guides (2004) define operations and maintenance as decisions and actions regarding the control and upkeep of property and equipment. These include, but are not limited to, the following: actions focused on scheduling procedures, work/systems control and optimizations; and performance of routing, preventive, predictive, schedule and unscheduled actions aims at preventing equipment failure or decline with the goal of increasing efficiency, reliability, and safety.

Importance of Facilities Operation

In the U.S. it costs 1.5 trillion annually to operate buildings. Facilities operation and maintenance often represent 50% to 70% of total annual facility operating costs. Of that 50% to 70%, 10% is spent on energy (IFMA 2010). Figure 2-10 provides insight into the intricacies of facilities operation and management. Facility management is complex and this flowchart simplifies the process between facility and its operations.

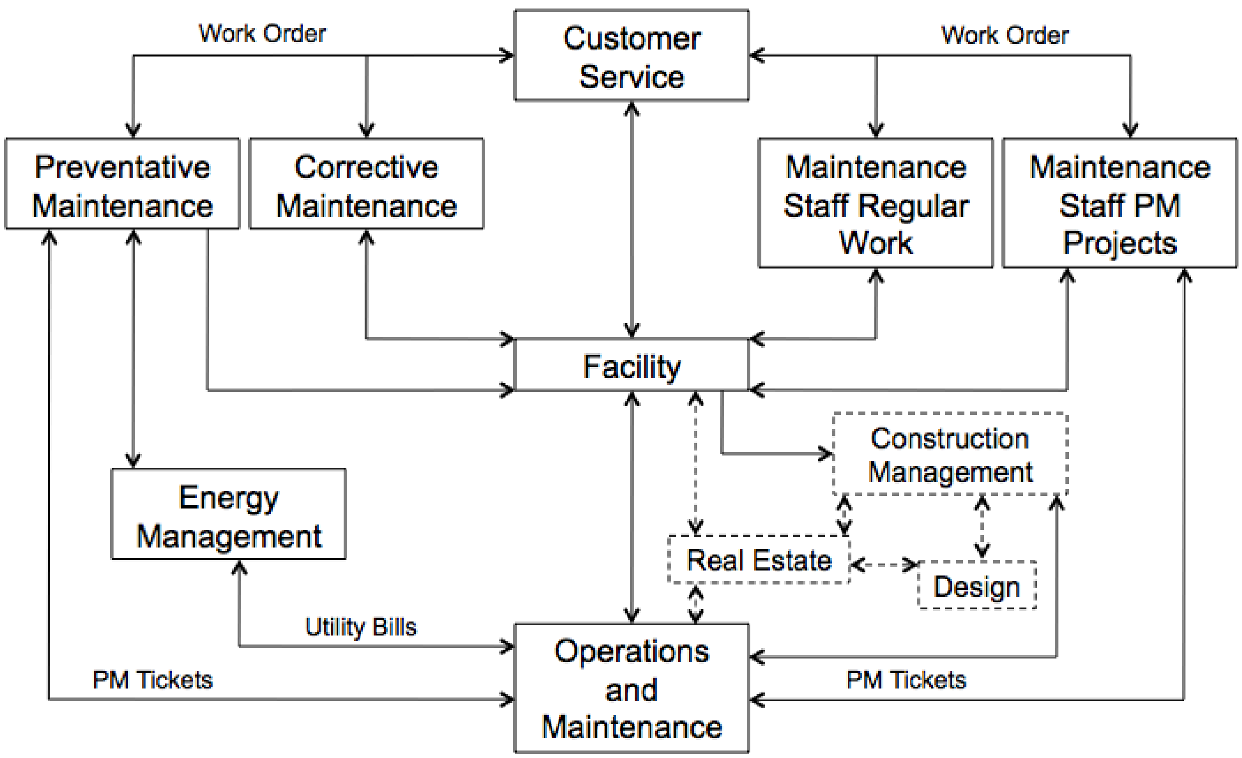


Figure 2-10. Facility operations and maintenance process flowchart

The flowchart includes construction management, design, and real estate and has them connected with the operations and maintenance staff. When it comes time to add another building to the campus operations and maintenance should be included in the planning, as they will be running it for many years after it is constructed. It is important to note that energy management is considered to be an important role in facility operations (Rondeau et al. 2006).

Management Principles

When it comes to operation and maintenance there are a few management principles that should be followed. These principles will help guide the staff to perform the needed functions for the facility while keeping the environment and occupant/worker health in mind. These principles are as follows (Kobet 1999):

1. Commit to people, education and communications.
2. Clean to protect health first, and appearance second.
3. Clean and maintain the building as a whole, not just the separate components.
4. Schedule routine maintenance.
5. Plan for accidents.
6. Minimize human exposure to harmful contaminants and cleaning residues.
7. Minimize chemical, particle and moisture residue when cleaning.
8. Ensure worker and occupant safety at all times.
9. Minimize the amount of pollutants entering the building, while maximizing the amount of pollutants extracted.
10. Dispose of cleaning waste in environmentally safe ways.

While these principles are all important for the purpose of this study schedule routine maintenance and commit to people, education, and communications will be the focus. Although scheduling routine maintenance is important for the staff sometimes items may be replaced too early. Utilizing building technology can help reduce routine maintenance, for example by only changing filters when need be not by a monthly basis. This can save time, money, and extend the life of the filters.

The other management principle, to commit to people, education, and communications, is also important. The most important aspect of facility operation and maintenance is the staff that comprises it. To improve the staff's ability to efficiently service the building they must be educated. Presently facilities are facing issues with staffs understanding of new technologies like BAS and controls. Technology is improving at a rapid pace and not just for facility systems but also for communication tools. Staff members for a large campus facility must know how to operate a computer, sometimes highly sophisticated computers, smart phones, and any other devices for building systems. These all make this management principle highly important when it comes to BAS and controls.

Facility Operations and BAS Controls

It is important for facility operations to recognize the importance of the relationship between equipment performance, proper controls and building occupancy. To maintain optimum conditions for comfort and maximum performance the distribution strategies become increasingly important, thermal zoning and controls that are understandable and easily adjusted. The ability for staff members to understand the alarms they are receiving and how best to fix them is of utmost importance in proper facility operation and maintenance. Large campus facilities like Shands HealthCare face difficulties utilizing BAS controls to monitor energy usage. There is not enough time to put out fires and plan for the future utilizing controls. Instead many controls alarms are bypassed and set to what the facility needs at that time. This defeats the purpose of having building system control.

Facilities Operations at Shands HealthCare

Shands HealthCare facility operations are quite extensive with a connection of many buildings that require constant monitoring. Figure 2-11 provides the Shands Organizational Chart showing that while they have an extensive team there is no one person available to address energy management.

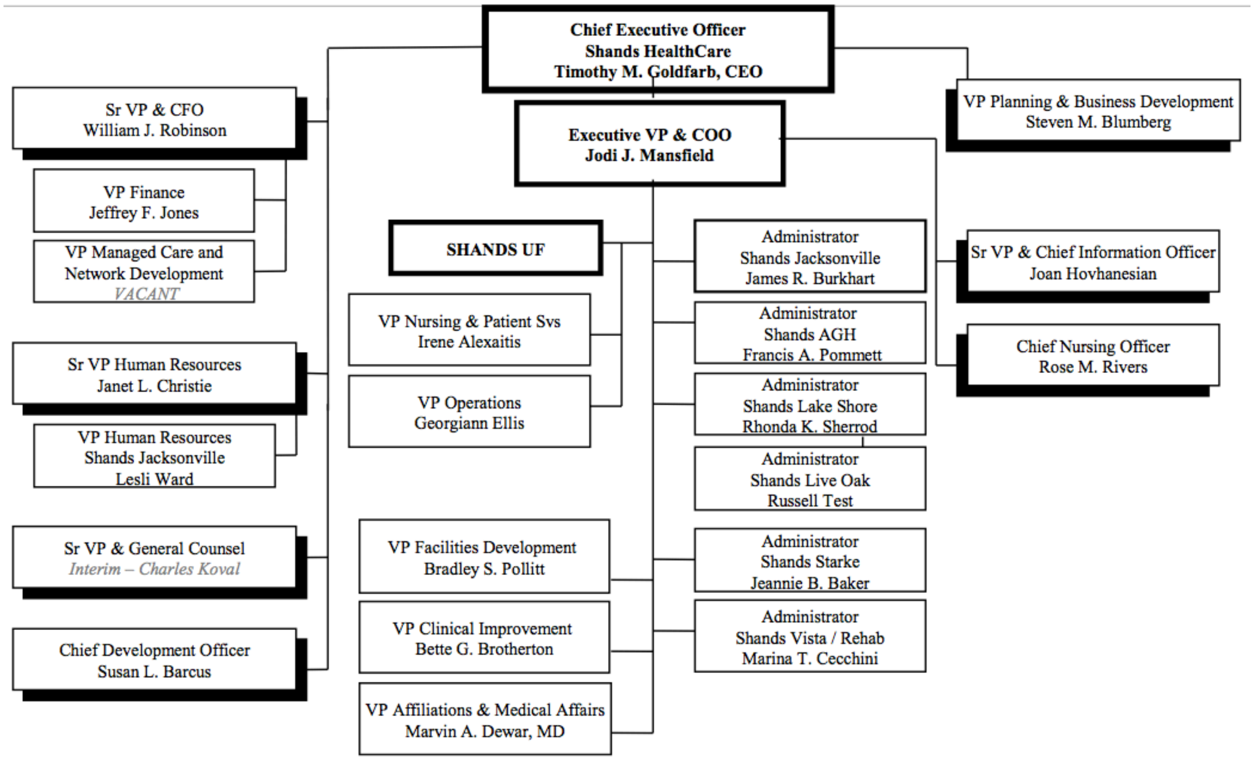


Figure 2-11. Shands organizational chart

They have the potential to improve their management by hiring an energy specialist that can focus solely on energy reduction strategies. This will allow for increased savings and a needed adjustment to their facility operations organizational chart.

CHAPTER 3
METHODOLOGY

The primary objective of this research is to develop a strategy for leveraging savings from easy to implement control strategies for Health Care Campuses, such as a night setback strategy, into additional savings that can be developed by hiring an energy specialist or analyst. This research uses the Shands Florida Surgical Center as a case study to demonstrate how the implementation of a night setback strategy can be used to generate significant savings that can be reinvested in staff to produce significant additional savings. Because many owners do not know the details of their facility, the strategy developed in this research will examine various types of outpatient facilities for the purpose of categorizing them and assessing them for potential savings due to implementing a night setback strategy.

While the green revolution for new construction projects is growing rapidly, existing buildings are being left behind. This vast stock of buildings is consuming considerable quantities of energy, contributing to climate change, pollution, and resource depletion. Energy usage in the United States is evaluated on an annual basis by the Department of Energy and they revealed that, in 2009, the building sector consumed 38.9% of all energy in the U.S. (EIA 2010). Health care facilities consume 8% of total energy, and 52% of this energy is used for heating, cooling, and ventilating buildings.

Currently many buildings are equipped with minimal to extensive HVAC controls but these are not used to their full capacity, nor are they monitored or their data analyzed due to a lack of time and human resources. A major controls manufacturer estimated that 50% of building management systems are not working properly (Audin 2008). Although one of the cited problems is insufficient training and retraining of operational personnel, it is not solely the operational personnel who are at fault. Blame should also be placed on designers and constructors for not properly commissioning the HVAC systems. Facility operators can also be at fault as they are responsible for keeping their facilities in peak operating condition. However with many additional demands placed on their time, investing in commissioning and retro commissioning of buildings is a low priority (Audin 2010).

In order to address this problem for medical outpatient facilities, the research methodology shown in Figure 3-1 was developed.

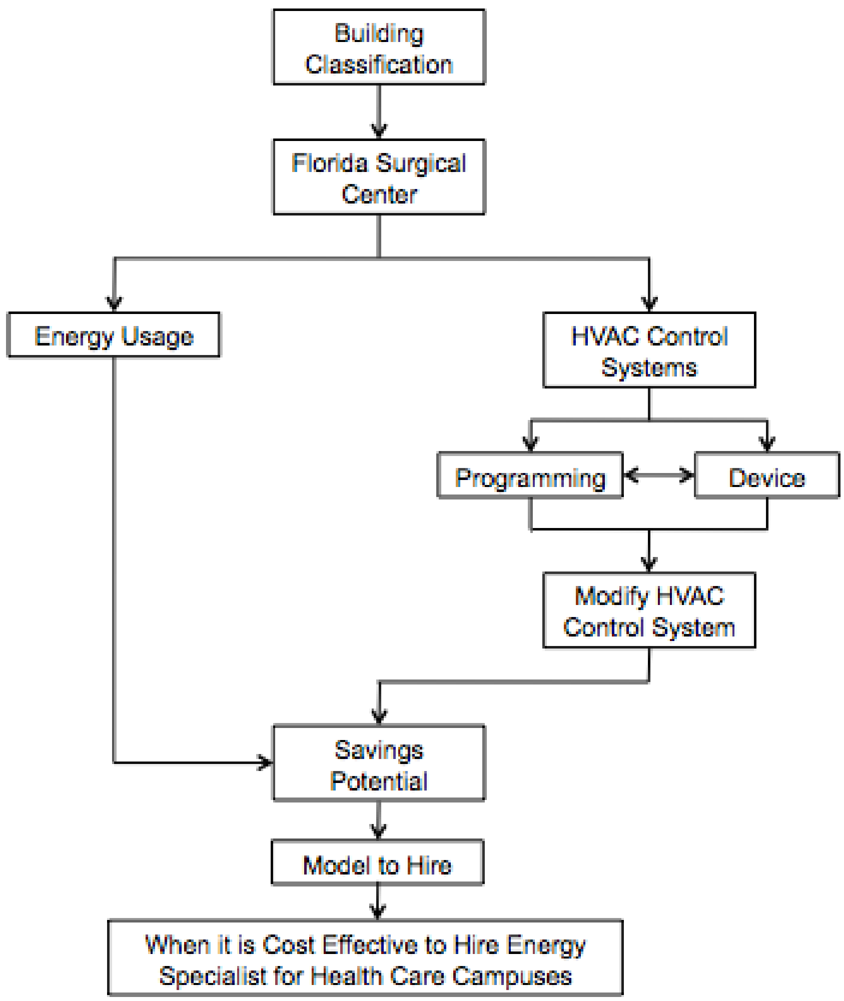


Figure 3-1. Research methodology diagram

In Gainesville, Florida a large campus health care facility, Shands HealthCare, has initiated a process to address the problem of energy consumption and the staffing needed to significantly impact the situation. Brad Politt, VP of Operations for Shands, provided insight into the difficulties they faced with building automation system controls. Michael Watts and Sanjyot Bhusari of Affiliated Engineers Inc (AEI) provided additional knowledge regarding HVAC controls and the technical drawings package for the Shands Cancer Center that was completed in 2009. The Shands Cancer Center implemented changes to the HVAC control system to increase patient comfort, with energy efficiency being an added bonus.

Shands Director of Operations, Don Glaser, took the initiative with Mark Dykes, a project manager in the construction management department, to implement energy efficiency strategies for their most energy intensive facility, the Florida Surgical Center(FSC) (Figure 3-2). This building was used as a case study for the development of an initial energy conservation strategy that could produce savings sufficient enough to support the hiring of an energy analyst for the Shands complex. The FSC is a 26,619 square foot facility that serves as an outpatient facility. The staff provided monthly energy usage information for the facility starting in October 2007, the month after it opened, through April 2010. In addition, they provided a detailed list of the strategies that were implemented and the timing of the implementation. The staff also provided energy usage data for three other outpatient buildings as well as information on Shands UF Hospital. This information was used for comparison and the energy savings from FSC were extrapolated to the three outpatient buildings. The application of lessons learned in the modifications to the FSC HVAC control systems to other similar buildings at Shands should provide a level of savings sufficient to hire an energy specialist.

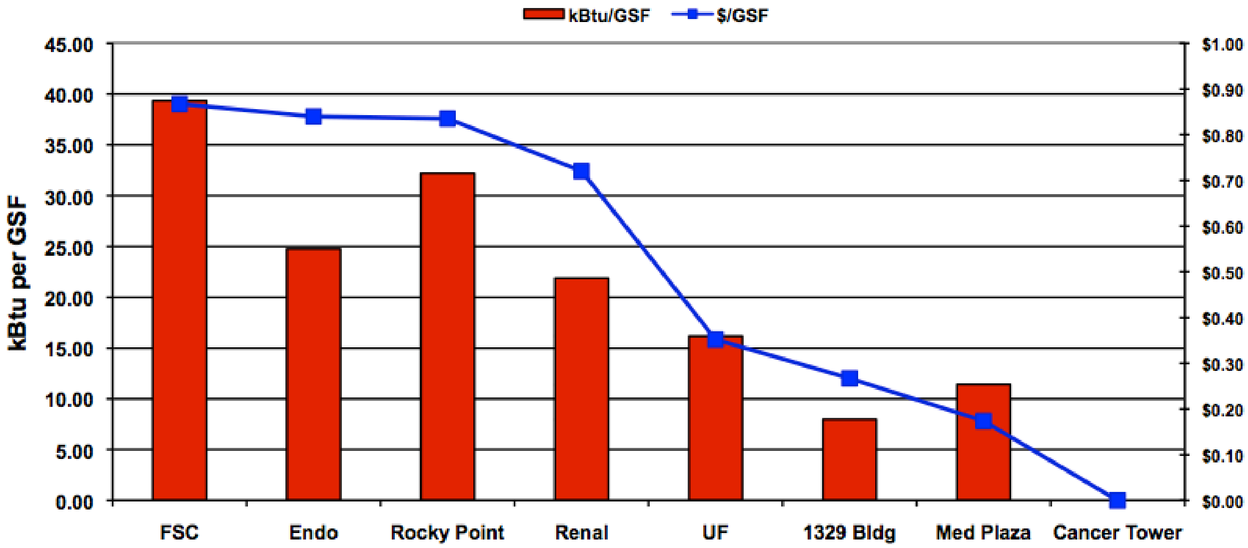


Figure 3-2. Building energy intensity for January 2009

Florida Surgical Center Building Description

The 26,619 square foot building located in Gainesville, Florida consists of eight operating rooms (ORs), private post-surgery recovery areas, space for health fairs and seminars, and administrative space. It was a design-build project that was fast-tracked, allowing for construction to be completed and the building opened in September 2007. In the design-build process it appears that minimal effort was invested in designing and specifying the HVAC controls. For example, the use of schedule programming was not detailed in the design specifications. The FSC building is Shand's newest outpatient building and their most energy intensive. Although the building did not attempt any green certifications, it is a newer building and should be operating more efficiently than it is at the present time. As a result of this substandard performance, it was clear to the staff that action had to be taken to improve the performance of this facility.

HVAC Controls Adjustments. The fast track nature of building the FSC did not allow enough time for full consideration of a control strategy that could minimize energy consumption. Controls were installed to monitor the facility and included three levels of controls: building, air handling units, and rooms. Table 3.1 indicates the control points that were implemented for the FSC, and it is clear from the list that although a wide range of controls were installed, few were actually used for the purpose of optimizing the building's energy performance.

Table 3-1. FSC air handling unit-A controls list

Point Description	Unit
Occupied Mode Command	Occupied/Unoccupied
Supply Fan Command	On/Off
Supply Fan Status	On/Off
Discharge Air Static Pressure	in wc
Discharge Static Setpoint	in wc
Supply Fan Output	%Open
High Static Pressure Alarm	Normal/Alarm
Return Fan Command	On/Off
Return Fan Status	On/Off
Return Fan Output	% Open
Return Air Static Pressure Setpoint	in wc
Return Air Static Pressure	in wc
Return Air Humidity	% RH
Outside Air Flow Setpoint	cfm
Outside Air Flow	cfm
Mixed Air Damper Output	% Open
Discharge Air Setpoint	Deg F
Discharge Air Temperature	Deg F
Cooling Valve	% Open
Mixed Air Temperature	Deg F
Low Temperature Alarm	Normal/Alarm
Prefilter Status	Clean/Dirty
Final Filter Status	Clean/Dirty
Static DP (Sterile HI/Non-Sterile Low)	in wc
Relief Damper Setpoint	in wc
Relief Damper Output	% Open
AHU-A Float Alarm	Normal/Alarm

The building controls have the capability for creating a schedule for the major components of the HVAC systems. In order to better utilize these controls, the staff decided to implement night setback, also known as load shedding, for the FSC building. The building has a 150-ton chiller and two HVAC zones, Zone A and Zone B. Zone A covers the operating suite and supporting space and Zone B covers the lobby and recovery space. On August 15, 2009 night setback was implemented and Table 3-2 describes what actions were taken for Zone A and Table 3-3 describes Zone B.

Table 3-2. Zone A night setback changes

Location	Original Settings	Night Setback
Operating Rooms (8)	Run 24 hours a day 7 days a week at 1500cfm	Between 8:00pm and 4:00am 300cfm in rooms VFD set to run return fan at minimum flow to keep positive pressure
Clean Holding Rooms	Run at 450 cfm	Kept at 50 cfm to keep positive pressure
Remaining rooms / office Space	Run 24 hours a day 7 days a week	Shutdown
Whole Zone		Exhaust fans off Outside air minimized to maintain building pressure High temperature alarm at 80 deg F High humidity at 60%

Table 3-3. Zone B night setback changes

Location	Original Settings	Night Setback
Whole Zone	Run 24 hours a day 7 days a week	Weekdays system is shutoff Weekends kept at 80 deg F

In addition, the Heating Hot Water (HHW) was turned off during setback times, from 8:00 p.m. to 4:00 a.m. weekdays and it was also turned off throughout the entire weekend. The result was significant savings in natural gas consumption.

FSC Data Analysis Methodology

The FSC is the only building that has implemented the night setback energy conservation strategy in the Shands complex. It will be used as the basis for determining the likely energy savings of other medical outpatient buildings in the Shands complex. The energy consumption and costs for energy were compared for the period October 2007 to May 2010. The data for the period after the implementation of the night setback strategy was adjusted based on degree day differences using data from Gainesville's Regional Airport found at degreedays.net. To determine accurate degree days, the baseline for heating and cooling is needed. The Shands facilities staff stated that the summer baseline is 70°F and the winter baseline is 72°F.

Savings were compared between two time periods: Year 1 is the baseline from August 2008 through July 2009 and Year 2, when the changes were made, starts August 2009 through July 2010. Energy information was not given for May, June, and July.

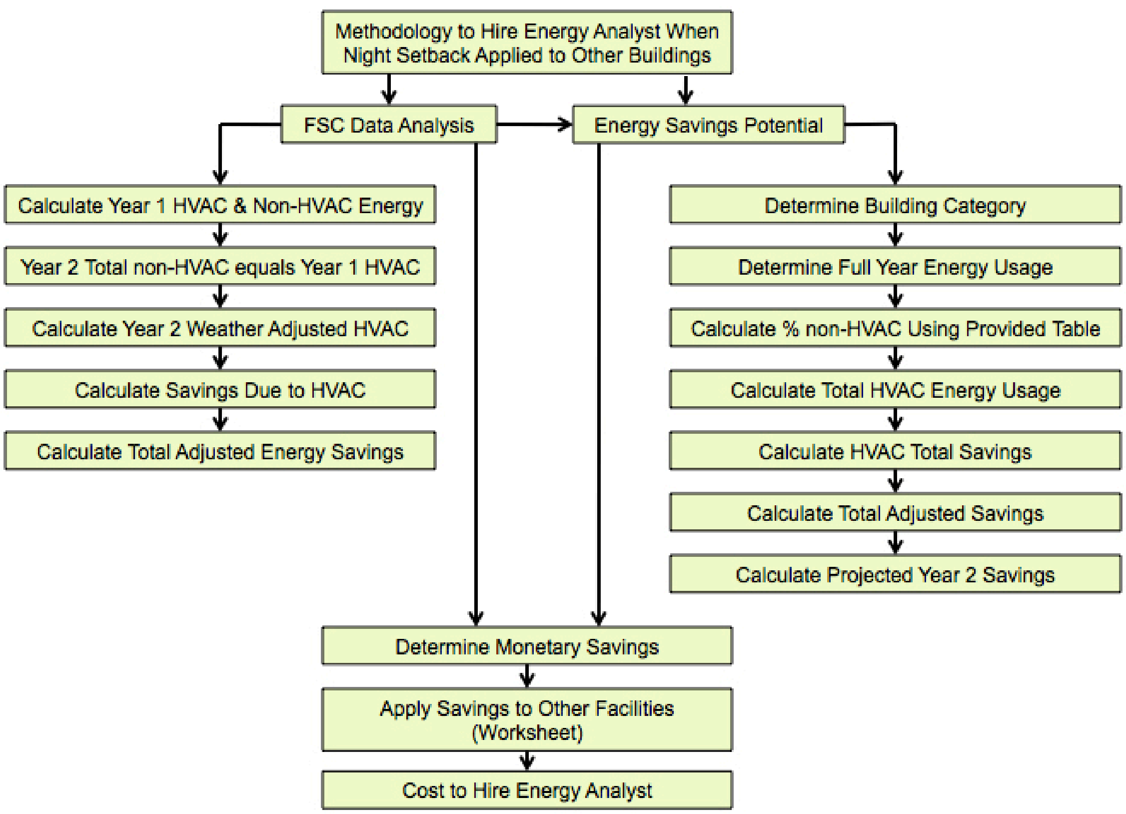


Figure 3-3. Detailed calculation methodology

To determine an energy value previous years were looked at in addition to the trend of savings exhibited. The three months listed are also the hotter summer months, which is why they will provide a higher savings percentage. To properly compare these two years the energy usage for Year 2 must be brought back to the equivalent weather conditions of Year 1.

The degree days were analyzed to determine how to adjust the Year 2 data for comparison to the Year 1 data. This was done by summing the total heating and cooling degree days for the two analyzed years and applying this information to the Year 2 energy consumption data. Figure 3-3 provides a visual of the calculation methodology.

The following is a more detailed description of the steps used to determine the amount of savings due to the night setback strategy, and how much savings can be attributed to the HVAC system.

1. Determine the fraction of total energy consumption that is attributable to non-HVAC system consumption.

   Yr 1 Total x Percent non HVAC Energy Use = Yr 1 non HVAC Energy Use

2. Subtract Year 1 Total Energy usage from Year 1 non HVAC to get Year 1 total HVAC.

   Yr 1 Total Energy – Yr 1 non-HVAC Energy Use = Yr 1 Total HVAC

3. The Year 1 total non-HVAC number translates into Year 2 total non-HVAC.

   Yr 1 Total non-HVAC = Yr 2 Total non-HVAC

4. Subtract Year 2 total non-HVAC from Year 2 total. This provides the amount of energy used for HVAC in Year 2.

   Yr 2 Total – Yr 2 total non-HVAC = Yr 2 HVAC

5. Multiply Year 2 HVAC by the ratio of degree-days to normalize energy information for comparison. This provides the adjusted HVAC Year 2.

$$\text{Yr 2 HVAC} \times \frac{\text{HDD} + (0.5 \times \text{CDD})_{\text{Year 2}}}{\text{HDD} + (0.5 \times \text{CDD})_{\text{Year 1}}} = \text{Yr 2 Adjusted HVAC}$$

Note: The reason for 50% of the CDD is that the refrigeration cycle has a Coefficient of Performance that must be accounted for. In this case it is assumed that the COP for the cooling systems is about 2.

6. Compare Year 1 HVAC to Year 2 adjusted HVAC to determine savings due to HVAC only based on the percent HVAC consumed in a particular building. This provides the total percent savings due to HVAC adjustments only.

$$1 - \frac{\text{Yr 2 Adj HVAC}}{\text{Yr 1 HVAC}} = \text{\% Energy Savings due to HVAC}$$

These calculated values can then be transformed into total energy savings for the facility. To determine general total energy savings Year 2 total must be divided by Year 1 Total. That value should then be subtracted from 1 to determine the percent savings. The formula for this is as follows:

$$1 - \frac{\text{Yr 2 Total Energy}}{\text{Yr 1 Total Energy}} \times 100\% = \text{Total Energy Savings}$$

To look more closely at energy savings another strategy is to, after adjusting Year 2 to include normalization for weather, add Year 2 total adjusted HVAC to Year 2 non-HVAC to get Year 2 Total Adjusted Energy. Then take Year 2 Total Adjusted energy and divide it by Year 1 total energy instead of Year 2 total energy. The formula does not change much but is as follows:

Yr 2 Total Adjusted HVAC + Yr 2 non-HVAC = Yr 2 Total Adjusted Energy

$$1 - \frac{\text{Yr 2 Total Adjusted Energy}}{\text{Yr 1Total Energy}} \times 100\% = \text{Total Energy Savings}$$

Essentially these numbers should be quite close but the second equation will be a bit more accurate as it accounts for the weather differences.

Savings Potential for Other Facilities Methodology

To extrapolate savings using a night setback strategy to similar facilities, a different process must be followed. This approach is a cursory estimate of the potential savings for a medical outpatient building. There are currently a few potential energy savings calculators available for night setback, but they require detailed information and a thorough understanding of HVAC systems, both of which many facility owners do not always have. With a systematic way of determining space type categories owners can determine which category their particular buildings fit into. They can then see how much HVAC energy they could save using the night setback strategy. This then translates into total energy savings. This will lead to when an energy specialist can be hired to monitor energy and increase savings at no additional first cost.

Energy Use Savings: Detailed

Outpatient facilities have normal office hour days, for example 8:00 a.m. to 5:00 p.m. Monday through Friday, and the facilities themselves have varying levels of HVAC requirements.

Table 3-4. Building descriptions associated with HVAC percent of total energy use

	Percent of Energy Use due to HVAC		
	40%	50%	60%
Facility Type	General Doctor	Treatment and Minor Procedures	Surgical and Major Procedures
Space Description	Similar to Office Space	Office Space with a few clean rooms	Office Space with many clean rooms
Level of outside air	Low	Medium	High
Percent of space requiring additional outside air	10-15%	16-20%	21-25%
Total HVAC Savings within % Value	75%	60%	50%

The FSC building is the only facility that has operating rooms that require significantly more outside air, requiring more energy to cool. For this reason an analysis is done on the percent of energy use due to HVAC by outpatient building type. For example the FSC building can attribute their high energy load to their number of operating rooms making their HVAC percent to be roughly 60% of the total energy load. Table 3-4 provides general descriptions that outpatient facilities can fit into to show the general savings. The rational for the savings due to HVAC is demonstrated in Figure 3-4.

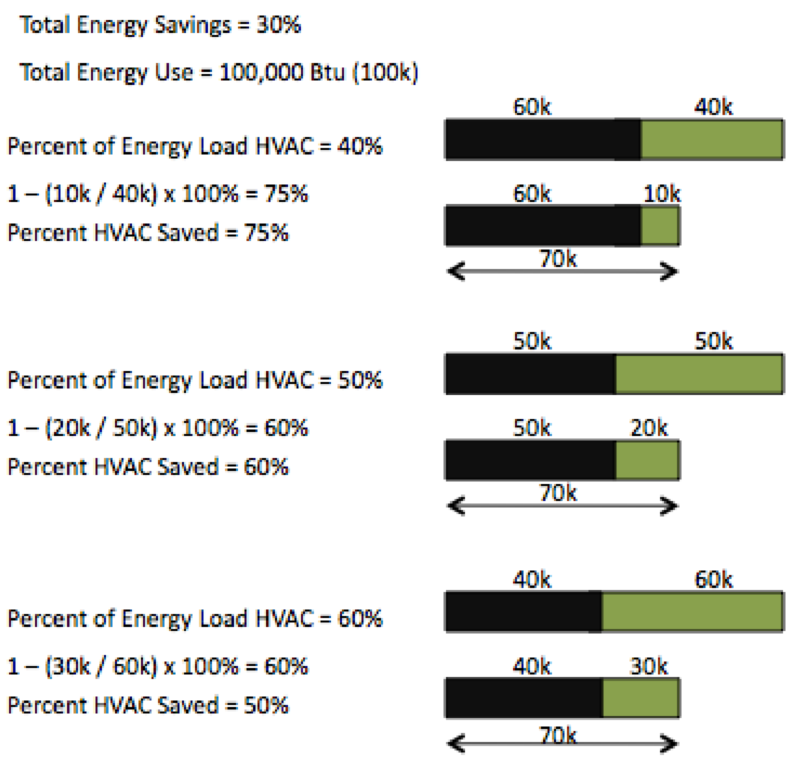


Figure 3-4. Explanation of energy savings due to HVAC percentages

Basically the percent that is not related to the HVAC load is the same from year to year as lighting, people loads, equipment loads, and most other loads are not changing.

Using Table 3-4 to determine where an outpatient building fits is the first step to potential savings if night setback is applied to an outpatient building. The following steps can be followed to see a more detailed savings analysis.

1. Determine category that building falls under
2. Use full year total energy usage for the building
3. Take the total Year 1 and multiply it by the percent non-HVAC determined by Table 3-7, this provides the total energy due to HVAC.

   1 – Percent found in table = Percent non-HVAC

   Yr 1 Total x % non-HVAC = Total non-HVAC Energy (kWh or kBTU)

4. Then take the total from Year 1 and subtract from the total non-HVAC value, this will provide the total HVAC value.

   Yr 1 Total – Total non-HVAC Energy = Total HVAC energy

5. Then take the Total HVAC Energy and multiply it by the savings exhibited under the correct building category, the last line of Table 3-7. This is the Total HVAC Savings.

   Total HVAC Energy x Total HVAC Savings % = Total HVAC Savings

6. The Total HVAC Savings should then be subtracted from the Total HVAC Energy to provide the Adjusted HVAC value

   Total HVAC Energy – Total HVAC Savings = Adjusted HVAC

7. Finally add the Adjusted HVAC to the non-HVAC to determine the estimated total energy for the next year. This should be 30% of the original, Year 1, total energy.

   Adjusted HVAC + Non HVAC = New Total Energy Yr 2

Note: This calculation does not address weather which is why this is an estimate of savings, not actual savings.

Monetary Savings: Using Detailed Calculations

To apply monetary savings to this value take the New Total Energy (Year 2) and multiply it by the appropriate dollar/energy unit. Then subtract the New Total Year 2 dollars spent from Year 1 dollars spent.

New Total Energy (Yr 2) x dollar / energy unit = Yr 2 Dollars ($)

Total Yr 1 Dollars – Yr 2 Dollars = Total Savings ($)

This approach is a bit more detailed and can provide direct savings based on energy consumption and the current unit rate for energy.

Monetary Savings Calculations: Basic & Case Specific

To determine the actual monetary savings for the FSC case study building the total cost for Year 2 is subtracted from Year 1. This provides the total monetary savings. Then to determine the percentage savings that can be applied to other medical outpatient buildings the following equation must be followed:

$$1 - \frac{\text{Year 2 Total (\$)}}{\text{Year 1 Total (\$)}} \quad \text{X } 100\% = \text{Percent Savings}$$

To apply this general monetary savings value to other buildings the following calculations must be done. Use the original, Year 1, total dollars spent and multiply it by the Percent Savings determined from the case study equation value to determine the total monetary savings.

Yr 1 Total ($) x Percent Savings (%) = Yr 2 Potential Savings ($)

Application to Multiple Outpatient Buildings

The case specific calculation utilizing the determined monetary percent savings will be applied to other existing outpatient buildings that are part of the Shands campus. This will be done using the listed equation. Once the monetary savings is determined for each building: FSC, Renal Dialysis (RD), Endoscopy (Endo), and the 1329 building (1329) the four buildings will be summed. This number will show the total savings for a year with the night setback strategy applied.

FSC Savings + Potential Savings (RD + Endo + 1329) = Total Savings

With these four buildings alone it will be determined if hiring an energy analyst will be possible. In addition the payback period for initial investment of this strategy will be calculated for FSC and the 1329 building. Respectively, this will show the low cost option if controls are already installed and the high cost option if additional controls are needed.

Payback Period

Through energy savings using night setback the initial investment can be returned. This return, or payback, period will be determined in months. The following steps should be followed:

1. Convert the total annual savings into monthly savings

   Total Annual Savings / 12 = Monthly Savings

2. Divide the Total Initial Investment by the Monthly Savings to determine payback period.

$$\frac{\text{Total Initial Investment}}{\text{Monthly Savings}} = \text{Payback period (months)}$$

This can be applied to multiple buildings to determine the total payback period it will take to pay off initial investment. Then a cost effective time to hire an energy analyst can be determined. From the payback period calculation the savings after the payback period for year 1 can be determined. This value will provide the basis for leveraged money that can be applied to hiring an energy specialist. To determine the savings after payback the Total Initial Investment should be subtracted from the Total Savings.

Total Initial Investment – Total Savings = Savings After Payback Period (Yr 1)

Cost to Hire Energy Analyst

Energy analysts provide the knowledge and expertise to implement energy savings strategies at a facility. In the beginning they can determine operational savings by improving management efficiency. Then move to installing and implementing building controls to improve efficiency. First it is important to understand the cost implications of hiring a full time energy analyst. Research on typical salaries for energy analysts should be conducted and determined. Then a percentage of fringe and benefits should be applied and added to salary to determine the total cost to hire energy specialist.

Applying Savings to FTE for Energy Specialist. Once the cost to hire an energy specialist is determined this must be translated into FTE after the savings have been implemented. The following steps describe this process:

1. Divide Savings After Payback Period (Yr 1) by Energy Specialist Salary to determine how many full time equivalents could be hired.

$$\frac{\text{Savings After Payback Period (Yr 1)}}{\text{Energy Specialist Salary}} = \text{FTE}$$

2. Determine how many hours per week the FTE equates to by multiplying the FTE value by 40 hours per week.

   FTE x 40 = Hours Per Week

3. Add multiple facilities to reach the desired FTE value.

   FTE (FSC + RD + Endo + 1329) = Total FTE

This allows for owners to know how many hours this buildings savings can sustain an energy specialist's salary.

CHAPTER 4
RESULTS AND ANALYSIS

Energy consumption is a growing concern with facilities but they lack time and knowledge to focus on this issue. With the results of this research, a plan of action is developed to determine how an energy saving strategy can be applied to a few existing medical outpatient buildings and provide the financial backing to hire an energy analyst. The FSC building is the basis for these results, it is important to understand the findings from FSC and how they apply to additional buildings. This is purely a back of the envelope analysis that does not necessarily provide actual savings, but will demonstrate a more efficient way of allocating funds. This analysis can aid owners in the decision process, as they can hire an energy analyst with the adjusted funds.

FSC Energy Analysis

The FSC energy data provided by Shands was collected over a nine-month period. With the information collected, an estimated total year savings was formulated. The following paragraphs describe how the above referenced data was analyzed.

First the degree days were determined using degreedays.net, one of the few weather sources that allows for the baseline to be changed reflecting actual building settings. Table 4-1 provides a list of the degree days since the building was open for its first full month in October.

The time period for comparison is as follows: Year 1 is August 2008, when night setback was implemented, to July 2009 and Year 2 is August 2009 through July 2010. Looking at the totals for each year’s heating and cooling degree days, Table 4-2, Year 2 has about 5% more. This is because of the extremes experienced during the winter and summer months in Year 2.

Table 4-1. Degree days for heating and cooling

Month/Year	HDD @ 72	CDD @ 70
10/1/07	76	183
11/1/07	352	41
12/1/07	369	42
1/1/08	538	17
2/1/08	393	36
3/1/08	366	44
4/1/08	212	96
5/1/08	76	234
6/1/08	27	317
7/1/08	10	336
8/1/08	6	325
9/1/08	35	281
10/1/08	194	132
11/1/08	437	39
12/1/08	413	40
1/1/09	576	19
2/1/09	517	20
3/1/09	317	70
4/1/09	218	87
5/1/09	76	207
6/1/09	14	338
7/1/09	9	328
8/1/09	7	338
9/1/09	27	278
10/1/09	120	206
11/1/09	297	48
12/1/09	467	23
1/1/10	708	9
2/1/10	623	4
3/1/10	462	19
4/1/10	199	100
5/1/10	43	282

To compensate for the changes in weather between the two years when analyzing the energy usage a ratio of degree days was determined. Table 4-3 shows the ratios for the corresponding months.

Table 4-2. Degree day comparison between Year 1 and Year 2

Month	Year 1 HDD @ 72	Year 2 HDD @ 72	Year 1 CDD @ 70	Year 2 CDD @ 70
August	6	7	325	338
September	35	27	281	278

Table 4-2. Continued

October	194	120	132	206
November	437	297	39	48
December	413	467	40	23
January	576	708	19	9
February	517	623	20	4
March	317	462	70	19
April	218	199	87	100
May	76	43	207	282
June	14	21	338	327
July	9	9	328	332
Total	2812	2983	1886	1966

Table 4-3. Monthly degree day ratio for normalization

Month	HDD + Adj CDD Yr 1 / HDD + Adj CDD Yr 2
August	1.044510386
September	0.945868946
October	0.857692308
November	0.703176342
December	1.105080831
January	1.216908625
February	1.185958254
March	1.339488636
April	0.952198853
May	1.025069638
June	1.008196721
July	1.011560694
Total	1.056191744

Energy Savings

The degree day ratios will be used when calculating the weather implications on the HVAC energy load, not total energy load. Table 4-4 shows the energy values in kilowatt-hours (kWh) for the study years.

To determine the HVAC energy load, total non-HVAC energy use from Year 1 must be determined as it will be the same value for Year 2. For this example it is assumed that 60% of the total load is due to the HVAC system. This should be applied to Year 1 by multiplying the total energy by the remaining percent, which is 40. This determines the amount of non-HVAC energy usage. This non-HVAC number is directly

Table 4-4. Study years energy consumption in kWh

Months	Year 1	Year 2
August	297,273.72	240,975.87
September	275,074.85	196,410.56
October	299,161.45	183,177.88
November	272,367.72	139,714.11
December	262,627.27	203,906.14
January	307,021.54	188,796.30
February	260,377.74	212,161.09
March	207,656.97	179,225.53
April	295,125.87	194,081.15
May	274,072.59	182,261.69
June	254,433.76	147,319.19
July	295,635.81	168,514.72
Total	3,300,829.29	2,236,544.23

Table 4-5. Year 1 and Year 2 adjusted HVAC loads and exhibited savings

Month	Yr 1 HVAC Energy	Yr 2 Adj HVAC Energy	Savings (kWh)
August	178,364.23	127,499.61	50,864.63
September	165,044.91	81,704.74	83,340.17
October	179,496.87	54,474.87	125,022.01
November	163,420.63	21,634.65	141,785.98
December	157,576.36	109,243.02	48,333.34
January	184,212.92	80,300.99	103,911.94
February	156,226.64	128,095.35	28,131.30
March	124,594.18	128,808.89	-4,214.71
April	177,075.52	72,396.44	104,679.08
May	164,443.55	74,453.53	89,990.03
June	152,660.25	45,919.01	106,741.24
July	177,381.48	50,841.44	126,540.04
Total	1,980,497.57	975,372.53	1,005,125.04

applied to Year 2 and subtracted from the total energy used in Year 2 to determine the HVAC energy quantity. This number is multiplied by the degree day ratio to minimize weather differences. A direct comparison of Year 1 HVAC and Year 2 Adjusted HVAC is show in Table 4-5 as well as the total kWh of savings per month.

The energy usage due to the HVAC load was cut in half, saving 51% of total HVAC load in the building. The monthly savings can be graphically viewed in Figure 4-1.

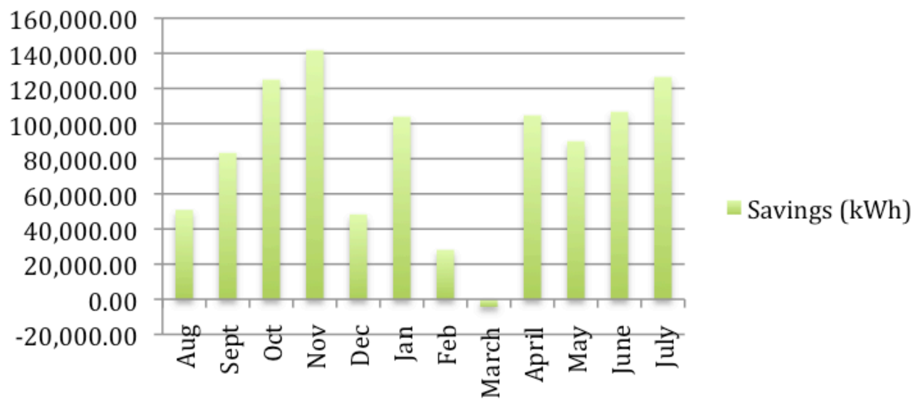


Figure 4-1. FSC total monthly normalized HVAC savings

The month of March exhibited negative savings when incorporating weather as extreme cold was exhibited in Year 2. March also had the largest difference in degree days for both Heating and Cooling, due to weather changes, which were shown in the degree day ratio by having the largest ratio.

In the created worksheet there is the ability to determine how much of the total energy is due to HVAC based on building type. The percentages were 40%, 50%, and 60%. Using 40% produces four negative values for Year 2 HVAC meaning that the savings is more than the HVAC energy, which in turn means that HVAC accounts for more of the total energy. When using 50% for this particular building the savings due to HVAC were all positive and can be seen in Figure 4-2.

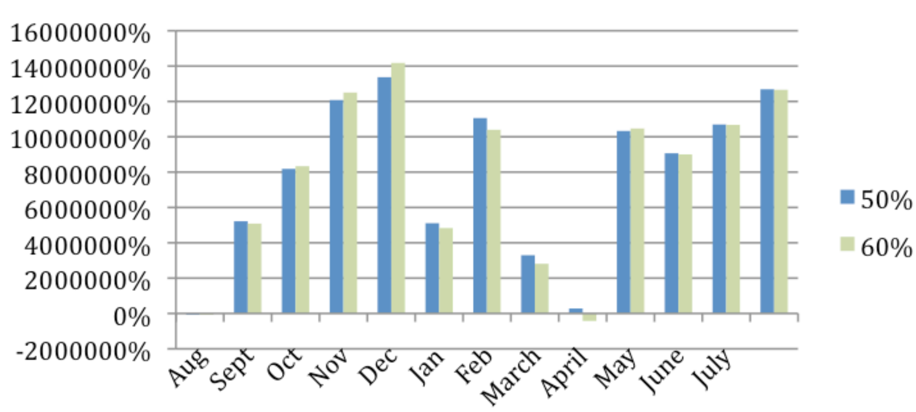


Figure 4-2. Comparison of normalized HVAC load percentages

The FSC building has roughly 25% outside air being drawn into the building, which requires a substantial amount of cooling. For this reason, HVAC is close to 60% of the total energy load. The total energy savings due to the night setback strategy is roughly 30% for an existing outpatient building.

To further demonstrate the table of values available, four percentage levels were used for energy due to HVAC: 40%, 50%, 60%, and 70%. Figure 4-3 provides a visual of this application and because of this visual 70% was eliminated, as that is a high percentage of building energy to be due solely to HVAC. The benefit of determining how much energy savings is attributed to HVAC is if other strategies are applied they can be calculated separately.

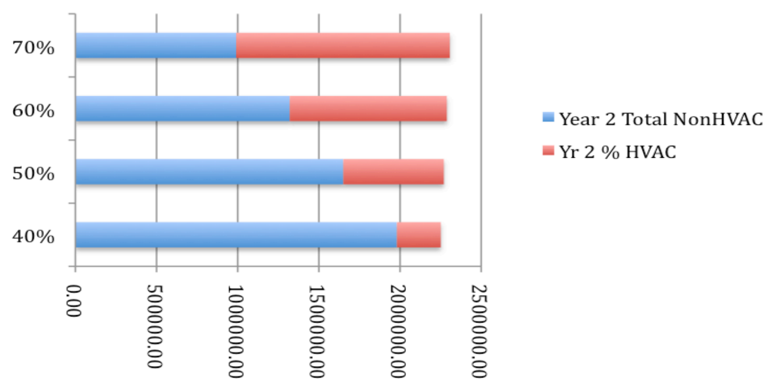


Figure 4-3. Building attribute percent savings due to HVAC

Nine months of the total time period observed had detailed energy usage data regarding energy type, gas and electric. These values can be seen in Figure 4-4 as a comparison of the two years.

Energy Savings Comparison

As a general rule of thumb, when looking at energy savings, a few commercial energy analysts state that commercial buildings save 2% for every degree setback at night. This rule of thumb provides a good gauge, but office buildings do not

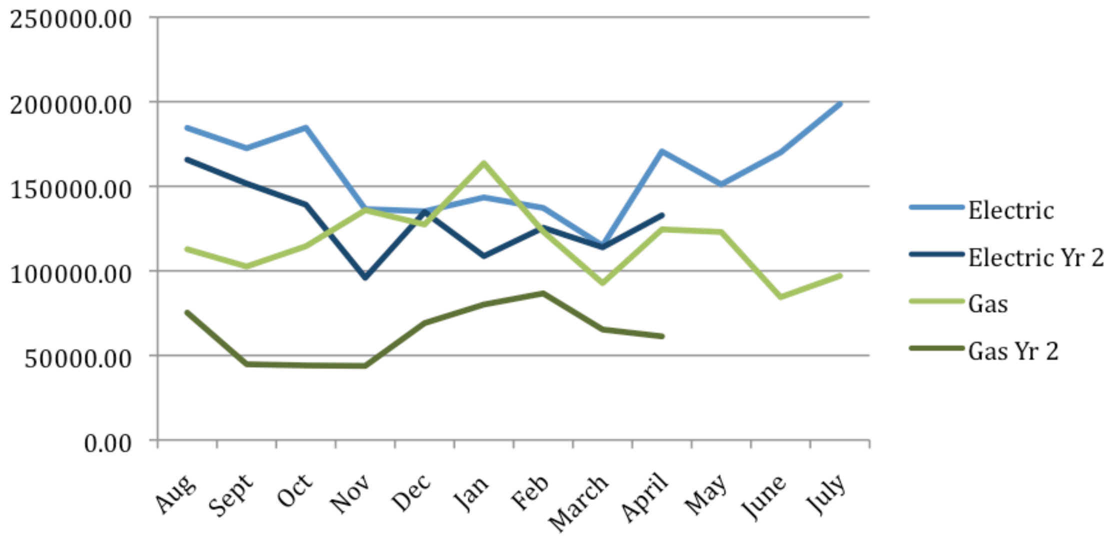


Figure 4-4. Monthly savings by energy type

require nearly as much outside air as a surgical facility. Outside air intake is one of the driving factors for energy consumption. The 30% energy savings witnessed in the FSC building is not far off base; as it consumes 25% outside air as compared to many office buildings that consume 5-10% outside air. It could easily provide 3% savings per degree setback.

Monetary Savings

When looking at monetary savings, the actual billed dollars were used as a comparison from Year 1 to Year 2. Year 1 cost $254,252.62 to run, while Year 2 cost $183,390.40, representing a 27.31% savings of $68,733.88. To ensure the accuracy of this figure, each month was calculated and back tracked to original units and cost per units to provide a 27.03% savings. To keep future calculations simplified 27% is the noted monetary savings due to this night setback strategy. The initial investment for this strategy was $1,800.00 in programming costs, as the facility was already equipped with the necessary controls. This money was made back within the first month leaving $66,933.88 for total energy savings that can be leveraged to hire an energy analyst.

This facility alone will only cover part of the cost, which will be calculated later. The night setback strategy can be applied to other similar buildings to solidify savings for hiring an energy analyst.

Savings Applied to Other Outpatient Buildings

The FSC outpatient facility provided enough energy information regarding night setback to provide a general idea as to the savings that can be extrapolated to other like facilities. These other facilities are listed in Table 4-6 with descriptions.

Table 4-6. Outpatient building descriptions

	FSC (Case Study)	RD	Endo	1329
Building Type	Minor Outpatient Procedures	Treatment	Minor Outpatient Procedures	Treatment
Hours of Operation	M-F 7:00 am - 5:00pm	M-F 8:00 am - 5:00pm	M-F 8:00 am - 5:00pm	M-F 8:00 am - 5:00pm
Current HVAC Running Hours/week	80	168	168	168
Potential Running Hours	NA	75	75	75
Percent Outside Air (Estimate)	25%	15%	20%	20%
Initial investment	$1,800.00	$36,000.00	$36,000.00	$72,000.00

Table 4-7. Total energy and monetary savings using HVAC night setback

	Savings ($)	Savings (kWh)	Initial Investment	Expected Return	Expected Payback Period
FSC	$68,733.88	1,036,181.10	$1,800.00	$25,425.26	1 month
RD	$24,017.38	266,167.74		$8,895.33	
Endo	$38,420.53	286,789.66		$14,229.82	
1329	$178,867.35	1,609,344.00	$72,000.00	$66,247.17	12-14 months
Total	$310,039.14	3,198,482.50		$114,797.58	

Using the determined 27% monetary savings from FSC, the savings for other facilities can be found. This value was applied to the three other facilities to provide a total monetary savings and can be found in Table 4-7. In addition, the 30% savings exhibited to the facility energy was applied.

Shands has done a preliminary analysis of minimal savings that could be exhibited with this strategy and found it to be 10% of the total energy consumption. FSC provided three times the expected savings. Shands hopes to implement this strategy on its Building 1329 project, but in order to do so the following must be done:

- Install Variable Frequency Drives on 10 HVAC Units to efficiently control airflow during setback while monitoring.
- Install 10 CO_2 Sensors to control the quantity of outside air to each zone while minimizing the latent load to the systems.
- As a convenience zone stats equipped with default buttons will be installed in strategic locations if the tenants need to use the building at night.

The total cost of the above referenced features is estimated at $72,000.00, which is at the higher end of the initial cost spectrum. If this $72,000.00 investment were made, the payback period would actually be in 5 months with the remaining 7 months saving money. This leaves $106,867.35 left for total energy savings and the potential to hire an energy analyst.

The two remaining buildings could range between to FSC and 1392. To be conservative, RD and Endo will cost the average of the two, $36,900.00 to apply night setback to. The adjustments to the total savings can be seen in Table 4-8.

Table 4-8. Adjusted first year monetary savings after initial investment

Building	Adjusted Savings ($)	Initial Investment	Estimated Payback Period
FSC	$66,933.88	$1,800.00	1 month
RD	-$12,882.62	$36,900.00	18 months
Endo	$1,520.53	$36,900.00	11.5 months
1329	$106,867.35	$72,000.00	5 months
Total	$162,439.14		

This provides for a total first year savings of $162,439.14. Every year after that should reach close to 30% savings off the baseline year with a total estimated yearly savings of $310,039.14. The transfer of these savings to an energy analyst will provide for an even greater potential of savings.

Cost to Hire Energy Analyst

In order to establish the cost of hiring an energy analyst, a typical energy analyst salary was determined. This was done using glassdoor.com, a website where employees of companies can report their yearly earnings, provided numerous company salaries. This analysis observed twelve companies because these companies had multiple listings. The average yearly salary was calculated for an energy analyst and found it to be $70,750.00. For simplicity sake, this analysis will refer to the average salary as $70,000.00. With just a quick glance at the numbers, it is easy to see that Shands is saving enough energy in the first year to hire an energy analyst. Unfortunately, this number does not include ancillary costs like training, employer taxes, sick and vacation days, and even cost to recruit for such a position. As a typical rule of thumb, consultants estimate their total additional costs to be half their salary or hourly wage. Additional fringes and benefits can include: building operation, taxes, additional training, vacation days, sick leave, vehicle costs, and more depending on their needs. One half of $70,000.00 is $35,000.00, which makes the total annual cost of hiring an energy analyst to be $105,000.00. For the purpose of this research, the cost of $100,000.00 to hire an energy analyst will be used.

Applying Cost Savings to Hire Energy Analyst

To apply the extrapolated potential cost savings, a preliminary worksheet has been developed to help owners make decisions based on rough estimates. It can be used as a tool for decision making when it comes to hiring an energy specialist but not as a tool predicting actual monetary savings due to night setback. This worksheet requires certain inputs from an owner and produces specific outputs, which are defined in Table 4-9.

Table 4-9. Input values required from owner to produce outputs

Owner Inputs	Produced Outputs
Previous Year Total Energy	Total HVAC Energy
Previous Year Total Dollars Spent	Total non-HVAC Energy
HVAC Percent Energy Use Based on Table 1	Total HVAC Savings
HVAC Savings Percent Based on Table 1	Adjusted HVAC
Energy Unit	New Total Energy (Year 2)
Dollars/Energy Unit (Optional Exact Entry)	Total Percent Savings
Initial Investment	Year 2 Dollars Spent
Energy Specialist Salary	Total Savings ($)
	Total Monetary Percent Savings
	Monthly Savings
	Payback Time (months)
	Savings After Payback (Yr 1 only)
	Hourly Rate
	FTE
	Paid Hours Per Week
	Building FTE
	Total FTE for All Buildings

While not all the outputs are pertinent to finding the total FTE that is created with the savings exhibited using night setback, they can come in handy for other reasons. For example, the total HVAC savings can be used when trying to determine what percent savings is due to HVAC and when applying other energy savings strategies.

Figure 4-5 provides an image of the worksheet instructions, Figure 4-6 shows the worksheet calculations portion, and finally Figure 4-7 shows the calculations to determine how much savings is required to hire energy analysts.

Figure 4-7 is important as it provides the payback period in months. At this point, it is at the discretion of the owner to determine within how much time it will be beneficial for them to actually hire an energy specialist. Logically, however, they should not be hired until all initial investment is made back. Applying this technique to three other

Instructions for Estimated Energy Savings Using Night Setback to Hire Full Time Energy Analyst

Important: This spreadsheet is an estimate as to the cost savings with a +/- 10% room for error. This is only to be used as an estimate for the required savings using night setback to hire an energy analyst for a health care campus facility.

To Complete This Spreadsheet the following are needed:

1.) Total Energy Consumption for One(1) Year or 12 months
2.) Total Dollars Spent During that One Year Period
3.) Estimated Initial Investment to implement night setback
4.) Estimated Total Salary for Energy Analyst (or other position, i.e. secretary) this is to include additional fringes and benefits. Use the one half of Salary Estimate to be added to salary.
5.) General Understanding of Building Type to Determine the Percent of Total Energy Load is attributed to the HVAC (Table 1)

Total of all buildings FTE instructions:

1.) Once the form has been completed for the first building copy the number from the calculated FTE value
2.) Right Click next to Building 1 under FTE and select paste special -> Value only.
3.) The Building Name can be Typed in for appropiate personal labeling purposes.
4.) If copying and pasting is not working properly the value can always be typed in.

Key:

To be Filled in By Owner
Owner Has Option to Enter Their Own Value
Value Should be Selected Using Corresponding Portion of Table 1
Value Should be Selected Using Corresponding Portion of Table 1
Cell to be Copy and Pasted Into FTE portion of Estimate to Hire Energy Analyst Table

Figure 4-5. Instructions for worksheet calculations

buildings, Shands can hire two full time energy analysts with their savings in the first year.

Model to Hire Energy Analyst

Using the worksheet, determining how many buildings this strategy has to be applied to in order to save enough to hire an energy analyst is made easier. Hiring an energy analyst can improve energy savings throughout the life of the facility. Owners

Energy Savings Potential in Existing Outpatient Health Care Buildings Using Night Setback

Total Energy Savings = 30%

Required Input Values

Year 1 Total Energy	5,364,480.00	Initial Investment	$72,000.00
HVAC Percent Use (see Table 1)	50%	Energy Specialist Salary	$100,000.00
HVAC Savings Percent (See Table 1)	60%	1 FTE = 40 hours/week	
Year 1 Dollars Spent	$662,471.68		
Energy Unit	kWh		
Total non-HVAC Energy	50%		
Dollars / Energy Unit	$0.12		

Calculations

Total HVAC Energy	2,682,240.00	Monthly Savings	$16,561.79
Total non-HVAC Energy	2,682,240.00	Payback Time (# of months)	4.34735567
Total HVAC Savings	**1,609,344.00**	Savings After Payback (Yr 1)	$126,741.50
Adjusted HVAC	1,072,896.00	Hourly Rate (based on 2088 hrs)	$47.89
New Total Energy (Year 2)	3,755,136.00	FTE	1.26741503
Total Energy Savings	1,609,344.00	Paid Hours Per Week	**50.6966012**
Total Percent Savings	30.00%		
Year 2 Dollars Spent	$463,730.17		
Total Savings ($)	**$198,741.50**		
Total Monetary Percent Savings	30.00%		

Table 1

Percent of Energy Use due to HVAC			
	40%	**50%**	**60%**
Facility Type	General Doctor	Treatment	Minor Outpatient Procedures
Space Description	Similar to Office Space	Office Space with few clean rooms	Office Space with moderate clean rooms
Level of outside air	Low	Medium	High
Percent of space requiring additional outside air	10-15%	16-20%	21-25%
Total HVAC Savings within % Value	**75%**	**60%**	**50%**

Note: Choose corresponding percentages when selecting for calculator, i.e. 40% goes with 75%

Figure 4-6. Calculation field showing building 1329 as an example

Estimate As to How Much Savings is Needed to Hire Energy Analyst

	Building Name	Payback (Months)	FTE	Paid Hrs/Week
Building 1	FSC	1	0.7447571	29.7902841
Building 2	Endo	10.11	0.06689473	2.6757894
Building 3	1329	4.34	1.26741503	50.6966012
Building 4				0
Building 5				0
Building 6				0
Building 7				0
Building 8				0
Building 9				0
Building 10				0
			2.07906687	83.1626747

Number of Full Time Analysts Able to Hire at Specified Salary	2

Figure 4-7. Estimated number of energy analysts that can be hired

often need to make decisions based on few facts, and in this case if a health care facility owner is looking to improve their operating performance they will be interested in hiring an energy analyst. Night setback has been shown to provide excellent savings, 30%, for a medical outpatient building. Applying this strategy to other buildings with similar operating hours can deem similar savings with a marginal percentage of error.

An owner can utilize this back of the envelope analysis of savings needed to hire

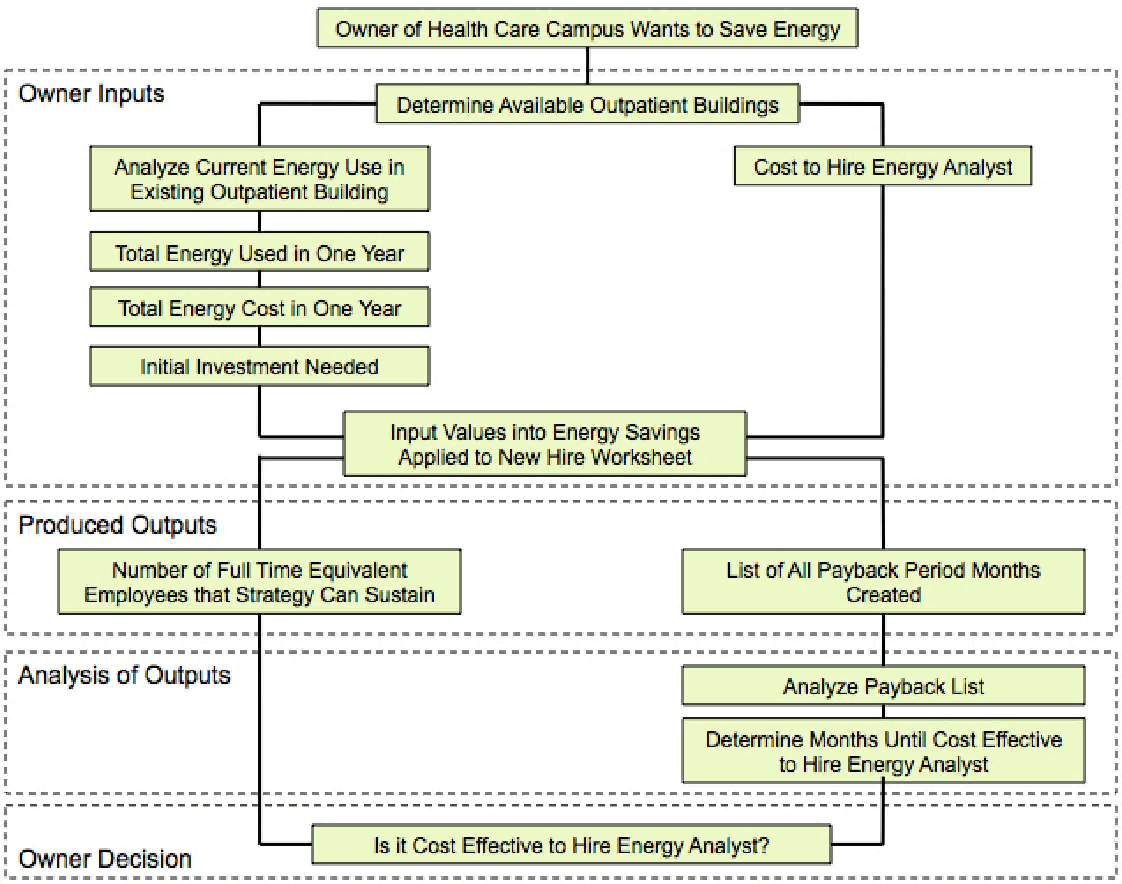


Figure 4-8. Model for owner decision process

energy analyst to determine how many buildings this strategy will have to be applied to sustain an energy analyst. Figure 4-8 provides a visual model of the steps that an owner should take in the decision process.

This model can be looked at in four stages: owner inputs, produced outputs, analysis of outputs, and owner final decision. This model provides a method to determine if a health care campus facility has the ability to hire energy analyst through night setback, i.e. they have enough outpatient facilities that this can be applied to. The following steps further explain this model.

Owner Input Stage:

1. Owner to decide that an energy analyst is needed.

2. Owner to analyze energy in existing outpatient facilities. Most importantly determine how many outpatient facilities are available and determine applicability of night setback to those buildings. If facilities are available, the owner will proceed with remaining steps.

3. Once existing outpatient buildings are determined, a years worth of energy data should be compiled. The data should all be converted into the same units.

4. The total cost for energy during the same time period should be determined.

5. At the same time as steps two through four the available budget and cost of hiring an energy analyst should be determined. If cost is determined and deemed worth the potential savings down the owner should move onto the next step.

6. Input all of the collected information into the New Hire Worksheet and proceed to the next stage.

Produced Outputs Stage:

1. This worksheet produces the number of full time equivalent employees that this strategy can sustain. If it meets owners' requirements then and if there is more than one FTE shown the owner knows that there should be additional savings.

2. In addition the payback periods for return on investment of initial costs spent to implement night setback are produced. If these are within reason at first glance the owner should move to the next stage.

Analysis of Outputs Stage:

1. The payback period list should be analyzed. All buildings should be looked at and owner should pay close attention to the longer payback periods.

2. The time period as to when it is cost effective to hire an energy analyst should be determined looking at the payback periods. If an appropriate time period can be identified the owner is ready for the last stage.

Owner Decision Stage:

1. The owner must decide if it is possible for their health care campus facility is able to hire an energy analyst with the savings provided by implementing night setback.

2. If there is enough FTE created through savings and a time period for when this new position can be filled the owner can decide to go forward.

Following this model an owner can use minimal time to get a rough idea as to how much savings is required to hire an energy analyst. The benefits of hiring an energy analyst are continually growing as they have the potential to monitor, trend, and adjust energy for the entire campus, which can lead to significant energy savings.

CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER STUDY

Many health care campuses have implemented an energy team and at a minimum a designated energy analyst. Some facilities are prohibited by time to implement such strategies. If these facilities can briefly step away from their daily requirements to analyze a few outpatient facilities for their savings potential, soon they can hire a specialist who's time will be dedicated to energy savings.

The Florida Surgical Center at Shands provided a wealth of information regarding energy usage and while that data was normalized for weather the remaining facilities that it is applied to will show an up to 10% difference. This analysis is a back envelope analysis that provides preliminary steps into the owners' decision-making process. At a minimum it can help owners determine to apply night setback as a strategy to their outpatient facilities as it provided 30% energy savings and 27% monetary savings. Applying this strategy to two of the three other facilities, it was determined that with the savings from the Endoscopy, Building 1329, and FSC up to two Full Time Equivalent energy specialists can be hired in the first year. Analyzing the payback periods it may be wise to wait until ten months down the road to ensure all savings can be leveraged into hiring the energy specialist.

For further study it is suggested that this model be applied to one of the listed facilities and the energy change monitored for a full year to see if the same savings is seen. In addition the decision model can be refined as more information is received from health care facility owners.

Health Care facilities have a means of determining potential energy savings due to night setback, the percentage of savings due to HVAC, and how the savings can be applied to hire an energy specialist. This case study of the Florida Surgical Center showed a 30% savings, almost double previously listed studies. This was determined to be due to the large amounts of outdoor air intake for health care facilities, when compared to the studies done on offices and homes. If an owner can follow this preliminary decision model with little information, a decision can be made as to whether they should go forward with wanting to hire an energy specialist. If yes, the health care campus can save up to 40% on their total energy usage. With minimal initial investment for the health care campus they can reap significant savings with an energy specialist.

APPENDIX
ASHRAE 90.1-2004 SECTION 6.4.3 CONTROLS

Section 6.4.3 of ASHRAE 90.1-2004, “Energy Standard for Buildings Except Low-Rise Residential Buildings” covers zone thermostatic controls, dead band, set point overlap restriction, automatic shutdown, setback controls, optimum start controls, zone isolation, and ventilation system controls. These are all important aspects of the control system that must be integrated if pursuing LEED or using ASHRAE 90.1-2004 as a design basis.

The optimum start controls are of interest as they are better than the night setback settings as it learns from previous start times to see how long the system takes to reach the desired set point after being raised or lowered significantly over night. For this standard systems that have a total capacity exceeding 10,000 cfm must have these controls.

LIST OF REFERENCES

AHA (American Hospital Association). (2010). "About the American Hospital Association." http://www.aha.org/aha/about/index.html (May 25, 2010).

AHCA (Agency for Health Care Administration). (2009). "About AHCA." http://ahca.myflorida.com/# (June 1, 2010).

AHD (American Hospital Directory). (2010). "Hospital Statistics by State." http://www.ahd.com/state_statistics.html (June 10, 2010).

Alachua County Growth Management. (2010). "History of Building Codes in Florida." http://growth-management.alachua.fl.us/building_department/florida_building_code/ (May 20, 2010).

ASHE (American Society of HealthCare Engineers). (2007). "Pair of Aces." *Inside ASHE,* 31-33.

ASHE (American Society of HeathCare Engineers). (2010). "About ASHE." http://www.ashe.org/about/ (June 1, 2010).

ASHRAE (American Society of Heating, Refrigerating and Air Conditioning Engineers and American National Standard Institute). (2008). *BACnet A Data Communication Protocol for Building Automation and Control Networks.* ASHRAE, Atlanta, GA.

ASHRAE (American Society of Heating, Refrigerating and Air Conditioning Engineers, and American National Standards Institute). (2004). *Thermal environmental conditions for human occupancy.* American Society of Heating, Refrigerating and Air-Conditioning Engineers, Atlanta, GA.

ASHRAE (American Society of Heating, Refrigerating and Air Conditioning Engineers). (1999). *Ventilation for acceptable indoor air quality.* American Society of Heating, Refrigerating and Air Conditioning Engineers, Atlanta, GA.

ASHRAE (American Society of Heating, Refrigerating and Air Conditioning Engineers, American Society for Healthcare Engineers, and American National Standard Institute). (2008). *Ventilation for Health Care Facilities.* ASHRAE, Atlanta, GA.

ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers). (2010). "ASHRAE." http://www.ashrae.org/ (April 20, 2010).

ASHRAE (American Society of Heating, Refrigerating and Air Conditioning Engineers, and American National Standards Institute). (2004). *Ventilation for acceptable indoor air quality.* American Society of Heating, Refrigerating and Air-Conditioning Engineers, Atlanta, GA.

ASHRAE (American Society of Heating, Refrigerating and Air Conditioning Engineers, and Illuminating Engineering Society of North America). (2004). *Energy standard for buildings except low-rise residential buildings.* American Society of Heating, Refrigerating and Air-Conditioning Engineers, Atlanta, GA.

Audin, L. (2010). "How to Squeeze More Savings From the EMS." *Building Operating Management,* 57(5), 58, 60, and 63.

Audin, L. (2008). "Avoiding Upgrade Headaches." *Building Operating Management,* 55(8), 67.

Bhusari, S., Evans, J., and Brooks, D. (2007). "Enterprise Building Management System (EBMS)." *Web Based Enterprise Energy and Building Automation Systems,* B. Capehart, ed., The Fairmont Press Inc., Lilburn, Georgia, 219-220.

Bisharat, K. A. (2004). Construction graphics : a practical guide to interpreting working drawings. J. Wiley & Sons, Hoboken, N.J.

Edwards, H. J. (1980). Automatic controls for heating and air-conditioning : pneumatic-electric control systems. McGraw-Hill, New York.

EIA (Energy Information Administration). (2008). "Commercial Buildings Energy Consumption Survey." http://www.eia.doe.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/detailed_tables_2003.html (April 4, 2010).

EVO (Efficiency Evaluation Organization). (2006). *Concepts and Options for Determine Energy and Water Saving.* EVO, Washington, D.C.

EVO (Efficiency Valuation Organization). (2010). "About EVO." http://www.evo-world.org/ (May 19, 2010).

Frumpkin, H. (2007). "Green Guide for Health Care." 2.2 287.

Gaglia, A. G., Balaras, C. A., Mirasgedis, S., Georgopoulou, E., Sarafidis, Y., and Lalas, D. P. (2007). "Empirical assessment of the Hellenic non-residential building stock, energy consumption, emissions and potential energy savings." *Energy Conversion and Management,* 48(4), 1160-1175.

Goble, G., and Stauffner, T. (2007). "Don't Be Alarmed." *InTech,* 42-44.

Gosse, J. (2007). *Mechanical and Electrical Systems for Construction Managers.* American Technical Publishers, United States of America.

Haines, R. W., and Hittle, D. (2003). Control systems for heating, ventilating, and air conditioning. Kluwer Academic Publishers, Boston.Herrmann, R. (2005). "Building Automation and LEED Credits." *ASHRAE Journal,* 47(9), S10-S17.

ICC (International Code Council). (2010). "About ICC." http://www.iccsafe.org/AboutICC/Pages/default.aspx (June 20, 2010).

ICC (International Code Council). (2004). Florida Building Code. ICC Publications, Country Club Hills Illinois.

IFMA (International Facility Management Association). (2010). "Whitestone Research Introduces New Building Operation Cost Reference." http://www.ifma.org/prod_briefs/?pg=/091107a.cfm (June 28, 2010).

Kastner, W., Neugschwandtner, G., Soucek, S., and Newmann, H. M. (2005). "Communication Systems for Building Automation and Control." Proceedings of the IEEE, 93(6), 1178-1203.

Knisley, J. (2003). "Building Automation Cabling Gaines Structure." Electrical Construction and Maintenance, 102(2), 41-42.

Kobet, B., Powers, W., Lee, S., Mondor, C., and Mondor, M. (1999). *Guidelines for Creating High-performance Green Buildings: A Document for Decision Makers.* Pennsylvania Department of Environmental Protection, Pennsylvania.

Levenhagen, J. I., and Spethmann, D. H. (1993). HVAC controls and systems. McGraw-Hill, New York.

Murray, J., Pahl, O., and Burek, S. (2008). "Evaluating the scope for energy-efficiency improvements in the public sector: Benchmarking NHSScotland's smaller health buildings." Energy Policy, 36(3), 1236-1242.

NLVCA (National Low Voltage Contractors Association). (2010). "Licensing Requirements for the State of Florida." http://www.nlvca.org/licensing/florida.php (June 11, 2010).

Piper, J. (2009). "VFD: Basic Tool For Energy Savings." Building Operating Management, 56(11), 31-32, 34, 36.

D. Prowler. (2010). "Whole Building Design." http://www.wbdg.org/wbdg_approach.php (May 28, 2010).

R.S. Means. (2006). Green building : project planning & cost estimating : a practical guide to materials, systems & standards; green products--specifying & Assessing cost vs value; resource efficiencies, health, comfor & productivity; commissioning. R.S. Means, Kingston, Mass.

Rondeau, E. P., Brown, R. K., and Lapides, P. D. (2006). Facility management. John Wiley & Sons, Hoboken, N.J.

Schaufelberger, J., and Holm, L. (2002). Management of construction projects : a constructor's perspective. Prentice Hall, Upper Saddle River, N.J.

Shands HealthCare. (2010). "About Shands HealthCare." http://www.shands.org/about/default.asp (April 15, 2010).

SMACNA (Sheet Metal and Air Conditioning Contractors' National Associates, Inc.). (2007). IAQ Guidelines for Occupied Buildings under Construction. ANSI, Chantilly, VA.

Tatum, R. (2009). "IT, XML and SOAP? Today They Spell BAS." Building Operating Management, 56(11), 25-28.

Tatum, R. (2009). "Web Technology Helps Connect Buildings to Enterprise Systems." Building Operating Management, 56(9), 12-14, 16.

USEPA (United States Environmental Protection Agency). (2010). "Energy Star for Health Care." http://www.energystar.gov/index.cfm?c=healthcare.bus_healthcare (May 25, 2010).

USGBC (United States Green Building Council). (2009). "LEED 2009 for New Construction and Major Renovation." 108.

USGBC (United States Green Building Council). (2009). LEED for Existing Buildings: Operations and Maintenance. United States Green Building Councol, .

Websters. (2010). Webster's collegiate dictionary. G. & C. Merriam co., Springfield, Mass.

Wong, J. K. W., and Li, H. (2008). "Application of the analytic hierarchy process (AHP) in multi-criteria analysis of the selection of intelligent building systems." Build.Environ., 43(1), 108-125.

BIOGRAPHICAL SKETCH

Kristin Gray has always had a fascination with buildings. As a child visiting New York City to see the large buildings were some of her favorite vacations. Coming to the University of Florida she was determined to pursue a career in Architecture, thinking it was the only option. Upon speaking with her advisor, Dr. Paul Oppenheim, she realized that there was a whole new world of construction management. A course was taken in each discipline and within a month she determined that construction management was exactly where she wanted her career to go. Completion of the upper division building construction program at the University of Florida and working in the Powell Center for Construction and Environment she realized that it would be wise to continue her education and get her masters. In a slow economy this gave her the upper hand over the competition. Kristin Gray received her Master of Science in Building Construction with a concentration in sustainability in the summer of 2010. She then plans to work for a large construction company to apply her knowledge of construction and critical thinking.