ENERGY EFFICIENCY IN HEALTHCARE FACILITY RETROFITS – KEY ISSUES

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ABSTRACT

Healthcare facilities consume significant amounts of energy as compared to average commercial buildings. This large rate of energy consumption can be improved by instituting energy conservation measures (ECMs) in healthcare facility retrofit projects. From a sustainability perspective, and under the current economic conditions, it is logical to consider energy efficiency-driven retrofit strategies for healthcare facilities instead of replacing aging healthcare facilities. To retrofit a healthcare facility, a project team needs to develop a clear understanding of energy conservation measures and the cost and benefits of instituting each measure. This paper explores the critical issues in achieving energy efficiency in healthcare facility retrofits. It identifies key considerations and reviews the various methods that are currently being adopted for saving energy in existing healthcare facilities. Preliminary results from two hospital case studies are also presented as a means of illustrating the key issues. An approach for developing a taxonomy of requirements for energy efficient healthcare facility retrofits is also outlined and the potential benefits to the healthcare sector discussed.

Key words: Healthcare Facilities, Retrofit, Energy Efficiency

INTRODUCTION

The annual cost of energy in the U.S. healthcare sector exceeds $5 billion and is equivalent to 836 trillion BTUs of primary energy (DOE 2009). Healthcare buildings are responsible for 8% of primary energy consumption among commercial buildings (Figure 1). Existing hospital buildings consume a significant amount of primary energy in the U.S. Figure 2 shows that energy consumption in these hospital buildings is growing dramatically. The increase in energy consumption is due to increased amount of square footage of healthcare facilities as a result of population growth and the aging population.

Therefore, there is a need to retrofit existing facilities to enhance energy performance of hospital buildings. At present, retrofitting hospitals is an inevitable solution to address new patient care requirements emanating from new regulatory standards that include enhanced levels of patient safety. This provides an opportunity to implement facility related energy conservation measures (ECMs) during the retrofit process. New studies have revealed that there are possibilities to reduce energy consumption in the healthcare sector. Right now, the U.S. Department of Energy (DOE) is promoting advanced energy efficiency and renewable technologies in retrofitting hospital

projects. DOE launched the Hospital Energy Alliance (HEA) as a Net-Zero Commercial Building Initiative to facilitate the combination of advanced energy efficiency and renewable technologies in the healthcare sector.

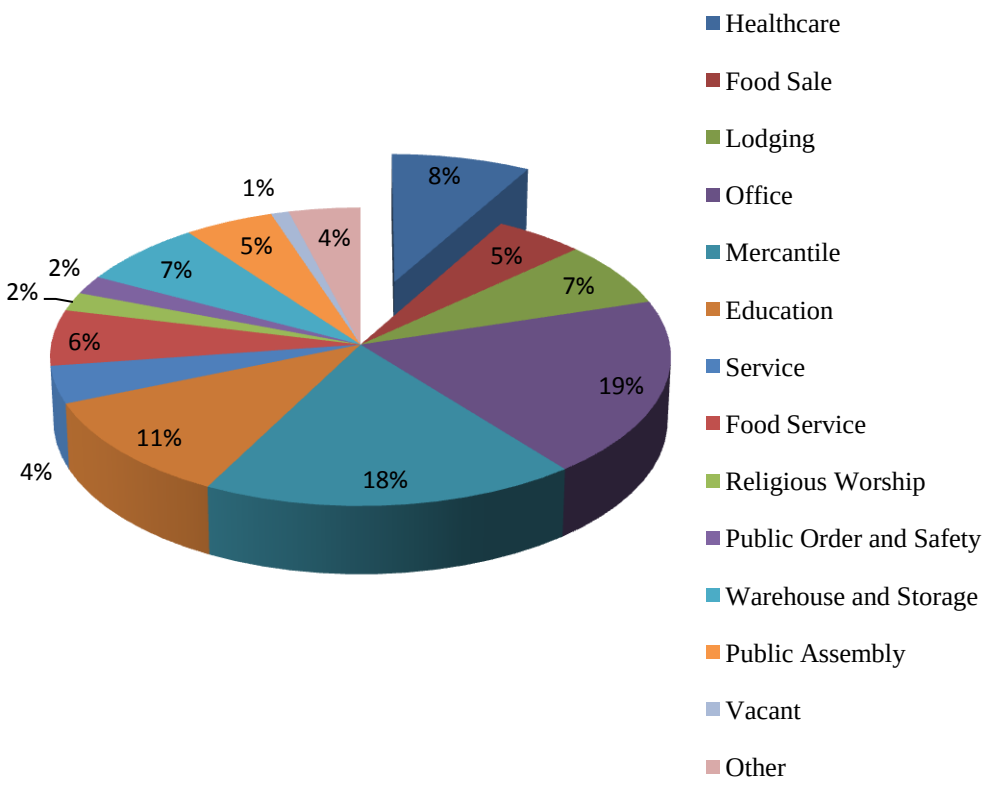

Figure 1. Commercial Primary Energy Consumption by Building Type (DOE 2003)

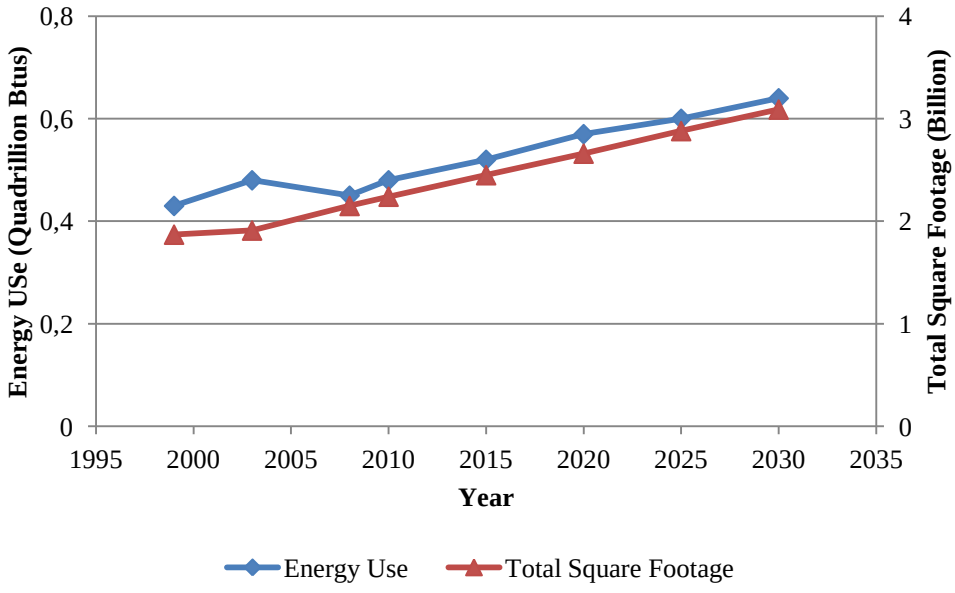

Figure 2. Actual and Projected Energy Use and Total Square Footage between 1999 and 2030 for Inpatient Medical Facilities (DOE 2003)

HEA was created to increase the implementation of high performance technologies to improve healthcare delivery, cut cost, reduce energy usage, reduce pollution, and share evidence-based strategies and best practices (DOE 2009).

Bonnema et al. (2010) believe that 50% of energy can be saved in large hospitals across all the U.S. climate zones through the following key approaches:

- Reducing lighting power densities;
- Installing daylighting sensors in applicable perimeter zones;
- Installing occupancy sensors in applicable zones;
- Using more insulated envelopes;
- Adding overhanging on south-facing fenestrations;
- Providing a multi-zone variable air volume dedicated outdoor air system with zone-level water-to-air heat pumps; the heat pumps should share a common condenser loop whose temperature is maintained through the use of a chiller and boiler;
- Providing high-efficiency chillers, boilers, and water heaters;
- Demanding controlled ventilation;
- Using more efficient pumps;
- Reducing infiltration through tighter envelope construction;
- Integrating subsystems to achieve whole-building performance.

It is important to note that not all of the above approaches will be applicable to every healthcare facility retrofit project. The applicability for each ECMs depends on the organizations trade-offs between the up-front cost and short-term and long-term savings. This paper discusses the ECMs opportunities, and critical issues related to retrofit projects in the healthcare facilities.

NEED FOR HEALTHCARE FACILITY RETROFIT PROJECTS

"The average age of a U.S. hospital building is 27 years" (Guenther 2010). Recently, the number of hospital renovation projects in the U.S. has greatly exceeded the number of new construction hospital projects by approximately 3 to 1 (Carpenter and Hoppszallern 2010). The study suggests that 73% of current hospital projects are associated with renovation or expansion projects, which illustrates a significant transition from new construction to retrofit projects in the healthcare sector. This shift has happened primarily due to the high cost of new construction, space limitations for new construction, the economic recession, and new legislation. Under the current economic conditions a solution is to retrofit these facilities in such a way to have an energy efficiency-driven retrofit. Figures 3 and Figure 4 show the current budget for renovation of existing hospitals and construction of new hospitals. These two figures show that the current dedicated budget for renovation of existing hospitals and construction of new hospitals are comparable.

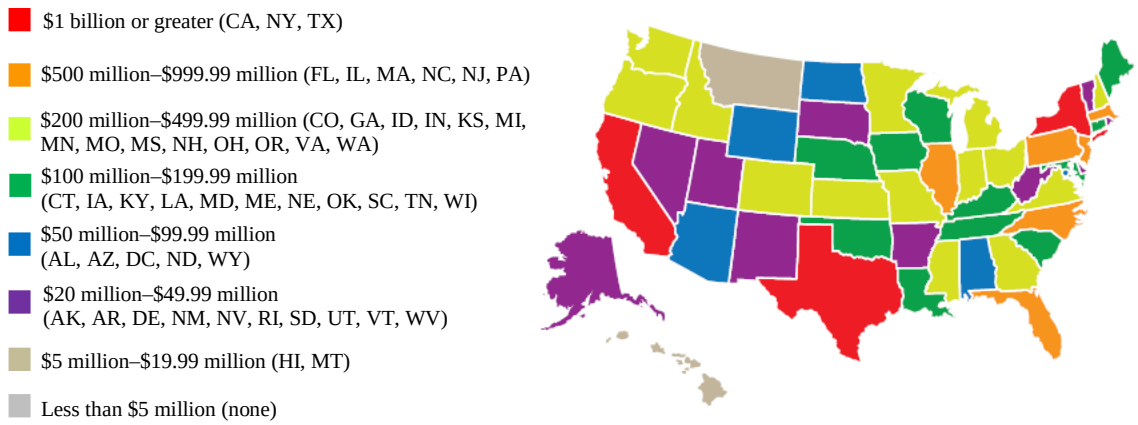

Figure 3. Dedicated Budget for Renovation of Existing Hospitals and Outpatient Clinics by States (Source: Carpenter and Hoppszallern 2010)

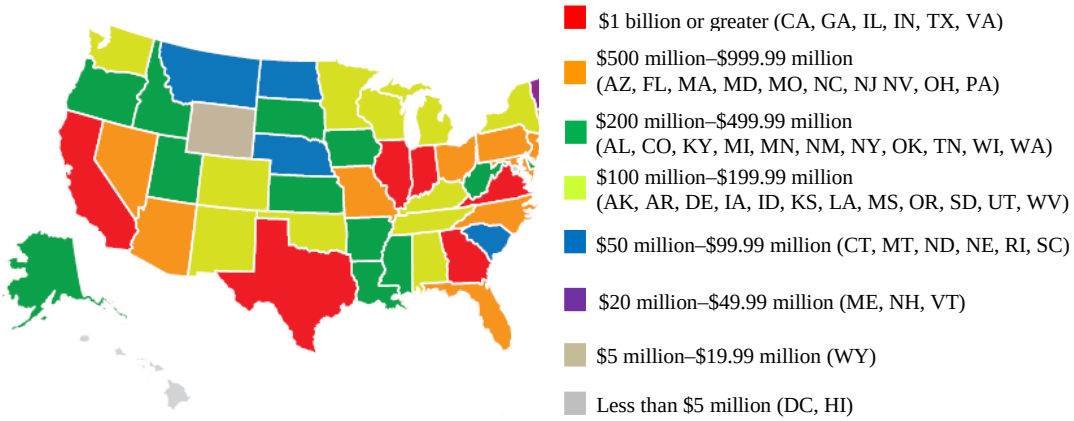

Figure 4. Dedicated Budget for Construction of New Hospitals and Outpatient Clinics by States (Source: Carpenter and Hoppszallern 2010)

A sensitivity analysis was performed on the dedicated budget in each state in the U.S. depicted in Table 1. The table shows the current budget for renovation of existing hospitals and construction of new hospitals. Each state was categorized into one of three groups: (1) states that allocated more funding to new construction of hospitals rather than renovations; (2) states with equal fund allocation to new hospital construction and renovations; and (3) states that spend more funding on hospital renovations than new hospital construction.

Results show that thirteen states plan to dedicate more funds to constructing new hospitals than to renovating existing facilities. Fifteen states spend about approximately the same amount of money for both renovation and new construction. Twenty two states and the District of Columbia plan to spend more money to renovate their facilities as related to the construction of new hospitals.

Hospital renovation projects can range from replacing windows to upgrading the mechanical system. Hospitals provide care 24/7 for the patient while serving visitors and the staff. In this context, hospitals are different from other types of commercial buildings.

Table 1. Allocated Budget for New Construction vs. Renovation of Existing Hospitals (Data from Carpenter & Hoppszallern 2010)

New Construction Projects in Hospitals and Outpatient Clinics (Dollars)	Renovation Projects in Hospitals and Outpatient Clinics (Dollars)							
	1 billion or greater	$500 million - $999.99 million	$200 million - $499.99 million	$100 million - $199.99 million	$50 million - $99.99 million	$20 million - $49.99 million	$5 million - $19.99 million	Less than $5 million
1 billion or greater	CA TX	IL	GA VA IN					
$500 million - $999.99 million		FL MA NC NJ PA	MO OH	MD	AZ	NV		
$200 million - $499.99 million	NY		CO MI MN WA	KY OK TN WI	AL	NM		
$100 million - $199.99 million			ID KS MS OR	LA IA		AK AR DE SD UT WV		
$50 million - $99.99 million				CT NE SC	ND	RI	MT	
$20 million - $49.99 million			NH	ME		VT		
$5 million - $19.99 million					WY			
Less than $5 million					DC		HI	

RESEARCH METHOD

The goal of this study was to gain a better understanding of the key issues in energy retrofits as implemented by hospital owners through an analysis of two case study projects. To meet this goal, the following objectives were achieved:

1) Determine the methods used by facilities group to identify ECMs;
2) Understand typical ECM categories used on case study projects;
3) Identify challenges and opportunities faced by the facilities group.

To begin the study several meetings were arranged with the facilities management (FM) team for the two healthcare facilities to understand the current FM methods. In one of the healthcare facilities, a full time project manager was leading the energy

efficiency projects for the facilities department. The project manager was coordinating daily with the facilities department and medical center to provide a non-disruptive environment for patients and staff during construction projects. In the other healthcare facility a Mechanical, Electrical and Plumbing (MEP) design engineer was responsible for providing a list of energy efficiency considerations / measures and opportunities.

In addition, the two healthcare facilities were audited to understand opportunities for conducting ECMs in healthcare facility retrofits. Through the literature review, meetings, face-to-face interviews and auditing ECMs of two healthcare facilities, the study was able to both find energy efficiency measures and also outline a taxonomy of requirements for energy conservation.

One of the case study healthcare facilities was a major hospital with more than 500 beds, and another one was an acute-care facility with 260 beds. Preliminary case studies data was obtained through informal interactions and face-to-face interviews with the healthcare facilities personnel. For these preliminary case studies it was not necessary to distinguish between the detailed practices of each hospital. Thus, the case studies are discussed together to provide an overview of the energy conservation measures being implemented. More in depth case studies are currently being conducted. Data analysis was performed to summarize the data which was collected. Data analysis involved the use of content analysis. Figure 5 shows the adopted research approach (the connection between healthcare facilities, retrofit and energy efficiency).

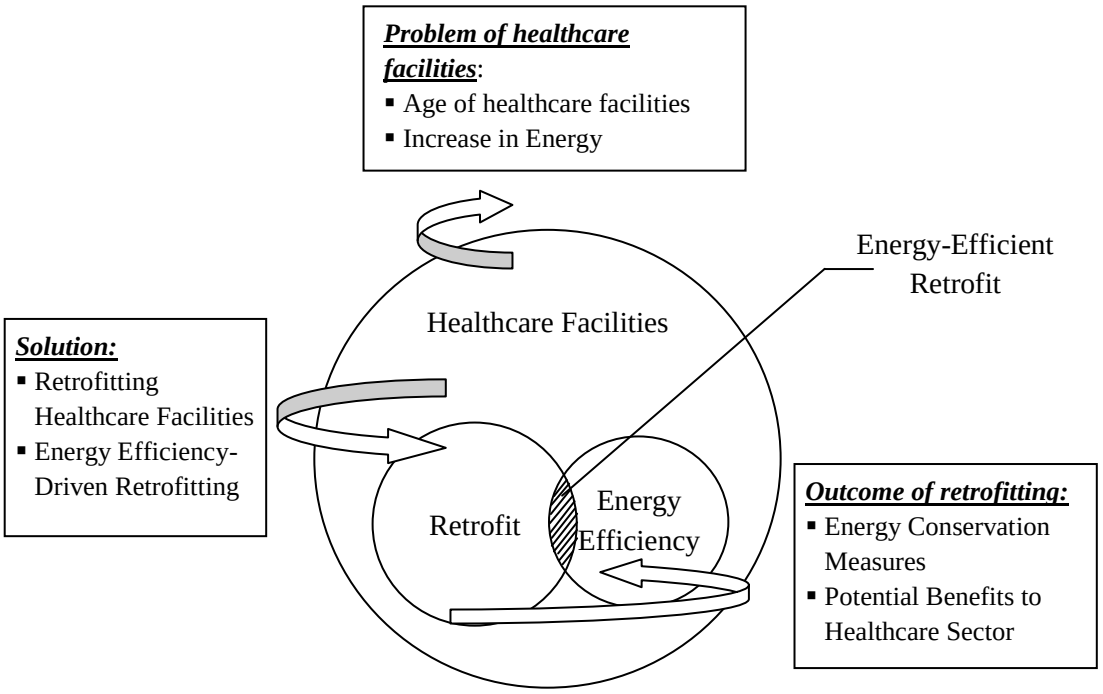

Figure 5. Adopted research approach

CATEGORIES OF ECMs

Several energy conservation measures (ECMs) have been undertaken or are under implementation in each of the healthcare facilities by the facilities group to save energy. The total projected annual savings in one of the healthcare facilities was more than one million dollars. Four main categories were identified in the two healthcare facilities (Figure 6). These four areas included 1) mechanical systems, 2) electrical systems, 3) facilities' interior finishes and 4) building envelopes. Each of these four areas and related ECMs to each group are described in the following sections:

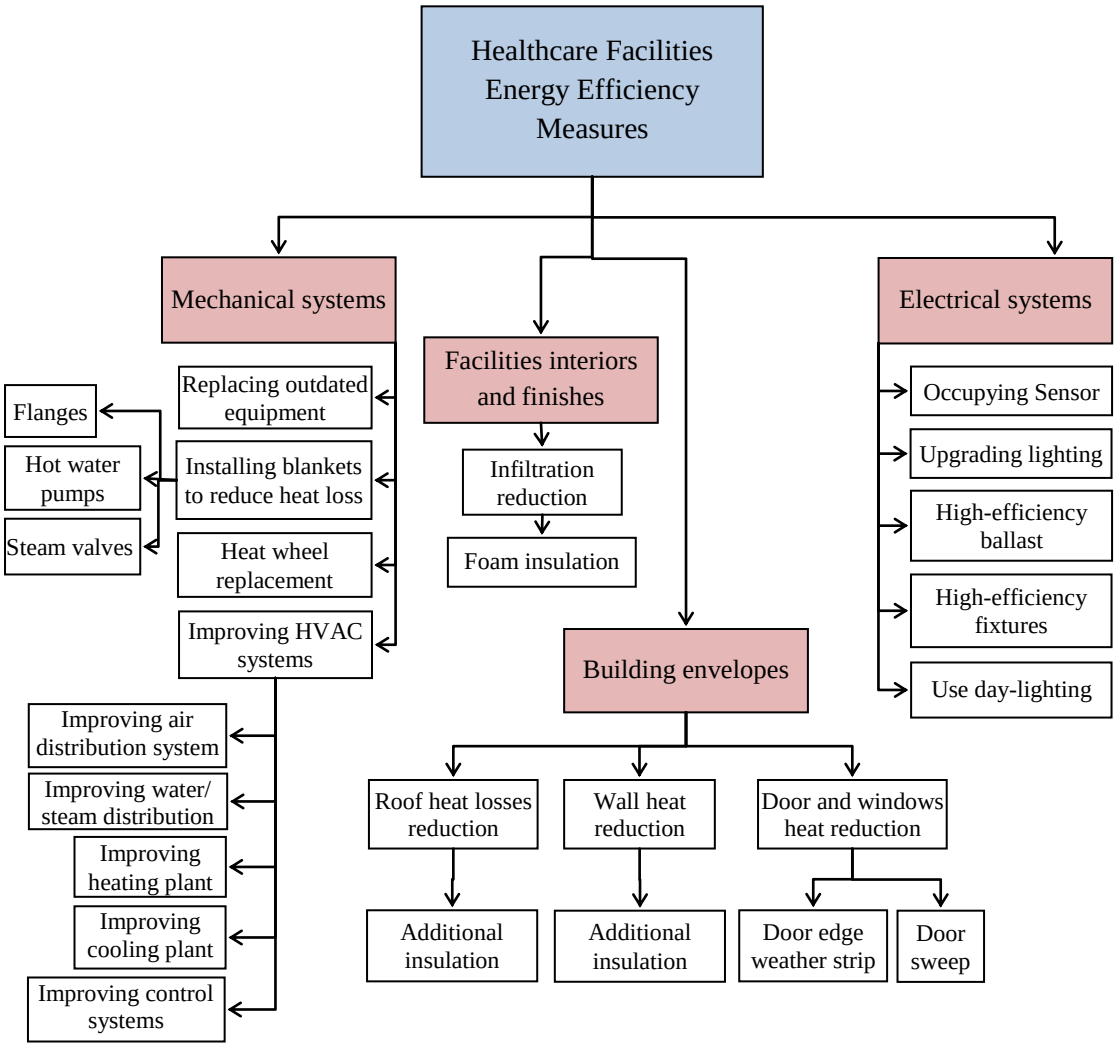

Figure 6. Implemented ECMs

Mechanical systems

Mechanical systems were one of the main concerns for ECMs in the two case study healthcare facilities with more than 50% of the total projected savings being related to mechanical systems. Some of the implemented ECMs included replacing outdated equipment, installing blankets to reduce heat loss (flanges, hot pumps, steam valves), replacing heat wheels (a device in ventilating system that works as an energy recovery heat exchanger), and improving HVAC systems (air distribution system, water/steam distribution, cooling plant, and control system) (see Figure 6).

Electrical systems
Facilities groups were interested in upgrading the electrical systems. ECMs were in different forms such as occupancy sensors, upgrading lighting, adding high efficiency ballasts, installing high efficient light fixtures, and using day lighting.

Facilities interior finishes
Infiltration reductions were done through attic insulation to reduce heat losses and exfiltration of conditioned air.

Building envelopes
The facilities groups used several techniques to improve the existing envelopes. These consisted of roof, wall, and door heat loss reduction by installing additional insulation including foam sealant (exterior holes and penetrations), and installing edge weather strips and sweeps. Improving the existing envelopes helped to increase patient and staff comfort and decrease heating and cooling systems load.

CRITICAL ISSUES RELATED TO ENERGY EFFICIENCY IN HEALTHCARE FACILITY RETROFITS

The healthcare industry is facing several challenges in retrofitting its facilities. Specific challenges and critical issues identified from the two case studies included: budget constraints; communication challenges; complexity of healthcare facilities; patient safety requirements; Lack of strategy and work structure in ECMs; and Lack of specialist personnel. The issues and challenges are described in the following sections.

Budget constraints
An increase in the cost of healthcare is one of the major challenges that healthcare providers in the U.S. are facing (Plunkett Research 2011). Generally, there is no dedicated budget for facilities groups to pursue the implementation of ECMs. Although ECMs are implemented to save energy in different types of buildings according to their usability, the savings require an initial investment, which only a subset of facilities groups is able to make. There is a risk to taking the initiative for promoting energy savings while there is no documented strategy or benchmark related to retrofitting healthcare facilities. For the above reasons, many facilities groups hesitate to implement ECMs widely or to make it one of their priorities.

Communication challenges
Effective communication is the key to information flow. There are no established and effective communication tools that provide a platform for all the stakeholders in healthcare facilities retrofit projects to exchange their opinions and share input on work strategies throughout the projects. For example, there are inadequate interaction protocols among the stakeholders (mechanical, electrical, structural, architectural engineers, operation and maintenance personnel, and facilities, infection control, and safety departments) in such retrofit projects.

Complexity of healthcare facilities
Healthcare facilities are complex and unique because they are non-stop work environments (24/7/365), shared by many people (Springer 2007). In addition, healthcare facilities are one of the most regulated building types (Rosenfeld 2005).

Due to this complexity and the regulatory environment for healthcare facilities, and also the specific attention that is needed to be paid to patient safety, the work processes for retrofitting the facilities are different from other types of buildings.

Patient safety requirements
After the Institute of Medicine's announcement regarding the death of 100,000 patients annually due to the lack of patient safety in U.S. hospitals, this issue has attracted considerable attention (IOM 1999). As such, any construction activity on healthcare facilities requires several considerations (such as conducting Infection Control Risk Assessment, ICRA) to be able to comply with patient safety standards and provide a safe environment for patients, staff and the general public.

Lack of strategy and work structure for ECMs
No documented strategy exists for the retrofitting of healthcare facilities, which provides step-by-step guidance, characterizes the critical energy efficiency opportunities, mechanisms/systems for implementing energy efficiency on healthcare retrofit projects. This makes it difficult to fully understand the shortcomings in the current approaches and identify opportunities for improvement.

Lack of specialist personnel
Implementing ECMs in the healthcare industry is often done by the Facilities Department and one individual is responsible for the implementation of ECMs. Some ECMs require limited specialists with high degrees of skills, or experiences through practice and work; these may need to be brought in by the Facilities Department, and budget constrains may not allow for this. Furthermore, facilities personnel may not be aware of several opportunities that exist for ECMs due to their busy schedules and other priorities in their daily work.

The two case studies illustrated a limitation in developing a clear understanding of the requirements for energy efficient retrofits particularly with regard to the interplay between achieving energy efficiency and maintaining patient safety. Providing a taxonomy for requirements will enable project team members to undertake the retrofitting of healthcare facilities from both a patient safety and energy efficiency perspective. As part of the detailed case studies a taxonomy is being developed to enable healthcare facilities management to understand the critical requirements for healthcare retrofits in accordance with enhancing patient safety and energy efficiency. Furthermore, a taxonomy would provide a synthesis of requirements that are well structured and illustrative of the conflicts and opportunities inherent in both energy efficiency and patient safety.

CONCLUSIONS

Based on the preliminary case studies and literature review, it was concluded that there are several challenges that need specific attention in healthcare retrofit projects. The critical issues that need further investigation include:

- There is an opportunity to simultaneously improve energy efficiency and patient safety in retrofit projects;
- There is limited understanding of the requirements for improving energy efficiency while concurrently ensuring patient safety;

- It is important to focus on synergies between energy efficiency and patient safety during the retrofitting of healthcare facilities (whole life cycle of retrofit projects from the feasibility and planning phase until the post-construction phase). This will provide a high level overview of the different stages involved in retrofitting healthcare facilities. Furthermore it will improve understanding of the value associated with patient safety and energy efficiency.
- The development of a taxonomy of requirements for energy-efficient healthcare retrofit offers the potential to improve the environment of care while also reducing operational costs.

The above issues are being explored further in detailed case studies and it is intended that this will result in an integrated framework for energy efficiency and safe healthcare retrofits.

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