RetroFit
AN RMI INITIATIVE

Project Case Study: Cleveland Clinic

Overview Section

Location: Ohio
Building owner: Cleveland Clinic
Building type: Medical research campus, acute care hospitals, testing and treatment centers, medical office buildings
Incremental Capital Cost of Retrofit: n/a
Total Cost of Retrofit: $0.03 per square foot per year
Building Portfolio Size: 24 million square feet
Main Campus Size: 13.6 million square feet, 189 acres, 50 buildings (4.7 acute care; 3.7 other clinical or clinical support; 0.8 research; 4.4 "other")
Completion Date: Ongoing
Annual Energy Use: 241 kBtu per square foot
Annual Energy Savings: 39.6 GW-hrs
Annual Energy Cost Savings: $5 million

Overview

Cleveland Clinic currently spends about $53 million a year on energy ($1.73 per second), which equates to just over 1% of its total annual expenditures. The clinic has calculated that the numerous efficiency measures adopted over the past few years amount to about $5 million dollars in avoided costs per year at this point. Strictly energy efficiency-based projects have rates of return of 0.62–10.91 years. All of that saved money is then reinvested back into improving clinical care.

Healthcare context:

The U.S. healthcare sector is incredibly energy intensive, with its facilities accounting for ~4% of all domestic site energy consumption (~8% of energy delivered to US buildings)[1]. As an integral part of our social fabric—one charged with promoting and protecting health above all else—tackling energy efficiency in hospitals presents unique challenges and opportunities for achieving radical results.

Acute care hospitals have one of the highest energy footprints of any commercial building type: 249 kBtu/ft2-y, second only to those of the food service industry and almost three times as much as an average building[2]. Experts have identified gross inefficiencies in such facilities that could lead to significant energy savings[3], yet several barriers impede deep energy retrofits. They range from cultural—institutional inertia and fear of new risks and liabilities are common—to logistical—construction can disrupt services and most hospitals don't have an alternative space to continue operations in during a retrofit. From a practical standpoint, there are few domestic models or experts to inspire or guide such projects. None of these obstacles have prevented the Cleveland Clinic from achieving energy savings of over 20% in a matter of years, however.

Cleveland Clinic:

Located in the eponymous Cleveland, Ohio, the Clinic has been a pioneering force in energy efficient healthcare retrofits. After an energy audit in 2007 revealed how inefficiently some of the clinic's systems were running, the facilities team embarked on a campus-wide mission to eliminate energy waste. Yet the Senior Director for Facilities, John D'Angelo, PE, remains adamant that he does not, nor will ever have, an energy program. Rather, he explains, Cleveland Clinic has a "Patient Program," of which "energy is a part." He looks for ways to "positively impact Patient Outcomes, Patient Safety, and/or Patient Experience and then figures out how to save energy in the process." Because adopting energy efficient strategies and measures often improves the performance of other aspects of healthcare, his approach creates positive-feedback loops between investments made to enhance patients' experiences and his hospitals' efficient use of natural resources.

The nonprofit Cleveland Clinic was founded in

[1] CBECS 2003; "Targeting 100"
[2] CBECS 2003
[3] "Targeting 100"

1921 and has since grown into one of the leading healthcare facilities in the world. It is now a multispecialty academic medical center composed of a main campus as well as dozens of regional hospitals, outpatient facilities, and specialized testing and treatment centers that cover 24 million square feet of real estate and directly employ over 40,000 people. The central campus, which is the heart of the organization, consists of 50 buildings spread out over 189 acres.

Innovation was a core principle espoused by the clinic's founders, a value which has been continuously fostered since its inception almost a century ago, as evidenced by the long list of firsts and inventions that have occurred there—from the isolation of serotonin to the performance of the world's first robotic single port surgery. A penchant for experimentation and comfort with the cutting edge are part of the clinic's institutional fabric. Thus it is no small wonder that Cleveland Clinic is also pushing boundaries outside of its laboratories and operating theaters with its energy efficiency measures.

Because the clinic is such a singular entity in the region—it isn't just a hospital, but an extensive portfolio of diverse building types—it is difficult to establish a baseline for how the medical campus should be performing and what types of savings are possible. As far as acute care hospitals go, however, the EPA's TargetFinder reports that the average healthcare facility in the region[4] has an energy use intensity (EUI) of 263 kBtu/ ft2-y. In 2007, the EUI of the entire Cleveland Clinic campus was ~300 kBtu/ft2-y.

Since he began hunting down and eliminating energy inefficiencies, Cleveland Clinic has spent an average of $825,000 per year[5] on efficiency measures, such as switching to higher quality, more efficient lighting, often controlled by occupancy sensors, for example. Such measures have reduced its energy use by more than 20% and are currently saving the clinic almost $5 million annually. Due to its success, Cleveland Clinic was named an EPA Energy Star Partner of the year in 2011.

Because Cleveland Clinic views its energy efficiency improvement as part of a broader focus on patient care and staff safety, it can be difficult to quantify its overall financial investment in energy efficiency measures. According to D'Angelo, most investments are made to maintain and improve overall building performance using the pre-existing building systems, rather than to dramatically increase energy efficiency through a complete system overhaul or replacement.

Facilities Management Approach

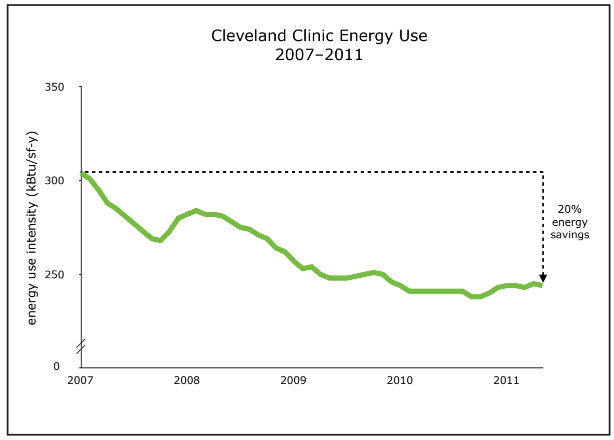

Fig 1. Cleveland Clinic portfolio-wide site-energy use intensity dropped from 304 in February of 2007 to 243 by February of 2011. These numbers include new buildings constructed during this period, all of which were built with energy efficiency in mind.

Project Process

Cleveland Clinic officials and staff tend to focus on the demand side of energy issues, having concluded that the site is not well-suited for substantial onsite renewable energy generation, due to a poor wind profile and significant rooftop activity that impedes the installation of large solar arrays (though the clinic does have one 110KW rooftop array and was recently awarded a contract for a second). The main campus' current central utility plant can't accommodate a combined heat and power (CHP) system, though the clinic is planning to build a new central plant within a decade, which will incorporate some CHP.

Implementing energy efficient practices and equipment is an ongoing process across the clinic's entire portfolio, particularly around the main campus. Most of the buildings have similar and/or shared systems, so upgrades tend to be system-wide and the cost of design tends to be minimal. The facilities team has been primarily

[4] Climate zone 5A, 527,000 million square feet, seven stories, 225 beds

[5] An average based on 2010 & 2011 costs

targeting low-hanging fruit and almost always opts for the more energy efficient options when replacing deficient equipment. Despite the sensible nature of such improvements, changes at the institution are usually made within the following framework of steps:

1. Identify energy inefficiencies
The Senior Director for Facilities at Cleveland Clinic believes that equipment that is not running properly accounts for the majority of energy waste in a given facility. Beyond its inefficiency, poorly functioning systems and equipment also require the largest share of man-hours and maintenance costs. The facilities management team at CC frequently uses simple infrared (heat-detecting) cameras to pinpoint problem areas, such as loose electrical connections and overloaded circuits (electrical systems tend to overheat before they fail), missing or damaged insulation, and building envelope air leaks. It also relies heavily on data-loggers to measure temperature and humidity to diagnose problem areas.[6]

2. Research/evaluate alternative technologies & practices
The facilities team researches all available alternatives, looking for technologies or practices that will reduce inefficiencies and allow both worker and financial resources to be redirected elsewhere. Though decreasing energy use is one of their goals, nothing will be considered that might jeopardize patients' health or experiences at the clinic.

3. Test options in non-critical space
Rather than simply trusting established practices or manufacturers' literature, the Facilities Director and his team then install and test the most promising alternatives in a non-critical campus space. They subject the new technology to a variety of conditions and take multiple performance measurements, determining how it functions over time (up to many months). In certain circumstances, if a given technology is relatively simple to install, the expected outcomes are straightforward, and it has already proven itself over time in other facilities, it will be recommended without an extensive trial period—such was the case for variable frequency drives on large air handlers, for example.

4. Share results with appropriate leadership
If the data collected in the previous step indicates that the new measure or technology will lower energy use and have a positive or neutral impact on patients and staff, the Senior Director for Facilities is informed of its potential.

5. Propose measures at annual infrastructure budgetary meeting
Once a year, the directors from all of the Clinic's facilities—who report to Senior Director for Facilities—meet to determine their budgets for the following year. Proposed projects for each facility are given scores based on a handful of metrics, both qualitative and quantitative, such as visibility, patient impact, and payback. Long term (up to five year) strategic plans for the facilities are also taken into account. Though energy savings are valued, they are not the top priority and thus not considered explicitly at this stage; instead, their effects are subjectively incorporated into the other categories being evaluated.

6. If approved, apply changes at appropriate scale
Some measures are one-time projects, while others may involve replacing equipment throughout a whole facility, or even across the Clinic's entire portfolio of buildings. Applying changes at a very large scale may enable bulk purchasing and other opportunities that drive better economics, as was the case with system-wide replacement of T12 lighting under a single contract, which yielded savings of 10% compared to what the same work would have cost if procured independently by each location.

Institutional Risk Analysis & Mitigation

Though innovative, Cleveland Clinic and its facilities team are risk adverse, as one would expect any hospital to be when human health is on the line. The wellbeing of patients and the staff who care for them is not the Clinic's only concern, though. The Clinic must also demonstrate fiscal responsibility to its board of trustees. The two basic types of risk that Cleveland Clinic must manage are described below.

The first type of risk— that to patient and staff wellbeing — is managed directly in Step 3 through trial periods. The relamping of the clinic's

[6] John D'Angelo, Cleveland Clinic Director of Facilities, Personal Communication.

parking structures provides a salient example of this process. Interested in determining whether or not LED lights could be substituted for the current fixtures, the Facilities Director decided to install one in a rarely-used corner of a parking garage. Because the spaces in the lower levels always filled up first, leaving the very top level virtually empty, D'Angelo replaced all lights in that deck (57, to be exact). Upon returning to the structure early one morning to take a light level reading, he noticed that the garage was unusually empty as he wended his way up the lower levels. Yet when he arrived at the top, the garage was packed with cars! Spotting a nurse returning to her vehicle, he asked her why she had parked so high up. "Because this is the safest spot," she replied, confirming at least qualitatively that the new light far outperformed its predecessor.

The second type of risk—that an efficiency measure is not worth the investment—is evaluated in Step 5. Because energy efficiency is not a priority in and of itself at Cleveland Clinic, more efficient practices and equipment must be rated according to their ability to improve other elements of the hospital's performance. Unless they promise to improve the patient experience, visitor safety, or clinical outcomes, they will not receive funding because the Clinic believes that that money could be better invested to achieve those results elsewhere. Thus, the source of risk is not so much the uncertainty around predicted energy cost savings or even the implementation cost, but a foggy view of how the measure will create non-energy benefits.

Energy Efficiency Measures

After retro-commissioning most of the main campus, the hospital's Office for a Healthy Environment (OHE) began re-investing in infrastructure. In conjunction with training employees in better energy practices, the clinic began installing modern, more efficient equipment. As part of this effort, the Clinic:

- Replaced thousands of incandescent bulbs with LEDs, when they were able to
- produce the same, if not better effects, and CFLs when not
- Is completely free of T12 fluorescent lighting
- Installed occupancy sensors to control lighting
- Installed variable-frequency drives (VFDs) on all applicable main campus motors
- Installed UV lights on cooling coils
- Locked thermostats to better control temperature setpoints

Each measure has multiple benefits (in fact, it had to in order to be adopted), though some measures created compounding efficiencies that led to remarkable results.

One good example of compounding efficiencies is lighting in the operating room. Directed lighting that provides high contrast is crucial during surgery—particularly for deep incisions—and is usually provided by 2–4 overhead task lights in conjunction with headband lights worn by the surgeons. The halogen task lights are about 2–3.5 ft (0.6–1m) in diameter and hold a tungsten filament that incandesces at a temperature over 3600° F (2000° C), radiating tremendous amounts of heat and making the doctors, who wear full personal protective equipment (masks, gowns, etc.), overheat quickly. To combat the effect, they turn up the air conditioning. By code, the temperature is not supposed to drop below 68° F, though most hospitals apply for an exception and keep their operating theaters at much cooler temperatures for surgeons' comfort.

Such low ambient air temperatures would make patients undergoing surgery essentially hypothermic. This condition causes blood to drain away from the skin, which in turn makes them much more vulnerable to post-operative infection. To mitigate this risk, doctors wrap the patient in an electric blanket, which is responsible for the largest electric draw in the room.

By replacing traditional halogen lights with LED surgical lamps, as the Cleveland Clinic and the majority of European hospitals are doing, the hospital reaps multiple benefits. First and foremost, the LEDs provide superior performance: their color rendering and temperature (light quality) and lumen output (light quantity) can be finely tuned to meet the needs of the situation, delivering excellent visual acuity for less energy. They also generate only a small amount of heat that dissipates upward and doesn't overheat the doctors who are performing surgeries. As a result, surgeons don't need to cool the operating room and patients don't require heating blankets. The simple change to LEDs saves 60% of the energy used for lighting while significantly reducing the energy demands of cooling the surgeons and warming their patients.

Barriers & Solutions

Acute care hospitals are particularly difficult structures to retrofit for numerous reasons, though two of the largest hurdles that must be faced are logistical and structural. First, hospitals cannot simply go offline for renovations. Almost no facilities have a temporary space to which they can transfer operations while the main building undergoes a deep retrofit. This means that an entire hospital structure cannot be shut down all at once without seriously jeopardizing the financial security of the hospital as well as the health of the people and community it serves. As such, capital improvements are often done piecemeal, with only certain divisions shutting down for a short period of time. Even these renovation projects are limited by the necessity of continuing critical care operations and protecting the well-being of patients and staff that remain in the building throughout construction.

At Cleveland Clinic, the impacts of a renovation are mitigated by the installation of high efficiency particulate air (HEPA) barriers and the adoption of interim life safety measures. These types of precautionary measures are especially critical in spaces used to treat immunocompromised patients.

The second large barrier that prevents deep retrofits is purely structural: many hospitals were built in the post-war boom and aging hospitals that were constructed in the 1950s and 1960s do not have adequate floor-to-floor ceiling spaces to incorporate modern HVAC systems. While those structures tend to have 12 ft (3.6m) floor-to-floor heights, new hospitals have floor-to-floor spaces of at least 14 ft (4.3m) to allow for large air ducts between floors (One attractive solution to the space issue would be to switch to a water-based heating and cooling system, which would only require pipes with a diameter of just a few inches instead[7].)

Despite these sizable challenges and a slew of others—some real, some imagined—, hospital retrofits for deep energy savings are not impossible. Generally speaking, the following barriers and solutions are all relevant to achieving deep energy savings in healthcare facilities:

Financing: The healthcare funding crisis doesn't allow for extended rates of returns. Similarly, the first cost of new equipment and technologies can seem too high to finance.

Solution: Demonstrate that upfront capital expenditures can generate rapid returns from energy cost savings as well as other benefits. Additionally, 80% of a buildings cost typically stems from operations and maintenance over the course of its lifetime. Analyzing life cycle costs is critical to an organization's future wellbeing[8].

False Perceptions: There is often a sense that greater energy use leads to better outcomes. Because there isn't always data or widespread knowledge about the relationship between energy use and performance, there isn't a clearly compelling business case for energy efficiency.

Solution: Need to have real and verified examples of efficiency measures increasing performance, such as by improving air quality[8], while using less energy.

Few Models & Specialists: The U.S. lacks models of deeply energy efficient hospitals and there are not many capable engineers, architects, and commissioners that specialize in the field. "Cream-skimming" occurs frequently when efficiency initiatives are adopted.

Solution: Need to generate more case studies of successful domestic and international counterparts, make reference materials easily accessible online, and host conferences and training sessions on these topics.

Low Awareness & Demand: U.S. hospitals aren't demanding high efficiency designs and equipment, so they aren't being developed and manufactured. Few incentives exist because common accounting practice is to separate capital and operating budgets

Solution: Hospitals can begin partnering with other entities—such as utilities, energy service companies, and equipment manufacturers—to create low-hassle solutions that deliver both technical design expertise as well as financing options.

Restrictive Regulatory Environment: Because

[7] Personal communication with Peter Rumsey, an ASHRAE Fellow and Director of Integral Group, who suggests that current ASHRAE codes may prohibit such a solution and if codes can be changed and from an architecture and engineering perspective it could be an elegant one.

[8] John D'Angelo, Cleveland Clinic Director of Facilities, Personal Communication.

[9] "Healthcare Ventilation Research Collaborative: Displacement Ventilation Research (Phase II: Summary Report)"

human health and safety is of paramount concern, safety codes and regulations can unnecessarily prohibit energy efficiency improvements.

Solution: Hospitals, particularly those tied with research institutions, need to produce more empirical studies and generate support for changing outdated codes and regulations[10].

Split Incentives: This is a common tension that exists between tenants and landlords, as well as within hospital departments that are competing for the same funds.

Solution: Incentives can be better aligned via demonstrations that show how savings that stem from energy efficiency measures can be reinvested in other departments down the road. This also ties back to a need to highlight how increased efficiency significantly enhances the performance of other elements of hospital operations as well.

Risk Aversion: New technology and designs—even if they have been proven in other hospitals—create uncertainty and risk and may expose hospitals to more types of liability.

Solution: More high-profile success stories with visible performance measures and widespread, positive publicity can help ameliorate these concerns.

Institutional Inertia: Familiarity with current practices, ownership of inefficient, though still functional, equipment and buildings, and anxiety about the unknown often prevent radical changes.

Solution: Long-term investment roadmaps can enable the timing of radical changes with building-equipment and component replacement cycles.

Lessons Learned

Despite the financial performance of its efficiency improvements, the Cleveland Clinic is not likely to realize much more substantial savings in the near future—getting the next 20% of savings will be significantly harder than the first 20% was. Though willing to try new things, the Clinic is in the business of human health, not energy, and is unwilling to pursue savings at the risk of negatively impacting patient outcomes, safety, or experience.

This case study demonstrates that large energy savings can be achieved within a portfolio of healthcare buildings simply by tackling low-hanging fruit, though also highlights the significant barriers that are preventing hospitals from achieving deep energy savings. Though challenging, hospitals are full of inefficiencies, and examples like the Cleveland Clinic provide a helpful framework for how to begin tackling them effectively.

- Hospitals are difficult retrofit candidates because:

1. Patient safety is of the utmost concern and most don't have backup facilities that they can transfer operations to while the main hospital undergoes a full renovation
2. Structurally, the demands of a modern hospital are very different than those built in the post-war era, making it difficult to transfer current practices to an old building. The primary constraint is floor-to-floor heights, which have increased to incorporate large HVAC ducts.

- Measures can be timed over several years to enable continuous hospital operation, lower incremental capital cost, and minimal disturbance of patients and staff
- Hospitals abound in low-hanging fruit, so retro-commissioning a facility can result in large energy savings.
- Energy efficiency measures benefit the health of patients, the community, and the planet, making them ideal candidates for enhancing the image of a hospital, which is designed to safeguard those very things.

[10] An example is the recent change in ASHRAE's relative humidity code, which was based on flammable ethers that are no longer used in operating rooms.

Works Cited

Burpee, Heather & J. Loveland. Targeting 100! University of Washington's Integrated Design Lab. University of Washington (2010).

D'Angelo, John. Energy Tools. (forthcoming)

D'Angelo, John. PE, CMVP. Senior Director for Facilities, Cleveland Clinic. Personal communications (2011).

Guity, Arash, PE, B. Gulick, PE, & P. Marmion, PEng. Healthcare Ventilation Research Collaborative: Displacement Ventilation Research (Phase II Summary Report). Healthcare Research Collaborative (2009).

Rumsey, Peter. PE, FASHRAE. West Coast Director, Integral Group. Personal communication (2011).

U.S. Energy Information Administration. Commercial Building Energy Consumption Survey, 2003. http://www.eia.doe.gov/emeu/cbecs/. (2003).