# The Art of Commissioning:
## A Cost Benefit Analysis of 23 Large-scale Federal Facilities

*Wesley Stanhope CEM EBCP*

ABSTRACT

Energy is being wasted, possibly unrecognizably, on a daily basis when commissioning is not performed. This results in a reduction in profit, equipment lifespan and overall sustainability. Common misconceptions can be that operating systems are already efficient since they work, making commissioning unnecessary, and that there is not much benefit from periodically commissioning a building throughout its lifespan.

This research details pre-commissioning energy consumption versus post-commissioning as well as commissioning costs of three different test groups of facilities which have undertaken various commissioning projects. This article will be a logical argument to motivate building owners to consider commissioning.

## INTRODUCTION

Commissioning is a living and adapting process that can be implemented throughout the entire lifespan of a building. The research and results of this report prove that buildings benefit from commissioning generally, and from a more continuous, ongoing form of real-time commissioning.

To maximize energy reductions, not only should simple repairs revealed during the commissioning process be implemented, but completion of the recommended minor repairs, deferred maintenance and capital improvements is necessary. A typical, but unfortunate, choice for many facilities is to complete only repairs with the shortest return on investment, while postponing those with longer but still significant paybacks.

This research analyzed the energy use intensity (EUI) of 23 federal hospital facilities, with various levels of commissioning. Further research examined the energy conservation measures (ECMs) recommended by nine major commissioning efforts. Analysis reveals that not only is it cost effective to implement commissioning and the minor repairs, and deferred maintenance and utility monitoring the process recommends, but that the savings from carrying out minor ECMs are enough to fund more major energy-saving capital improvements.

## COMMISSIONING

Commissioning is a term that has been used for centuries when a newly constructed naval vessel is tested through multiple trials to ensure seaworthiness. Deficiencies found must be corrected prior to a ship's being commissioned. With modern vessels the process can last several years before a ship is deemed commissioned.

Buildings may not be commissioned to similar standards for the reason that they fail silently—slowly over time without a catastrophic event. According to studies by Seppanen *et al*, sick building syndrome is estimated to cost a range of $20-160 billion a year in lost productivity in the USA, which could be reduced or eliminated if building systems operated properly.

Equally important, when building systems are not operating as originally designed, they will cause an increase in energy consumption and pollutants within the environment. In 1998 it is estimated the buildings in the USA contributed to 523 million metric tons of carbon every year[1]. The built environment within the United States consumed 36% of the country's primary energy in 1998[2]. This equates to 33.7 quadrillion Btu. In 2008 the mechanical and HVAC alone within residential, commercial and industrial equates to 11.65 quadrillion Btu.

Building commissioning has the opportunity to provide the most logical and systematical approach to ensuring peak performance of a building and its sub-systems. Commissioning within the built environment was first carried out by The Public Works Canada, in 1977[3]. In 1981, Disney included commissioning in the design, construction and startup of Epcot[4]. ASHRAE began formalizing building commissioning procedures in the USA when their Commissioning Guidelines Committee published its first guidelines to commissioning. Throughout the next

two decades many utility companies, government agencies and private organizations began to require building commissioning. It is now an integral part of green building certification procedures such as Leadership in Energy and Environmental Design (LEED) and Energy Star, and is widely used by government agencies such as EPA, DOE, GSA, VA and FEMP.

As far as new construction is concerned, and according to LEED, the intent of fundamental commissioning is to "verify that the building's energy related systems are installed, calibrated, and perform according to the owner's project requirements, basis of design and construction documents."[5] The common goal of all building commissioning is to reduce energy consumption while operating at peak efficiency, thus reducing costs and becoming more sustainable.

The most advantageous time to evaluate problems is early in the design process, when a facility's requirement specifications are being prepared. The typical breakdown in relative cost to repair problems is shown in Figure 1.

As the facility passes through each subsequent phase, the cost to repair an issue becomes greater, the time to repair it more extended, and the repair itself more elaborate. The best time to start a commissioning process is prior to construction. Figure 2 demonstrates the three main stages of a facility and on average how many problems began in each phase. The design stage contributes to about 35% of all building faults, the construction stage contributes to about 33%, and the maintenance

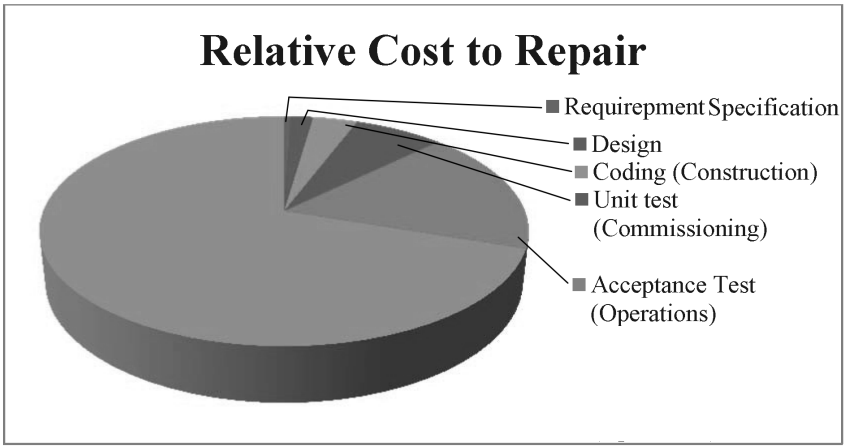



**Figure 1: Relative Cost to Repair Facility Problems**

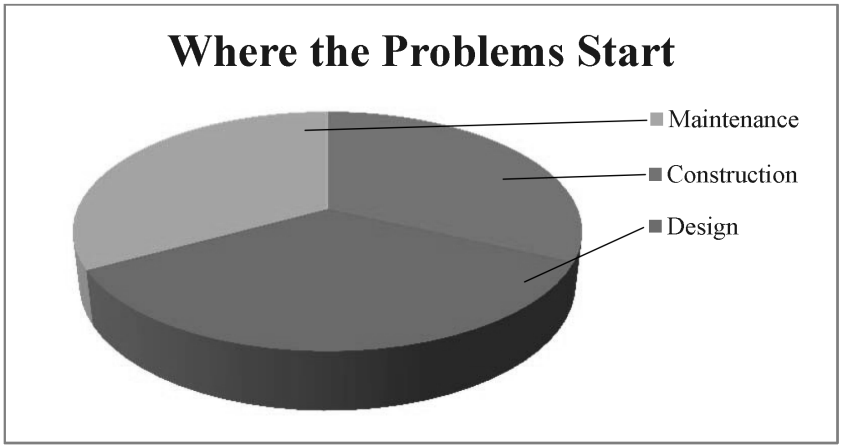



**Figure 2: Where the Problem Started**

stage contributes the least at about 32%.

Commissioning new buildings is becoming increasingly routine. Unfortunately, most of the building stocks in this country, and particularly in the federal building portfolio, are existing buildings. For example the DOE reported in 2003 that nearly 4.9 million office buildings exist in the US. Every year 170,000 buildings are constructed while 44,000 are demolished. With this ratio, a maximum of only 3.5% of all buildings will be able to implement commissioning from the specification and design stage.

**Existing Building Commissioning**

Building commissioning is the term used for testing and verifying environmental systems to ensure individual pieces of equipment or environmental systems as a whole are operating properly. There are four building commissioning processes as outlined below:

- **Commissioning (Cx)**: when new construction or a renovation is commissioned.
- **Retro-commissioning (RCx)**: when a building is commissioned for the first time after it has been constructed and typically after a warranty period.
- **Re-commissioning (Re-Cx)**: when a building is commissioned again, sometime after it has been commissioned or retro-commissioned.

- **Real-time-commissioning (RTCx)**: when a building is continuously monitored, preferably with real time data, and evaluated whenever there is a spike in energy consumption.

Since the majority of buildings within the USA already exist, the focus of this study was on RCx, Re-Cx and RTCx. According to the Energy Independence and Security Act 2007 (EISA-2007) the term "retro-commissioning" means "a process of commissioning a facility or system that was not commissioned at the time of construction of the facility or system.[6]"

Once a building is commissioned or retro-commissioned any further commissioning is called "re-commissioning," which according to EISA-2007 means "A process (i) of commissioning a facility or system beyond the project development and warranty phases of the facility or system; and (ii) the primary goal of which is to ensure optimum performance of a facility, in accordance with design or current operating needs, over the useful life of the facility, while meeting building occupancy requirements[7]." Buildings should be re-commissioned periodically.

According to Federal Energy Management Programs,[8] the Real-Time-Commissioning (RTCx) is described as an "ongoing process that improves building operation using measured hourly energy use and environmental data."

The RTCx process can rely on regular utility bill analysis—a reactive approach to finding problems and instituting corrections. Utilities are generally monitored in monthly intervals. A spike in utility consumption may thus occur at any point in time and may be up to a month before the data are available for review. For a proactive approach, a facility must be able to generate real time data and feedback on the its operations. To better manage periodic or continuous building data, a facility may require advanced metering as an integral aspect of RTCx. Metered data are used to develop baseline operations of the systems, and evaluate conditions which are not within the design characteristics. The facility manager can then implement corrective action when needed.

**Deferred Maintenance vs. Minor Repairs and Capital Improvements**

For the purpose of this analysis, "deferred maintenance" repairs are typically larger than minor field repairs, take longer than 15 minutes, and could have materials to repair, but are not as great as capital

improvements. Payback for deferred maintenance improvements is typically more than 3 years and less than 15 years, whereas for simple repairs it is typically less than 3 years, and for capital improvements it is typically more than 15 years.

Deferred maintenance differs from routine maintenance in that it is typically the upkeep of equipment that is postponed due to lack of resources. In many situations the equipment can continue to operate without the deferred maintenance, but the equipment would operate more efficiently and have an extended lifespan if the deferred maintenance were performed. These can be minor issues requiring repairs that will evolve into a more serious problem and ultimately reduce the useful life of the equipment.

**Facility Energy Use Intensity (EUI) Analysis**

Twenty-three large federal hospital facilities (names held anonymous for this study) were analyzed using actual energy use data from facility utility bills. Facilities were separated into three groups.

- A first group, six facilities, had never been through a commissioning process.
- A second group, eight facilities, had recently experienced commissioning for the first time, some years after they were built (retro-commissioning). This group reported implementation of simple repairs but no implementation of minor repairs, deferred maintenance or capital improvements.
- A third group, nine facilities, experienced retro-commissioning with full implementation of minor repairs and deferred maintenance. Facilities in this group had all recently begun to implement real-time commissioning. Because of the relevance of their experience, this third group will be referred to in this report as the "Energy Use Intensity Analysis Group."

The average EUI of all three groups taken together was approximately 180 kBtu/sq.ft. and was relatively constant over 9 years. Over this time, however, there were some external influences that increased EUI, and some that decreased it.

Three potential external influences were examined to isolate the effect of building commissioning on EUI: weather extremes, the extent of construction projects undertaken, and the size of patient populations.

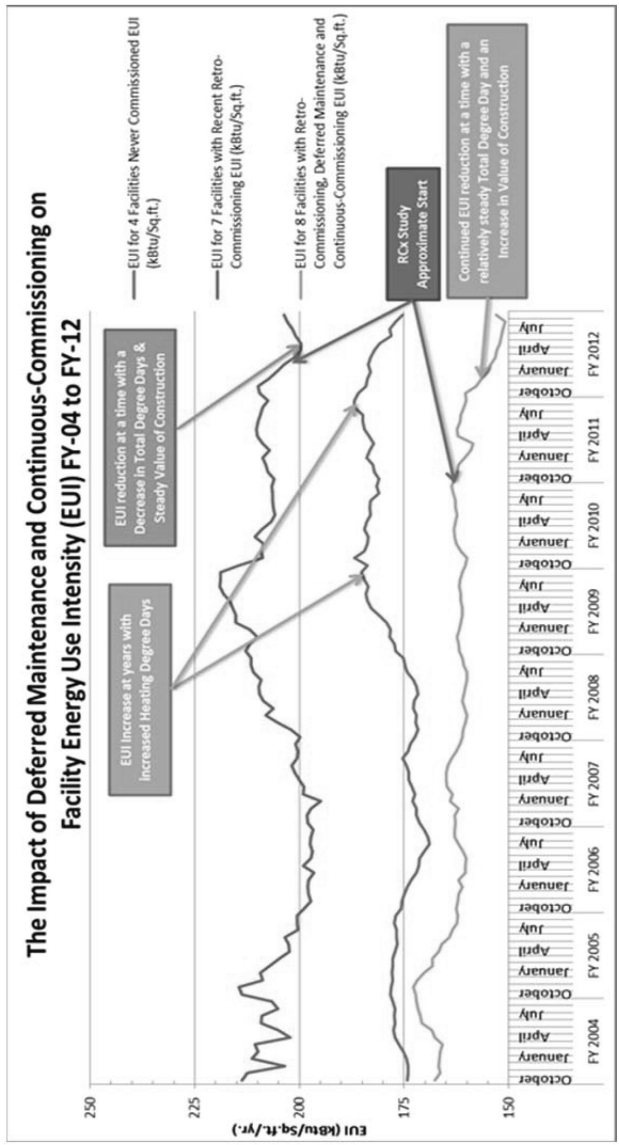



**Figure 3: Impact of Deferred Maintenance and Real-time Commissioning on EUI**

These influences were hypothesized to affect EUI as follows:

A. **Heating degree day (HDD) & cooling degree day (CDD)**: Facility EUI was expected to increase during years with higher heating and cooling demand.

B. **Construction values**: Facility EUI was expected to increase during periods of construction and renovation because the energy needed for construction would be added to the base energy without an increase in the size of the facility.

C. **Total patient population**: Facility EUI was expected to increase/decrease with the increase/decrease of patient population which was assumed to occur without changes in facility size.

These influences could be examined independent of building commissioning by looking at Groups One and Two (the six facilities that had not experienced commissioning and the eight facilities that experienced only very recent retro-commissioning). Examining the trends of EUI within these groups confirmed the hypotheses that EUI increases with the increase of heating degree days (although it did not seem to increase as much with cooling degree days), and that it increased as the value of construction undertaken increased. Patient population remained relatively constant over the 9 years for these two groups and thus was eliminated as a potential factor influencing EUI.

The first group includes six facilities, none of which has been through a commissioning or retro-commissioning process. Although the EUI fluctuates over the 9 years for all of the facilities, as a whole it stays relatively constant.

Overview of facilities without commissioning:

- EUI has remained relatively constant over the 9 years analyzed;
- EUI increases with the increase in heating degree days;
- EUI does not appear to be affected by cooling degree days;
- Patient population is relatively constant for this group and thus does not impact EUI;
- EUI increases with the increase in construction value.

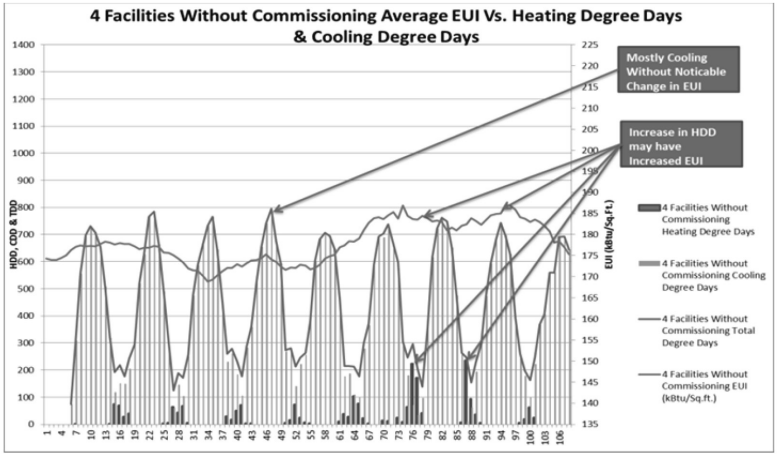



**Figure 4: Facilities without Commissioning**

The second group of facilities, eight in total, has experienced a recent retro-commissioning process. Most of the retro-commissioning has taken place in the last fiscal year, so the minor repairs probably have not been implemented by the end of FY-12. These facilities decided to implement only minor repairs of 15 minutes or less and did not implement deferred maintenance. Also there might not have been sufficient time to monitor and confirm substantial and lasting effect in EUI reductions. EUI is only slightly lower in FY-12 than in FY-04.

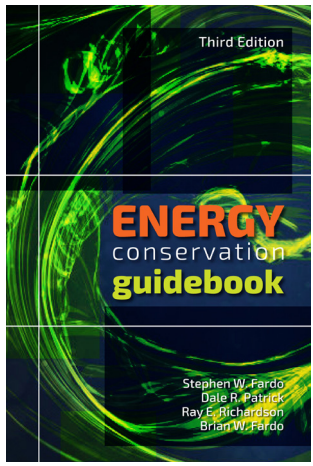
Overview of facilities with retro-commissioning:

- There is not enough evidence in this case to evaluate the benefit of retro-commissioning, as the benefit would be realized in FY-13.
- There is not enough evidence or reduction in EUI in this case to evaluate the benefits of only implementing minor repairs under 15 minutes without other minor repairs and deferred maintenance.
- EUI increases with the increase in heating degree days;
- EUI does not appear to be affected by the cooling degree days;
- Patient population remains constant and does not appear to affect the EUI;
- EUI increases with the increase in construction value, and decreases with the decrease in construction value.

10% Online Discount
Use Code JR10

# ENERGY CONSERVATION GUIDEBOOK, 3rd Edition

*Stephen W. Fardo, Dale R. Patrick, Ray E. Richardson and Brian W. Fardo*




Revised and edited, this new third edition reference covers the full scope of energy management techniques and applications for new and existing buildings, with emphasis on the "systems" approach to developing an effective overall energy management strategy. Foremost in the enhancements to the new edition is content that reflects the emphasis on conservation for green energy awareness. Building structural considerations are examined, such as heat loss and gain, windows, and insulation. A thorough discussion of heating and cooling systems basics is provided, along with energy management guidelines. Also covered are conservation measures which may be applied for lighting systems, water systems and electrical systems. Specific energy management technologies and their application are discussed in detail, including solar energy systems, energy management systems, and alternative energy technologies.

ISBN: 0-88173-716-X

6 x 9, 553 pp., Illus.
Hardcover

*$125*
*Order Code 0699*

CONTENTS



## BOOK ORDER FORM

① Complete quantity and amount due for each book you wish to order:

| Quantity | Book Title | Order Code | Price | Amount Due |
|---|---|---|---|---|
| | **Energy Conservation Guidebook, 3rd Edition** | **0699** | **$125.00** | |

② Indicate shipping address: CODE: Journal 2014

NAME (Please print) BUSINESS PHONE

SIGNATURE (Required to process order) EMAIL ADDRESS

COMPANY

STREET ADDRESS ONLY (No P.O. Box)

CITY, STATE, ZIP

| | |
|---|---|
| Applicable Discount | |
| *Georgia Residents add 6% Sales Tax* | |
| *Shipping $10 first book $4 each additional book* | **10.00** |
| **TOTAL** | |

**MEMBER DISCOUNTS—A 15% discount is allowed to AEE members (discounts cannot be combined).**
☐ **AEE Member (Member No._____)**

③ Select method of payment:
☐ **CHECK ENCLOSED**
☐ **CHARGE TO MY CREDIT CARD**
☐ *VISA* ☐ *MASTERCARD* ☐ *AMERICAN EXPRESS*

CARD NO.

*Expiration date* *Signature*

*Make check payable in U.S. funds to:*
**AEE ENERGY BOOKS**

④ Send your order to:
**AEE BOOKS**
P.O. Box 1026
Lilburn, GA 30048

**INTERNET ORDERING**
**www.aeecenter.org/books**
**(use discount code)**

**TO ORDER BY PHONE**
**Use your credit card and call:**
**(770) 925-9558**

**TO ORDER BY FAX**
**Complete and Fax to:**
**(770) 381-9865**

**INTERNATIONAL ORDERS**
Must be prepaid in U.S. dollars and must include an additional charge of $10.00 per book plus 15% for shipping and handling by surface mail.

10% Online Discount
Use Code JR10

# RESIDENTIAL ENERGY AUDITING AND IMPROVEMENT

*Stan Harbuck and Donna Harbuck*


Here is your complete guide to the effective practice of residential energy auditing, covering in detail the specific procedures, techniques and standards practiced within the profession today. The book is intended for use as an educational resource by energy auditors or residential retrofitters, whether working in a weatherization program or in the private arena. Specific topics include the house as a system, the auditor's tools, weatherization, sealants, insulation and barriers, retrofitting, heating and cooling, base load, and new construction. The content of this book is also designed to serve as a preparatory vehicle for auditors seeking to achieve several professional certifications, including programs offered by BPI, RESNET-HERS, DOE/NREL and AEE. Appendices provide a wealth of valuable information, covering weatherization standards and calculations, math basics, conversion tables, climate data, insulation assessments, utility bill interpretation and more.

ISBN: 0-88173-726-7

6 x 9, 660 pp., Illus.
Hardcover

*$150*
*Order Code 0694*

CONTENTS



## BOOK ORDER FORM

① Complete quantity and amount due for each book you wish to order:

| Quantity | Book Title | Order Code | Price | Amount Due |
|---|---|---|---|---|
| | **Residential Energy Auditing and Improvement** | **0694** | **$150.00** | |

② Indicate shipping address: CODE: Journal 2014

NAME (Please print) BUSINESS PHONE

SIGNATURE (Required to process order) EMAIL ADDRESS

COMPANY

STREET ADDRESS ONLY (No P.O. Box)

CITY, STATE, ZIP

| | |
|---|---|
| Applicable Discount | |
| *Georgia Residents add 6% Sales Tax* | |
| *Shipping $10 first book $4 each additional book* | **10.00** |
| **TOTAL** | |

**MEMBER DISCOUNTS—A 15% discount is allowed to AEE members (discounts cannot be combined).**
☐ **AEE Member (Member No._____)**

③ Select method of payment:
☐ **CHECK ENCLOSED**
☐ **CHARGE TO MY CREDIT CARD**
☐ *VISA* ☐ *MASTERCARD* ☐ *AMERICAN EXPRESS*

*Make check payable in U.S. funds to:*
**AEE ENERGY BOOKS**

CARD NO.

*Expiration date* *Signature*

④ Send your order to:
**AEE BOOKS**
P.O. Box 1026
Lilburn, GA 30048

**INTERNET ORDERING**
**www.aeecenter.org/books**
**(use discount code)**

**TO ORDER BY PHONE**
**Use your credit card and call:**
**(770) 925-9558**

**TO ORDER BY FAX**
**Complete and Fax to:**
**(770) 381-9865**

**INTERNATIONAL ORDERS**
Must be prepaid in U.S. dollars and must include an additional charge of $10.00 per book plus 15% for shipping and handling by surface mail.

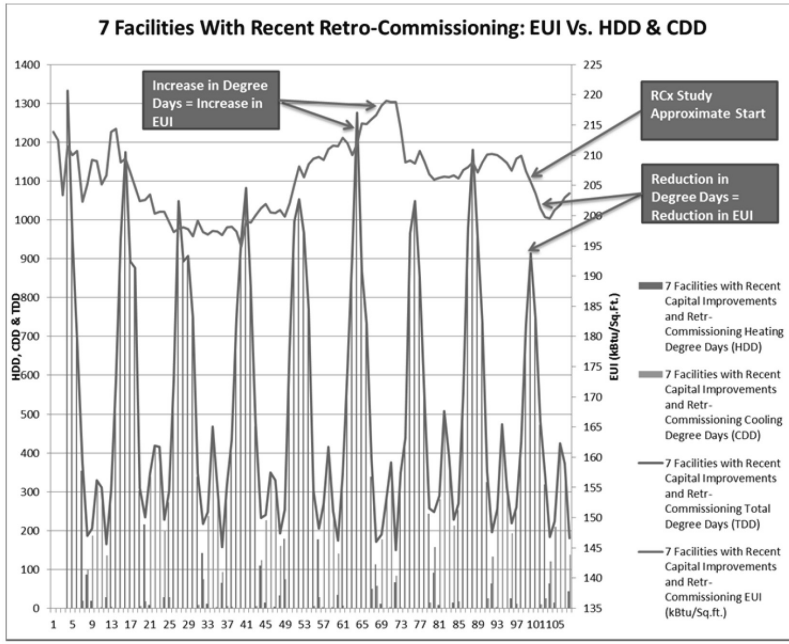



**Figure 5: Facilities with RCx Only**

Although the second group of facilities did experience retro-commissioning, there was not enough evidence to evaluate its benefit because the payoff for retro-commissioning would be realized for this group in FY-13, beyond the time in which data were collected.

The most important findings of the study come from the analysis of Group Three, the nine facilities that experienced retro-commissioning several years ago, with deferred maintenance and minor repairs implemented as a result of that commissioning. In FY-12 this group also started to implement real-time commissioning. Significantly, for this group, EUI decreased with the advent of retro-commissioning and continued to decrease further with the implementation of minor repairs and deferred maintenance (see Figure 6).

An analysis was undertaken to ensure that it was indeed the commissioning effort and not external influences causing the observed reduction in EUI.

Group Three's EUI reduces by nearly 10 kBtu/sq.ft./yr. on average, starting when commissioning efforts are first implemented around August 2010. This happened during a time when both heating degree

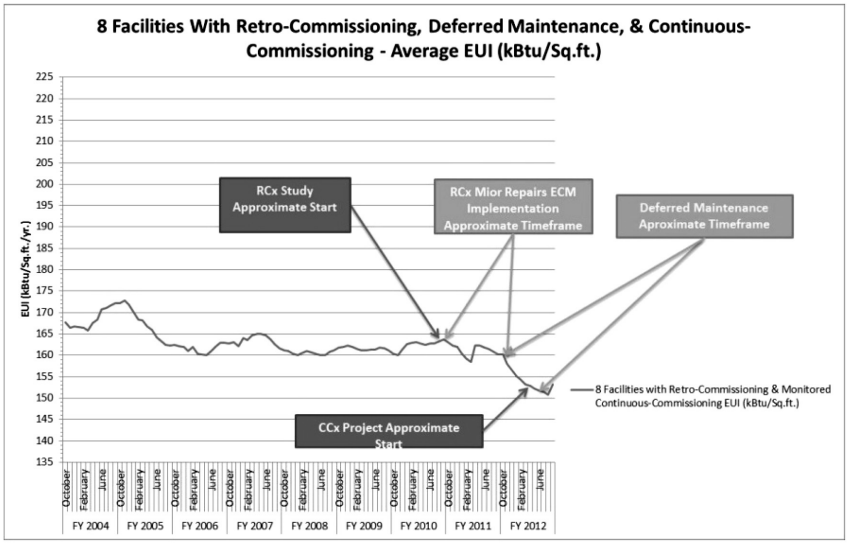



**Figure 6:**
**Retro-commissioning, Deferred Maintenance & Real-time Commissioning**

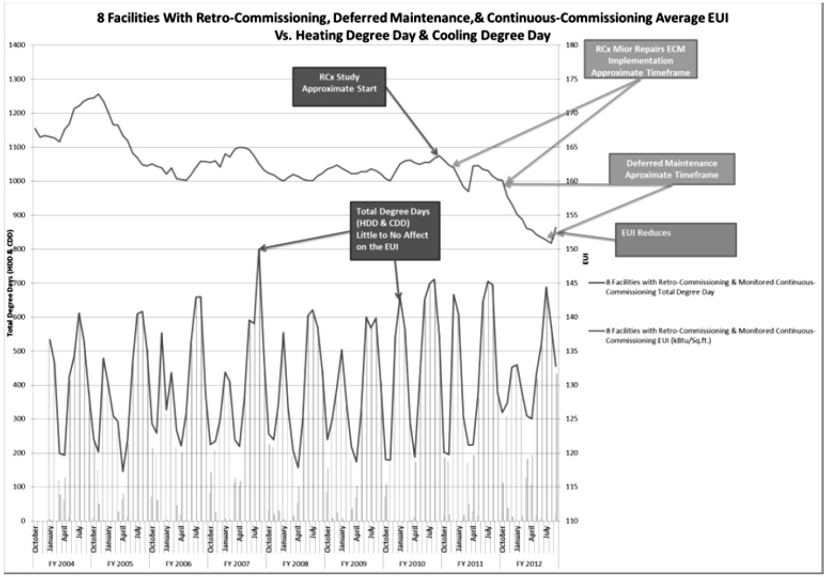



**Figure 7: Heating and Cooling**

days and cooling degree days remained fairly constant. The effect of climate was thus ruled out as explaining this trend.

Construction undertaken began increasing steadily from the year that Group Three facilities started retro-commissioning, yet on average the EUI reduced through the same period. Trends in construction can thus also be ruled out as explaining the reduction in EUI. The size of patient populations remained relatively constant during the period under analysis so can also be dismissed as a factor.

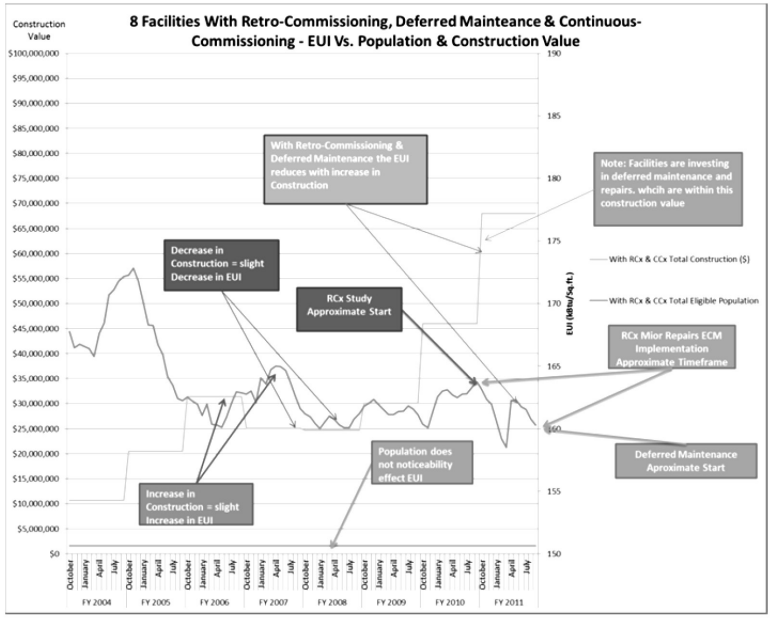



**Figure 8: Patient Population vs. Construction Values**

This group of facilities has a common energy manager who implemented overall group energy improvements. The initial common goal of this group was to reduce energy consumption by implementing professional retro-commissioning starting in fiscal year 2010 (FY-10), and the original commissioning contract was limited to typical 15-minute simple field repairs only. Each facility had a $10,000 budget for simple field repairs. Throughout the project, the energy manager understood the benefit that would be lost if the retro-commissioning did not include the minor repairs and deferred maintenance[9].

The initial retro-commissioning of these facilities found typical maintenance and operational issues (simple 15-minute repairs that were corrected to reduce energy consumption and utility costs). When an engineering analysis of utility savings was performed on the minor repairs and deferred maintenance issues, the facility energy managers recognized that their facilities could annually save even more money if deferred maintenance and minor repairs were implemented. The money saved could be reinvested in future maintenance and eventually provide enough routine savings to fund regular deferred maintenance. Funding was added to the scope of these contracts to include deferred maintenance and corrections of minor repairs. The group agreed upon a budget, which on average for each facility was about $320,000 for deferred maintenance and $180,000 for minor repairs. These were implemented between FY-11 and FY-12.

Once deferred maintenance was implemented, managers of these facilities reported fewer "hot and cold calls" from occupants as the equipment operated to higher standards, and the equipment also had fewer breakdowns. This resulted in the facilities HVAC and mechanical staff having more time to conduct preventative and deferred maintenance. Once this process had been started, the effect continued to increase. As part of a follow up contract, the facilities are now implementing real-time-commissioning to ensure continued energy reductions.

This group of facilities has an estimated yearly utility savings of about $385,000 from minor repairs and about $655,000 from deferred maintenance. Analysis of this group indicates that by implementing recommended changes, a facility will realize a quick return on investment, and will steadily reduce its EUI. For these facilities, the process of ongoing commissioning with implementation of deferred maintenance and minor repairs has led to real reductions in EUI. Investment and savings are plotted on Figure 9.

The strength of the conclusions reported in this study for a significant number of large federal facilities, suggests that, by extension, retro-commissioning with implementation of deferred maintenance and minor repairs is a viable path to energy savings and reduced operational costs for many buildings and campuses. If a facility opts not to invest in real-time commissioning, the data suggest that re-commissioning should be performed on a regular, periodic basis to ensure sustained utility savings. Implementation of the simple/minor repairs and capital improvements revealed that building commissioning maximizes utility

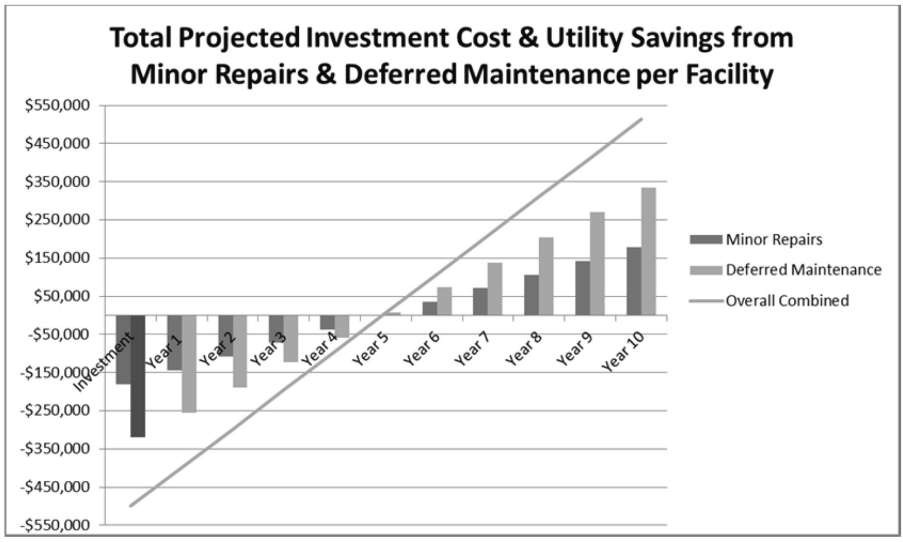



**Figure 9: Total Projected Investment Cost & Utility Savings from Minor Repairs & Deferred Maintenance per Facility**

savings and improves occupant satisfaction.

Summary, facilities with retro-commissioning, deferred maintenance and real-time commissioning:

- EUI decreases with the advent of retro-commissioning.
- EUI continues to decrease with implementation of minor repairs.
- EUI steadily decreases when deferred maintenance is implemented.
- EUI decreases persist even in years when cooling degree days increase.
- EUI decreases persist with the increases in construction undertaken.
- Patient populations remain constant and do not appear to affect EUI for this group.

This study has found that to date the facilities have shown a 9% reduction in EUI alone, and the retro-commissioning agent indicates up to 16% total utility cost savings. The estimated utility savings for each

facility is about $65,500 per year for deferred maintenance and about $35,800 per facility for the simple and minor repairs. Simple payback for the overall investment for these facilities is about 4.9 years. After the money has been paid back, the facilities intend to keep the same yearly operating budgets but use the excess money to fund capital improvements.

**Cost Benefit Analysis Overview of Commissioning Case Studies**

Also within this study, a series of nine commissioning reports on various facility types, including medical facilities, were used to analyze energy conservation measures (ECMs) in terms of implementation costs and utility savings. In each of the 125 energy conservation measures analyzed in this study, the cost of implementation of that measure and its impact on energy consumption were grouped into three categories:

- Simple repairs defined as those repairs typically taking less than 15 minutes of labor and without monetary value of materials, sometimes known as field repairs.
- Deferred maintenance and minor repairs defined as those repairs that are more than that of a simple repair, but less than that of capital improvements, typically with a 3- to 15-year return on investment.
- Capital improvements defined as those with costs and payback greater than that of minor repairs and deferred maintenance.

As anticipated, the "low-hanging fruit" of simple repairs and some minor repairs were found to have a faster return on investment than larger capital improvements. Significantly, however, the data also show that implementing only minor repairs will produce only one third of potential 10-year utility savings. On average, each facility in the study would save about $222,000 within 10 years from the relatively small investments of minor repairs. Some simple repairs have almost no investment cost, such as reprogramming sensors.

Investment in capital improvements recommended by commissioning would represent a substantial increase in cost, about $500,000 total for the group, or $55,500 average per facility. But when these capital improvements are undertaken, the savings amount to more than $6,000,000 for the group as a whole or about $666,600 per facility over 10 years.

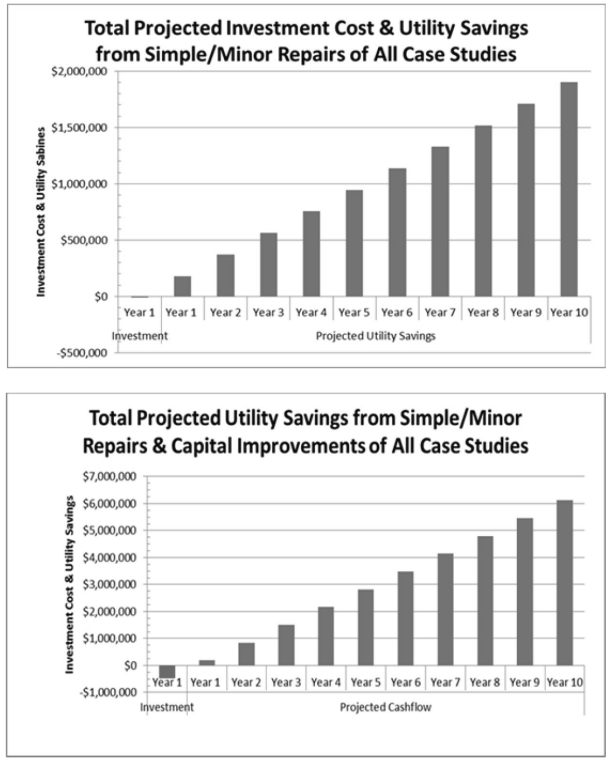



**Figure 10: Investment Cost & Utility Savings**

All of the nine facilities reported non-energy benefits as well, relating to the occupants' experience of their environment and to changes beneficial to the facility maintenance staff, such as recalibration of maintenance equipment.

## CONCLUSIONS

Buildings will consume more energy as equipment and systems deteriorate through age, lack of maintenance, incorrect controls or sensors out of calibration. Because equipment and systems often fail slowly and without obvious indication, corrective action typically is not implemented at the time of failure.

To determine the benefits of building commissioning, different data sets were used including:

- **Facility Energy Use Intensity (EUI) Analysis**: The EUI of 23 federal medical facilities was analyzed to determine if actual energy consumption was impacted by commissioning.

- **Cost/Benefit Study of Energy Conservation Measures revealed during building commissioning**: Nine extensive retro-commissioning reports on facilities, including medical, provided by a commissioning agent were analyzed, both as individual case studies and as a group, to evaluate the cost effectiveness of commissioning recommendations.

Now that all three groups have been analyzed and the causes of the fluctuations in EUI have been examined, the impact of retro-commissioning and monitored real-time commissioned can be evaluated. When the three groups are now compared again in Figure 11, the reasons for the EUI reduction for both the group without commissioning and the group with only recent retro-commissioning is a reduction in degree days; i.e., the weather was less harsh, putting less strain on the heating and cooling systems.

The group of facilities with retro-commissioning which included minor repairs, deferred maintenance and real-time-commissioning is the only group with sustained and continuous reduction in EUI. This continues to reduce even when factors are intensified that will typically increase EUI such as an increase in degree days or construction undertaken.

Research reported here indicates that commissioning provides a number of concrete benefits to a facility and leads directly to recommendations that it is cost effective for facilities to:

- Be commissioned when constructed.

- Be retro-commissioned if never commissioned.

- Be re-commissioned periodically every 2 to 4 years.

- Implement the majority of energy conservation measures recommended by commissioning agent.

- Implement monitored, real-time commissioning with real-time feedback when possible.

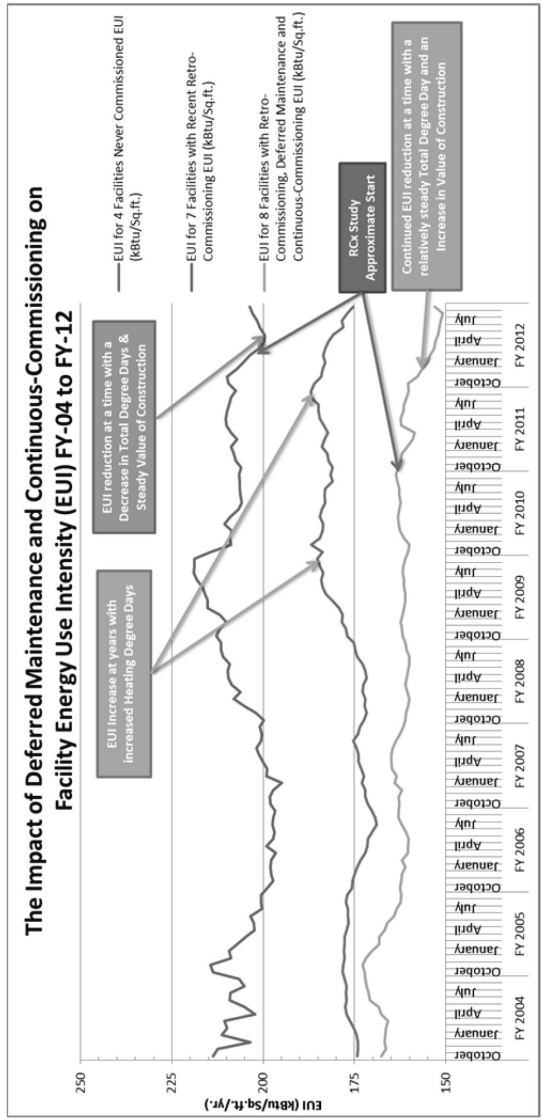



**Figure 11: The Impact of Minor Repairs, Deferred Maintenance and Real-time Commissioning on Facility Energy Use Intensity**

The case studies show an average payback of about 2.5 years if all of the simple and minor repairs recommended are implemented, with a maximum payback of 4.3 years. The third group of eight facilities undergoing the energy use intensity analysis, showed an approximately 4.9-year return on investment. The EUI analysis group has a slightly longer payback on average, but is relatively consistent with the facilities with maximum payback.

Data from the energy conservation measures group indicate that on average simple repairs can reduce a facility's EUI by up to 7 kBtu/sq.ft./yr. for a facility, and capital improvements can reduce the EUI by about 14 kBtu/sq.ft./yr., which could achieve a total of 21 kBtu/sq.ft./yr. Data from the EUI analysis group indicate that on average the facilities EUI was reduced by 12 kBtu/sq.ft./yr. with the implementation of minor repairs and deferred maintenance alone. Both of these studies indicate that this is a substantially better EUI reduction than that from implementing simple repairs alone.

Finally, data from the energy conservation measures group indicate an implementation cost averaging $5,500 per 1-kBtu/sq.ft./yr. reduction of EUI, which comes to about $0.043 per square foot. Data from the energy conservation measures group indicate a cost of a little over $40,000 per kBtu/sq.ft./yr. in EUI reduction, which comes to about $0.048 per square foot. The costs per square foot are comparable.

As expected, the group of facilities that implemented retro-commissioning which included minor repairs and deferred maintenance has the best reduction in EUI with a fairly short return on investment.

**Successful Commissioning Projects**

Widespread implementation of real-time commissioning will require challenging a number of entrenched perspectives. Facility staffs often do not understand the extensive benefits of commissioning. As this study indicates, commissioning is likely to provide real benefits to a facility. On average, energy conservation measures recommended through building commissioning have a substantial return on investment, many with a payback of just over a year. Case studies analyzed here indicate that implementation of minor repairs and deferred maintenance should be undertaken as well as simple repairs, and that implementing capital improvements recommendations will bring about even more savings. Finally, a process of real-time commissioning with real-time data will ensure continued energy savings within a facility

and maintain optimum building performance.

Facility staff can easily become defensive during the commissioning process because they expect that they will come under attack through finding faults in their maintenance and operations. For a building commissioning to be successful, the commissioning agent must work with the facility management and maintenance staff to ensure that they have full "buy-in" to the project.

## Footnotes

1. Embedded Commissioning of Building Systems
2. Embedded Commissioning of Building Systems
3. 3Embedded Commissioning of Building Systems
4. CXE Group LLC
5. http://www.facomgrp.com/Cx_For_LEED.htm
6. Energy Independence and Security Act 2007
7. Energy Independence and Security Act 2007
8. Continuous Commissioning Guidebook for Federal Energy Managers
9. For this contract simple field repairs are ECMs with a payback of 0-3 years; deferred maintenance are ECMs with a payback of 3-15 years; and anything above 15 years is a capital improvement.

## References

110th Congress of the United States of America. *Energy Independence and Security Act 2007*. Act of Congress. Washington DC: US Government, 2007.

Akin, Omer. *Embedded Commissioning of Building Systems*. Norwood, MA: Artech House, 2012. Book.

ASHRAE. *Proceduers for Commercial Building Energy Audits; Second Edition*. Atlanta: ASHRAE, 2011.

—. *The Commissioning Process; ASHRAE Guideling 0-2005*. Atlanta: ASHRAE, 2005.

—. *Thermal Environmental Conditions for Human Occupants*. Standard. Atlanta: American Socierty of Heating, Refrigeration and Air-Conditioning, 2004. PDF.

Bench, Mark. *Commissioning, Recommissioning, retrocommissioning and continuous commissioning. Details on recommissionng and the ability to benchmark easier through retro and continuous commissioning*. 2008. Details on recommissionng and the ability to benchmark easier through retro and continuous commissioning. (Bench). 15 01 2012. <http://findarticles.com/p/articles/mi_m0BPR/is_9_24/ai_n27366173/?tag=content;col1>.

Boll, Sarah. *Identifying Energy Conservation Measures. Tailoring Retro-Commissiong to meet your needs*. New York: New York University; FCM. NYUGREeN, n.d.

Camp Dresser & McKee. *Final Energy Audit Report*. Audit. Hackettstown: Hackettstown Municipal Utilities Authority, 2009. Document.

Concord Engineering Group. *Local Government Energy Audit Program: Energy Audit Report*. Audit. Monmouth Junction: CEG, 2010. Document.

Doty, Steve. *Commercial Energy Auditing Reference Handbook; 2nd Edition*. Lilburn: The Fairmont Press, Inc, 2011. book.

Energy Star. "Retrocommissioning; Strategic methodology of the process of planning a retrocommissioning project." 2007.

Environarc Design. *Level 2 Energy Audit Report*. Audit. Parolowie: EnvironArc, 2007. Document.

Federal Energy Management Program. "Maximizing Building Energy Efficiency and Comfort; Continuous Commissioning Guidebook; Documented casestudy for the benefits of retro-commissioning published by the DOE." 2002.

FEMP. "A Case Study on In-House Retro-commissioning at a DOE National Library; Detailed Fedral measures and plans for continuous commissioning within federal buildings

detailing basics, AHU, Water/Steam, Chillers, Hearing, Thermal Storage and Optimum Building Pe." 2004.

Harrell, Steve. *Optimize Building Systems with Commissioning; Study and article on the energy consumption reduction through commissioning*. 01 01 2009. 15 01 2012. <http://www.buildings.com/tabid/3334/ArticleID/6837/Default.aspx#top>.

Harvard University. *Harvard Divinity School—Andover Library; ASHRAE Level II Energy Audit*. Audit. Andover: Facilities Maintenance Operations; Harvard University Office for Sustainability, 2009. Document.

—. *Quincy House New Residence Hall Faculty of Arts and Sciences*. Audit. Cambridge: Facilities Maintenance Operations; Harvard University Office for Sustainability, 2010. Document.

Nadel, Jennifer Thorne & Steven. *Retrocommissioning: Program Strategies to Capture Energy Savings in Existing Buildings*. Washington DC: American Council for an Energy-Efficient Economy; Marketing and programme methodology strategy for retrocommissioning within existing buildings., 2003.

One Hundred and Tenth Congress of the United States of America. *Energy Independence and Security Act 2007*. Act of Congress. Washington DC: US Government, 2007.

Oregon Office of Energy. *Retrocommissioning Handbook for Facility Managers; Guide detailing the process of retro-commissioning and the persons involved and effected, with samples of plans and commissioning*. Oregon: Oregon Office of Energy, 2001.

Ravanesi, Bill. *The Yawkey Center Rooftop: Capping off Boston's Green Building; Local casestudy detailing the results of retro-commissioning an existing and semi-new building and the benefits. Through continuous commissioning and combining cooling heating and power can i*. 01 06 2006. 15 01 2012. <http://www.healthcaredesignmagazine.com/article/yawkey-center-rooftop-capping-bostons-green-building-0?page=show>.

Thurmann, Al, William J Younger and Terry Niehus. *Handbook of Energy Audits*. Lilburn: The Fairmont Press, Inc, 2010. Book.

University of Georgia. *Driftmier Energy Audit Report*. Audit. Athens: Engineering Outreach Service, University of Georgia, 2006. Document.

Wapner, Mike. *Commissionig: Re-, Retro-, Ongoing or Continuous, They All Pay Off; Benefits of continuously commissioning buildings will far outweigh the professional cost. Commissioning costs can add approximately up to 1.5% onto the cost of the new construction of b*. 17 12 2010. 15 01 2012. <http://www.pikeresearch.com/blog/articles/commissioning-re-retro-ongoing-or-continuous-they-all-pay-off>.

---

## ABOUT THE AUTHOR

**Wes Stanhope** is a senior project manager for Conservation Services Group (CSG), which delivers energy, sustainability and commissioning services. Wes is also a lecturer at Mount Wachusett Community College teaching energy auditing and analysis as well as sustainable building O&M. Wes' experience includes energy auditing of approximately 23 million sq. ft. of hospitals, offices, courts, commercial and multi-family structures. His retro-commissioning experience includes approximately 11 million square feet of 10 hospitals, and third-party commissioning of hospital, commercial and multi-family renovation projects. He holds an MDS degree in sustainable design from Boston Architectural College and a B.Sc. degree in construction management from Limerick Institute of Technology. Wes is also a Certified Energy Manager and Existing Building Commissioning Professional. To contact Wes: WESLEY.STANHOPE@CSGRP.COM or WLSTANHOPE@YAHOO.COM.