SUSTN-104
Course

MILWAUKEE AREA TECHNICAL COLLEGE
TECHNICAL AND APPLIED SCIENCES (MATC/T&AS)

Sustainable Facilities Operations Program

SUSTN-104 Energy Auditing and Managing Energy Use

National Science Foundation - National Center for Building Technician Education

Center for Energy Conservation & Advanced Manufacturing
ECAM
Milwaukee Area Technical College

BEST
Building Efficiency for a Sustainable Tomorrow

NSF

2014-05-18

Course Documentation

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Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

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Table of Contents

Catalog description

This course takes students through the energy auditing process. Topics include gas, electric, and water billing analysis, ASHRAE (American Society of Heating, Refrigeration, and Air conditioning Engineers) process/levels of audits, energy analysis of savings (including Energy Star), developing the energy audit report and presenting it to clients. Actual building(s) are audited and used for students to develop reports. Students are encouraged to use a facility they have a connection to such as where they work. Course requires computer skills in word processing, Power Point, and spreadsheets.

Class hours

24 hours of lecture and 24 hours of self-directed research.

The self-directed research part of this course involves walking of buildings and meeting with "clients".

Units

3 Credits

Entry skills needed

The following are required for admission to the course:

- A high school diploma or GED
- Demonstration of proficiency in basic skills through a course placement assessment
- Course requires computer skills in word processing, spreadsheets, and Power Point.

In addition, the potential for success in the program will be enhanced if students have:

- Work experience
- Familiarity with building energy using systems (lighting and mechanical)
- A strong interest in sustainability and facilities management
- Critical thinking and problem-solving skills
- And have organizational skills.

Syllabus

See Appendix A for sample syllabus with course schedule and policies.

Student learning outcomes

The exit skills listed in the next section support these three learning outcomes:

Energy Use Analysis and Documentation

Student understands detailed billing data, the importance of a thorough utility analysis and comparison of benchmark data in the energy auditing process

ASHRAE energy auditing process

Student can discuss and apply the ASHRAE Procedures for commercial building energy audits.

Conduct an energy audit

Student can conduct a walk through survey, perform all the necessary task and analysis and write up an energy audit report for a client.

Exit skills

Course content to achieve student learning outcomes:

Student can describe the levels of ASHRAE audits

Student can use the ASHRAE auditing process to complete an energy audit.

The student can describe ASHRAEs Building Energy Assessment Professional certification.

Student can understand detailed gas and electric bills.

Student can analyze energy billing data including:

- Determining what data from billing is important for analysis
- Setting up and inputting data into spreadsheets for analysis
- Manipulating data in spreadsheets for analysis and presenting including calculating benchmarks
- Graphing the data in multiple formats for analysis and presenting.

Student is able to use Energy Star Portfolio Manager:

- to generate a rating for a specific site

- to track facility use over time
- to benchmark and determine energy saving potential of a facility

Student can conduct a simple walk through of a building to collect appropriate information for an ASHRAE level 1 audit.

Student conducts energy analysis of at least 5 best practices in energy conservation work using the CPEM worksheets.

Student learns the importance that accurate information for items such as operating schedule plays in determining, and not over estimating, energy savings

Student can describe the basic components of a good energy audit report including:

- Executive Summary
- Introduction/Building information
- Utility Analysis
- Energy Conservation Measures (ECMs)
    - Operational
    - Low/no cost
    - Capital intensive
- Strong conclusion with recommendations
- Appendices with detailed data and analysis supporting the utility analysis and ECMs

Student understands the importance of taking simple measurements when onsite for lower level audits.

Student can describe the importance of using all the body senses when conducting an audit.

Student understands the importance of being able to talk and interpret information out of the people encountered when conducting an onsite audit walk through.

Course materials

Principal text

ASHRAE, T. 7. 6. (2012). Procedures for commercial building energy audits. (2nd ed.). Atlanta, GA: ASHRAE. Retrieved from http://www.techstreet.com/ashrae/products/1809206

Lecture materials and handouts

Refer to Appendix B for an example

- Presentations (PowerPoint):
    - ASHRAE Key Elements of The Audit Process
    - PCBEA Preface
    - Lighting Survey Lab
    - ASHRAE PEA
    - Utility Billing Discussion
    - Energy Star
    - Lighting Overview
    - ASHRAE Guidelines
    - ASHRAE Levels of Effort
    - ASHRAE Site Visit
    - Energy Savings Calculations (not a PowerPoint)

Other reference materials

Focus On Energy Commercial Practical Energy Management spreadsheets (FOE CPEM Best Practices Spreadsheets)

Procedures for Commercial Building Energy Audits, 2nd Edition, Supplemental Files: https://xp20.ashrae.org/PCBEA/PCBEA_Supplemental_Files.html

Software required

Access to computer with:

- Microsoft Office Programs (Word, Excel, PowerPoint, etc.).
- Adobe Reader (for pdfs). Price: Free. Source: www.adobe.com.
- Access to computer with internet access. (i.e. Internet Explorer, Mozilla Firefox, Safari, etc.).

Lab setup and materials

The "lab" is the buildings that students arrange to be audited. Students are encouraged to arrange an audit of a building they have a connection with. Building types audited:

- Office Buildings
- Construction shops, warehouses, and associated office space.
- Churches / places of worship
- Schools
- Daycare centers
- Union halls
- Banks
- City hall / police department / Municipal building
- Ice skating rink

Equipment & instruments required

Flashlight, clip board, camera - student provides these items.

Light meter (MATC has set these up to be checked out in the library)

Assessment

Methods

- Reviews: These are "tests" taken in Blackboard that are simply going over the reading material for that week. It is assumed that the student reads the items first.
- Homework:
- Class Participation: There are activities, such as the "Targeted ECM for the Night". If you are not in class when that item is submitted, there is no making it up.
- Reports: There is an energy audit report required for this course. Make sure you follow the rubric used for scoring reports.
- Presentations: Each student is required to present their energy audit report in class. Use of power point is required. Length of presentation varies depending on the size of the class, but it is typically about 5 minutes with time for questions

Sample test questions

There are six quizzes for this course:

1. NCBC Paper Barber Kent
2. LP01 BCA Intro to Cx
3. LP02 Pre-Design Phase
4. LP02 OPR
5. LP03a Design Phase
6. LP04 Construction Phase part 1: ASHRAE Guideline 0-2005

Refer to Appendix D for an example

Sample of weekly assignments

There are nine assignments for this course spread over the 8 week period.

1. HW ES01 Portfolio Manager Registration: Requires student after first night to register on Energy Star Portfolio Manager.

2. HW PEA ASHRAE: Students are required to down load the PEA files from ASHRAE and enter data into the forms based on a generic set of data. The facility where the class is held is used at MATC. If there is data from a building that will be audited during the course, that data is encouraged to be used instead

3. HW ES02 Portfolio Manager Rating: Students are required to use Energy Start Portfolio Manager to rate a facility. The facility where the class is held is typically used. If there is data from a building that will be audited during the course that data is encouraged to be used instead. The student has to enter the data and obtain a rating. Also, the data must be shared in Portfolio Manager with the instructor account so it can be graded.

4. HW Utility History: Utility data must be entered into a spreadsheet, summarized and graphed. Again, same data as from previous homework. The spreadsheet used is the Focus On Energy Utility History spreadsheet. This automatically summaries, provides benchmarks and graphs data in multiple ways for analysis.

5. HW ECM01 Energy Savings Calculations: Lighting savings analysis to be completed using the FOE CPEM Best Practices Spreadsheets.

6. HW ECM02 Energy Savings Calculations: Boiler Replacement savings analysis to be completed using the FOE CPEM Best Practices Spreadsheets.

7. HW ECM03 Energy Savings Calculations: Air Handler energy savings analysis to be completed using the FOE CPEM Best Practices Spreadsheets.

8. HW ECM04 Energy Savings Calculations: Domestic Hot Water (DHW) system savings analysis to be completed using the FOE CPEM Best Practices Spreadsheets.

9. HW ECM05 Energy Savings Calculations: Students Choice of system savings analysis to be completed using the FOE CPEM Best Practices Spreadsheets.

Refer to Appendix C for an example

Project

Every student is required to conduct an energy audit covering most of the ASHRAE Level 2 attributes. The audit must be on one of the 3 to 5 buildings walked during the semester. Ideally, the student will use the homework assignments for helping prepare their audit reports.

Adaptability to on-line format

This course should not be delivered on-line due to required project work.

Currently the entire course is in BlackBoard online but taught in lecture / discussion /lab format. Test is online. All homework is available online.

Appendix A – Sample syllabus

MILWAUKEE AREA TECHNICAL COLLEGE
Course Syllabus

Fall, 2013

Course: *Energy Auditing*		**Credits:** *3, Accelerated*
Subject Abbreviation: SUSTN	**Course Number:** 104	**Section Number:** 500A
Class Meets*: Tuesdays,5:459 PM to 8:40 PM in room #E114*		
Instructor: *Ted Wilinski*		
Office: *E108*	**Office Hours:** *Before class, Tuesdays ~4:30 PM to 5:45 PM in room E114B or rm E108*	
Phone number: (*414) 571-4570*	**E-mail:***wilinskt@matc.edu*	

Course Description*:* Energy is an important part of our lives. Using it effectively is critical to extending world resources and for businesses being profitable. People who can assist firms with saving energy and operating efficiently are a valuable and limited commodity. Many firms are looking for knowledgeable personnel who understand energy and how it is used.

This course covers utility bill analysis, conducting walk through energy audits, determining energy use of specific equipment, breaking out where all the energy in a building is being used, calculating energy savings, prioritizing energy saving measures, and pulling all this information into a report. Spreadsheets and reporting formats are provided. Students will be required to use Energy Star Portfolio Manager to rate a building for Energy Star Certification.

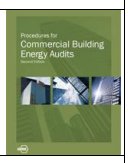
Prerequisites: *Familiarity with buildings energy using systems*

ADA Statement:

If you have a disability that impacts your classroom performance and wish to request an accommodation, contact the Office of Student Accommodations (414)297-6838. They may require documentation regarding your disability to enable them to comply with your request. Admission of a disability is voluntary and will be handled in a confidential manner. MATC does not discriminate against individuals with disabilities and fully complies with the Americans with Disabilities Act.

To ensure your academic success in this program, you are strongly encouraged to provide your instructor with a copy of the Instructor Notification Form from the Office of Student Accommodations. This should be done at the beginning of the semester.

Textbook(s): *REQUIRED:* ASHRAE, T. 7. 6. (2012). *Procedures for commercial building energy audits*. (2nd ed.). Atlanta, GA: ASHRAE. Retrieved from http://www.techstreet.com/ashrae/products/1809206



PLEASE NOTE: MATC book store does not carry this text, students may purchase their copies through the online vendors or book stores of their choice.

Attendance Policy: **Miss first two classes and you are automatically withdrawn from the class!**

Attendance will be taken on a daily basis. Students are expected to attend class regularly and *to arrive on time*. It is the student's responsibility to discuss absences with the instructor and follow up with an email. No email, no consideration for an excused absence. When an absence occurs, the student is responsible for making up the work. Work can be found in Blackboard. As a general rule, no exceptions for not meeting due dates are given for being absent. If there is an exception, it has to be detailed in a response from the instructor to your email explaining the absence. Miss 3 classes and you will be withdrawn from the course.

Tests/Assignments Make-up Policy:

It is the responsibility of the student to keep track of work and grades. In Blackboard, the "MyGrades" tab can be very helpful to check on completed work and view your grades. Ignorance of not knowing an item was due is not an excuse.

Any late work will have 5% taken off for each day it is late. For instance, a review done the morning of class will be considered one day late. Five percent will be taken off the score. So, if a score of 13 points out of 15 is awarded for that review, then 13/15= .867 or 86.7%. Five percent will be taken off, or 87%-5% = 81.7% for a final score.

Any item over two weeks late is not accepted and the student will receive a zero for that grade.

There can be extenuating circumstances but these have to be discussed and agreed upon in writing by both parties at the time the work is due, not after the two week period.

For Course Schedule see:
http://www.google.com/calendar/embed?src=gmatc.matc.edu_mnn28ehchs3u5o9uf9fs8vnd6k%40group.calendar.google.com&ctz=America/Chicago
It is best if you are logged into your Google Email and Calendar so that you can see details for the day.

Assessment Activities: note: assessment activities are subject to change as the semester progresses.

- **Reviews:** *These are "tests" taken in Blackboard that are simply going over the reading material for that week. It is assumed that the student reads the chapter first. Refer to Blackboard for details.*
- **Homework:** *Refer to Blackboard for details.*
- **Class Participation:** *There are activities, such as the "Targeted ECM for the Night". If you are not in class when that item is submitted, there is no making it up.*
- **Reports:** *There is a report required for this course. Make sure you follow the rubric used for scoring reports. Submittal of a report topic roughly 3 weeks ahead of time and submittal of an outline one week ahead of time is required. Refer to Blackboard for details.*
- **Presentations:** *Each student is required to present their report in class. Use of power point is required. Length of presentation varies depending on the size of the class, but it is typically about 5 minutes with time for questions afterwards. Refer to Blackboard for details.*

Grading Standards: note: grading standards are subject to change as the semester progresses.

- **15% Reviews:** *Each Review is typically weighted the same. Five Reviews in a semester anticipated.*
- **30% Homework:** *Each may be weighted differently.*
- **20% Class Participation:** *There will be various activities each day in class. If you are not there, late or leave early there is no opportunity to make it up since most of it requires you to see equipment at ECAM. See Blackboard for more details.*
- **25% Reports:** *Report is weighted as 13.5% of the final grade. Report outline is weighted as 1% of the final grade. Report topic is 0.5% of the final grade.*
- **10% Presentations:** *Presentation is weighted as 5% of the final grade.*

*Refer to Blackboard for **UPDATED** details.*

Grading scale is as follows:

A - 4.00	Superior	for grades between 94% and 100%
A- 3.75		for grades between 90% and less than 94%
B+ 3.25	Above Average	for grades between 87% and less than 90%
B - 3.00		for grades between 84% and less than 87%
B- 2.75		for grades between 80% and less than 84%
C+ 2.25	Average	for grades between 77% and less than 80%
C - 2.00		for grades between 74% and less than 77%
C- 1.75		for grades between 70% and less than 74%
D+ 1.25	Below Average	for grades between 67% and less than 70%
D - 1.00		for grades between 64% and less than 67%
D- 0.75		for grades between 60% and less than 64%
U - 0.00	Unsatisfactory/Failing	for grades less than 60%

Instructor Support: Students are encouraged to contact the instructor before or after class, and during office hours, if they have questions or problems related to the class. It is suggested that students contact the instructor immediately in order to avoid falling behind in class. Please do not wait until the end of the semester to discuss issues that should have been resolved much earlier.

Academic Support Services: In addition to obtaining course-related assistance from the instructor, students may obtain assistance from the Academic Support Centers located at the Milwaukee, North, South, and West campuses. These centers are open to all MATC students. Services include, but are not limited to, assistance in computer applications, course assignments, Internet use, math, science, social studies, study skills, and writing. Please call the Academic Support Center at your campus for more information.

Instructor Recommended Withdrawals: You may be dropped for absenteeism when:

1. You are absent three consecutive classes.
2. Your attendance is sporadic (e.g., you miss three class periods), and you are unable to make up the instruction missed.
3. You fail to meet attendance requirements of licensing agencies.
4. You pose a safety hazard to yourself or others because of missed instruction critical to safe class or lab performance.
5. You are unable to make up instruction missed in a lab/shop class.
6. You have not attended class during the first two weeks of the term.

Dropping or Changing Courses: Students who are considering dropping the course should first discuss this with their instructor, counselor, or faculty advisor before dropping. They may be able to recommend an alternative course of action. Please be aware that dropping a course could result in a student being placed on warning or suspension at the end of the semester. Also, please be aware that dropping a course does not mean you will be refunded.

Students who wish to drop a course may voluntarily withdraw from the course up to two weeks before the last day of the semester. Course Change forms are available in the Registration office at the Milwaukee Campus or in Student Services at the regional campuses.

A student who does not report for the final examination and does not formally withdraw nor arrange for an incomplete grade, will be given a U grade for the course.

Incompletes: A grade of Incomplete may be granted, at the discretion of the instructor, in cases where the student has completed at least 75% of the course with a C or better at the time the Incomplete is requested. Students must complete the missing work within one semester or else the Incomplete grade will revert to a U.

Student Complaint Procedure: MATC has established a formal system to assist students in resolving academic problems and course-related issues. In order for a complaint to be valid, the following steps must be followed in order:
Step 1: Meet with the instructor to discuss any questions related to the course (e.g., requirements or assignments) or if you are experiencing academic problems. If the issue is unresolved after meeting with the instructor,
Step 2: Meet with the associate dean of the department. If the issue is unresolved after meeting with the associate dean,
Step 3: Meet with the dean of the department. If the issue is unresolved after meeting with the dean,
Step 4: Go to the Office of Student Life for assistance.

Retention Alert: MATC is interested in the success of all of its students. Retention Alert is a tool that instructors, along with the counseling and advising department, use to help improve student success. There are three areas of Retention Alert: financial, personal/confidential, and retention. Retention Alert is designed to identify students who may be at risk of academic difficulty or failure as early as possible. Throughout the semester, an instructor may create Retention Alerts or referrals for some of their students. After a referral is made, the student will be contacted by someone by phone or email to discuss resources or set up an appointment to meet in person. The Retention staff follows up with the student and the student's instructor to facilitate support efforts. Prevention and intervention are key with students so timing and resources are important. With Retention Alert, hopefully students can get the help they need, when they need it.

OTHER IMPORTANT INFORMATION:

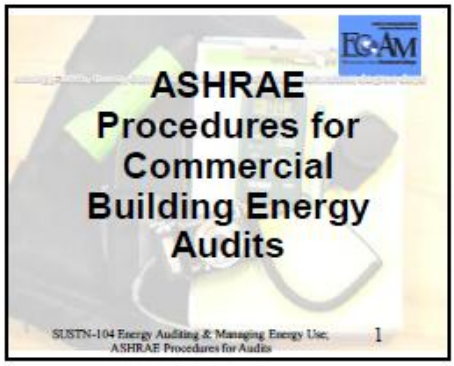
No texting; No ear buds or other head phone set up.
Please refer to the links in Blackboard under the “Syllabus” tab. Those links are:

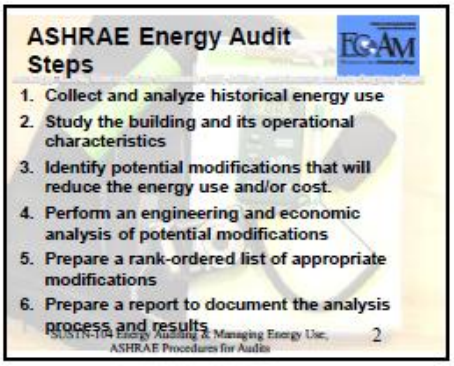
- Student Code of Conduct
- Student Accommodation Services
- Student Handbook

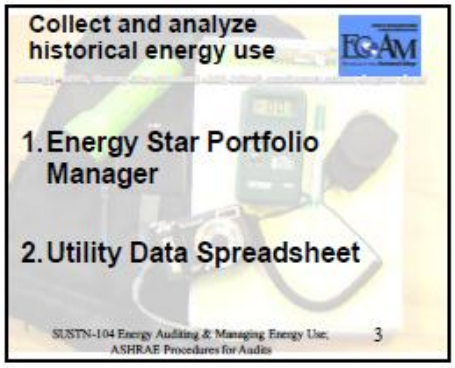
Week	Topic
1.	Introduction Overview ASHRAE
2.	Energy Star Lighting Survey
	Potential Walk-Through of Facility (different day of week)
3.	Utility Analysis Star Class Project Discussion – Energy Audit / Report
	Potential Walk-Through of Facility (different day of week)
4.	ECM Discussion
	Potential Walk-Through of Facility (different day of week)
5.	End Use Breakdowns
	Potential Walk-Through of Facility (different day of week)
6.	Conservation Measures
	Potential Walk-Through of Facility (different day of week)
7.	Conservation Measures Report Writing / Wrap up
8.	Project Reports due and Presentations (potentially)

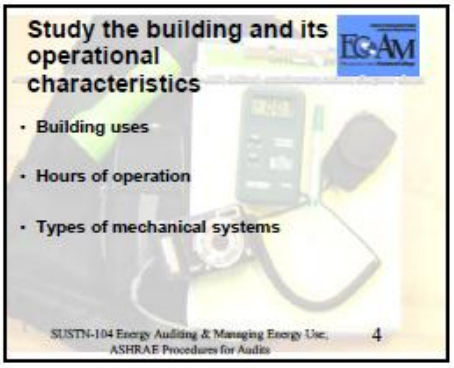
*Schedule is only approximate and may vary somewhat depending on the progress of the class
The 24 periods to be assigned are for a combination of onsite discussions/audits, extra work, and class presentations.

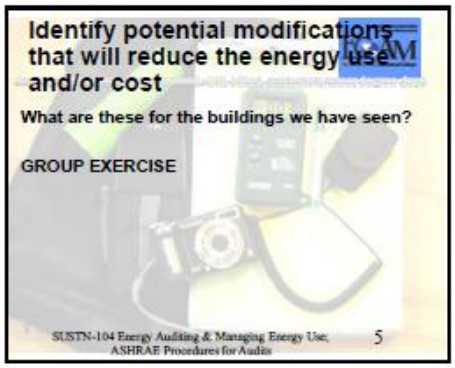
Appendix B – Sample Power Point

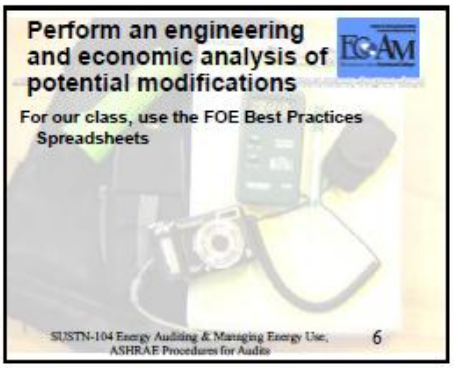




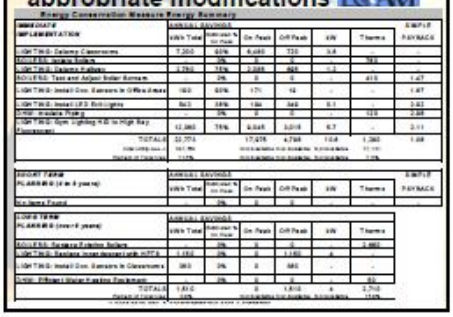








Prepare a rank-ordered list of appropriate modifications



Prepare a report to document the analysis process and results

See examples online

SUSTN-104 Energy Auditing & Managing Energy Use, ASHRAE Procedures for Audits 8

ASHRAE Levels

- Preliminary Energy Use Analysis
- Level I Analysis-Walk-Through Analysis
- Level II Analysis-Energy Survey and Analysis
- Level III Analysis-Detailed Analysis of Capital Intensive Modifications

SUSTN-104 Energy Auditing & Managing Energy Use, ASHRAE Procedures for Audits 9

Preliminary Energy Use Analysis

Analyze historic utility use and cost. Develop the Energy Utilization Index (EUI) of the building. Compare the building EUI to similar buildings to determine if further engineering study and analysis are likely to produce significant energy savings.

SUSTN-104 Energy Auditing & Managing Energy Use, ASHRAE Procedures for Audits 10

Level I-Walk-Through Analysis

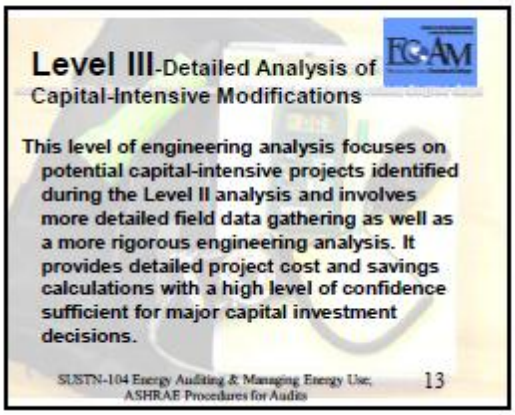
Assess a building's energy cost and efficiency by analyzing energy bills and conducting a brief on-site survey of the building. A Level I energy analysis will identify and provide a savings and cost analysis of low-cost / no-cost measures. It will also provide a listing of potential capital improvements that merit further consideration, and an initial judgment of potential costs and savings. A walk-through analysis of a facility will utilize all the forms in the Procedures for Commercial Building Energy Audits (ASHRAE) publication except those in the section on "Building and Systems Report."

SUSTN-104 Energy Auditing & Managing Energy Use, ASHRAE Procedures for Audits 11

Level II-Energy Survey and Analysis

This includes a more detailed building survey and energy analysis. A breakdown of the energy use within the building is provided. A Level II energy analysis will identify and provide the savings and cost analysis of all practical measures that meet the owner's constraints and economic criteria, along with a discussion of any changes to operation and maintenance procedures. It may also provide a listing of potential capital-intensive improvements that require more thorough data collection and engineering analysis, and a judgment of potential costs and savings. This level of analysis will be adequate for most buildings and measures

SUSTN-104 Energy Auditing & Managing Energy Use, ASHRAE Procedures for Audits 12


Level III-Detailed Analysis of Capital-Intensive Modifications
This level of engineering analysis focuses on potential capital-intensive projects identified during the Level II analysis and involves more detailed field data gathering as well as a more rigorous engineering analysis. It provides detailed project cost and savings calculations with a high level of confidence sufficient for major capital investment decisions.
SUSTN-104 Energy Auditing & Managing Energy Use; ASHRAE Procedures for Audits
13

Appendix C – Sample Homework

HW ES02 Portfolio Manager Rating

Attached Files:

Portfolio Manager Questions UPDATED 20130910.rtf (43.599 KB)
MATC SUSTN PEA Utility Data (1).xls (64.5 KB)
MATC South Campus tw 20111001 Energy Star.pdf (161.051 KB)

This assignment is in Portfolio Manager, enter the supplied utility data and information required, obtain an Energy Star rating (0-100) of that facility, share your building with "joewilinski" in Portfolio Manager before the start of class week 3.

Buildings that do not have a rating report as demonstrated in class will be deducted points as follows:

-30 points for No Energy Star Rating or a rating outside the normal of the class (+/- 5 of instructor rating)

-20 points for not sharing with the instructor at "joewilinski"

(discretionary points per missing input) for missing necessary input to the program.

The pdf file above is an example of what MATC South should look like when entered into Portfolio Manager (although it is for a year or so ago, not current which yours needs to be).

Name your building "FA2013 your name" but use the data in the file for the rest.

Best Center Notes: In the files listed above:

FROM: Portfolio Manager Questions UPDATED 20130910.rtf

UPDATED 9/10/2013

YEAR IS 1965
Gross Floor Area: 323,259 sf
Is this building normally open at all on the weekends? Yes
Number of PCs 835 PCs
Number of walk-in refrigeration/freezer units 3
Presence of cooking facilities: Yes
Percent of the gross floor area that is cooled: 70%
Percent of the gross floor area that is heated: 100%
Is this building a high school (teaching grades 10, 11, and/or 12)? Yes **(NOTE – you must treat this as K-12 – not a college - in Energy Star to get a score)**
How many months is this building in use? 12
School District Leave Blank

METERS:

Electric –
Check Entire Facility
Energy Type should be Electricity
Generation Method – Grid Purchase
Units – kWh
Add this Meter to Total Facility Energy Use – Yes
Is this meter currently active – Yes
No temporary meters
When adding Energy Use select 24 months and a start date of 02/06/2009

Gas –
Check Entire Facility
Energy Type should be Natural Gas
Units – therms
Add this Meter to Total Facility Energy Use – Yes
Is this meter currently active – Yes
No temporary meters
When adding Energy Use select 24 months and a start date of 01/22/2009

Appendix D – Sample Quiz

Listing of Quizzes for class:

- PCBEA Preface
- ASHRAE PEA (example shown below)
- Utility Billing Data
- Energy Star

SUSTN104 Energy Auditing PEA Quiz

True/False
Indicate whether the statement is true or false.

____ 1. Determining targeted (goals) energy, demand and cost indices by comparing the building to a building with the same characteristics is part of the PEA process.

____ 2. To understand the costs that are associated with building energy use, it is important to obtain each rate structure from the utility provider(s)

____ 3. Monthly and annual energy use from collected utility bills is most easily analyzed using tables or graphs.

____ 4. Graphs or charts of energy usage by fuel type by month does not provide valuable information for an auditor.

____ 5. Graphs of 15-minute power demand indicate when peak building energy use occurs. Comparing this data to building equipment operation schedules, occupancy schedules, and weather data can be used to determine if and during what periods the potential for energy-efficiency improvements exists.

Multiple Choice
Identify the choice that best completes the statement or answers the question.

____ 6. When is the best time to conduct at PEA (Preliminary Energy-Use Analysis)?
a. Before the walk through of the facility
b. During the walk through of the facility
c. After the walk through of the facility
d. When writing up the report

____ 7. The PEA requires the building's floor area. Which is the floor area that is needed?
a. Net square footage
b. Gross conditioned floor area
c. Gross conditioned plus unconditioned floor area
d. Cleaning Floor Area

____ 8. Which is not a step of the PEA?
a. Classify primary use of building
b. Compare data to other similar buildings
c. Determine building gross conditioned floor area
d. Conduct a walk through
e. Review utility rate structures
f. Develop the EUI (Energy Use Index)
g. assemble copies of utility bills and summarize
h. Develop the ECI (Energy Cost Index)

____ 9. What is the desired amount of utility data to have for the PEA?
a. 9 months to a year
b. 1 year to 18 months
c. 2 - 3 years

____ 10. Which is not a form of demand charge?
a. Ratchet Clauses
b. Demand Charges
c. Power Factor Charges
d. Other charges

Multiple Response
Identify one or more choices that best complete the statement or answer the question.

____ 11. What are some of the items, as directly stated by ASHRAE, that are conducted during the PEA? Select all that apply.

a. Utility data is graphed
b. Historic utility use is analyzed
c. Peak demand is analyzed
d. Cost is analyzed
e. The ECI (Energy Cost Index in $/sf/yr) is developed
f. The EUI (Energy Use Index in kbtu/sf/yr) is developed
g. Energy conservation measures are determined.
h. EUI data is compared to similar buildings

____ 12. In a PEA, analyzing historical utility data and preliminary building information can provide important insight into: (select all that apply)

a. ECM costs
b. performance
c. energy end uses
d. current building operation

____ 13. The PEA can give an auditor: (select all that apply)

a. a basis for understanding where the potential energy savings are.
b. information on implementing construction project costs
c. potential to identify any billing anomalies.
d. ideas on specific equipment to target for energy savings.

____ 14. Some common ways to look at utility data are: (select all that apply)

a. tables
b. graphs
c. normalized
d. by outdoor air temperature
e. by square foot per year

Appendix E – Audit and Report

Grading Rubric:

Student Name: _____

20.1 pts	CATEGORY		86.9 pts	CATEGORY		107
1	**COVER PAGE**	_____ / 5	1	**Overview of Utility Data**		_____ / 32
1	Title (some wording for audit)		5	Annual kWh, ths, mmbtu, $		
1	Student Name		5	Benchmarks (units/sf/yr) (gas, electric, mbtu)		
1	Facility Name		5	Energy Star Information		
1	Date		2	Electric		Table
			2			Graph(s)
1	**Body of Report 5 - 15 pages**		2		Weather Impacts	Discussion
			2	Gas		Table
1	**Table Of Contents**	_____ / 2.5	2			Graph(s)
0.1	Exec Summary		2		Weather Impacts	Discussion
0.1	ASHRAE Level of audit		4	Quality		
0.1	Introduction					
0.1	Overview of Utility Data		2	**Overview of EUB**		_____ / 3
0.1	Overview of End Use Breakdown		1	Graph/Table		
0.1	Immediate Implementation Measures					
0.1	Operations and Maintenance Measures		1	**Break out of measures - least 3 diff categories**		
0.1	Capital Planning Measures					
0.1	Conclusion			**ECMS - at least 12**		_____ / 25
0.1	References		3	Table of Meaures for each of 3 Categories		
0.1	Appendix A		12	Discussion of each measure		
0.1	Appendix B		5	Savings for 5 measures		
0.1	Appendix C		5	Project cost for 5 measures		
0.1	Appendix D					
0.1	Page numbers			**Conclusions**		_____ / 6
			1	Not same as Exec Summary		
1	**Executive Summary**	_____ / 5	3	Lists Specific Measures		
1	Project discussed		2	Makes Strong Recommendations		
1	Utility/benchmarks discussed					
1	Recommendations discussed		1	**References (APA)**		_____ / 1
1	Table of recommendations		1	**Appendices**		_____ / 1
			3	**Utility Data Detail** (use and graphs, Ele		_____ / 3
5	**ASHRAE LEVEL OF Effort**	_____ / 5	1	**Energy star Rating Report**		_____ / 1
	Followed ASHRAE Table for decision?		5	**Energy Saving Measures Calcs / data**		_____ / 5
1	**Introduction**	_____ / 1.6	1	**Drawings or other supporting informat**		_____ / 1
0.1	Why doing audit?			**Report Typed** (minus 5 if not)		_____ / 0
0.1	Description of Building			**No Binder** (-5 if in a binder)		_____ / 0
0.1	Uses of Building			**Double Sided Print Bonus (2 points)**		_____ / 0
0.1	Occupancy Schedule(s)		7.9	**Quality and Bonus Points Available**		_____ / 7.9
0.1	Mechanical Systems	COMMENTS:				
0.1	Lighting Systems					

SAMPLE REPORT:

Local Union XXX

Energy Audit,
An Example of a Quality Project from an Actual Student

Joe Student

10/14/2013

Table of Contents

Executive Summary

This report was compiled for Local Union XXX located at XX00 S XXrd street in Milwaukee, WI. Our investigation consisted of a physical investigation of the facility, an interview with the facilities manager, and an analysis of the utility statements from January of 2012 to October of 2013. This facility of 34,691 square feet had a combined total utility bill of $47,771 for 2012. $38,361 for electricity and $9,419 for gas.

During our investigation, we noticed that there are some energy saving strategies in place. All lighting appeared to be uniform so as not to interfere with training. The use of condensing boilers when replacing the original draft boilers. As well as educating staff to turn off lights when not in use. But, we also noted that many other opportunities for potential energy savings which, if implemented, could yield over $20,000 in savings per year.

Some of these opportunities include:

1) Reduction of Outside air intake
2) The use of Variable Frequency Drives (VFD) on hot water and chilled water pumps
3) Upgrade or outright replacement of HVAC controls
4) Placing all computers in Power Saving mode when not in use
5) Conversion of electric water heater to gas
6) Conversion of lighting from T8 fluorescent tubes to High Performance T8 fluorescent tubes
7) Use of Occupancy sensors in various parts of the facility
8) Conversion of Exit lights from incandescent to LED
9) Retro Commissioning
10) Replacement of metal halide lights in Brazing shop
11) Setback/ Setup of HVAC system by 10 degrees when not in use
12) Chiller Replacement

AHSRAE Level

Due to the fact that this building has never undergone an Energy Assessment, a Level I ASHRAE Energy Assessment was conducted. This consists of analysis of the recent utility statements and a brief physical survey of the facility. Because this is a first level audit, potential costs and savings are approximations. However, it may help identify areas where further analysis may be necessary to realize the greatest potential for savings.

Introduction

Local Union XXX is a 35,000 square foot building built in 1992. The building itself is brick and mortar construction with a flat roof. There are several offices, classrooms, a large meeting room, and a weld shop of significant size. The building is heated by two hot water boilers with a hot water supply and return system. It is cooled with a 50 ton commercial chiller and a chilled water supply and return system. Ventilation for the building is carried out by several air handling units or fan coils that are scattered throughout the building. They take in fresh air from the roof and supply it to the duct system supplying various areas. Lighting in the building is provided by fluorescent fixtures throughout the building. There are a few metal halides within the building but the majority are on the exterior with the main concentration being in the parking lot.

There are two principle functions for this building. One is the management of union business. This function is carried out in the front offices from 8 am to 5 pm Monday through Friday. The other function is the training of steamfitter apprentices. This occurs in the classrooms from 5 pm to 9 pm Monday through Friday. The large meeting room is utilized once a month for 3 hours in the evening. Due to these varied hours of operation in different places, the building is really only occupied about 50 percent of the day on any given day.

This facility was selected by the surveyor because it is a training center for skilled craftsman. The construction industry has been trending towards more energy conscious construction in recent years. It seemed only natural that the training facility be as energy conscious as the craftsman they are educating. When approached with the concept, the business agents were very eager to have this done as this would be the first energy survey performed on this facility.

Overview of Utility Data

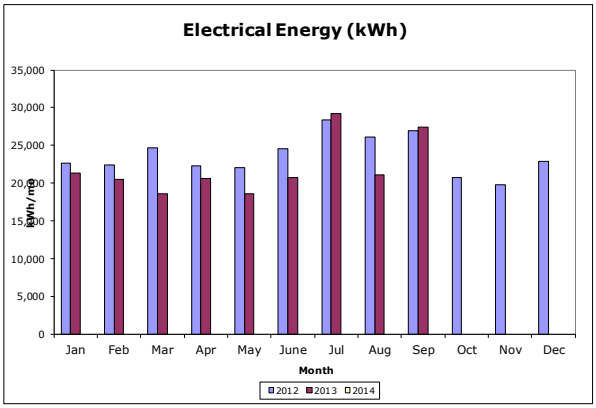
An initial review of the Utility Data shows that Steamfitter's Local 601 is actually performing better than the national average when compared to other buildings of similar size. It was also noted that the cost per kWh was comparable to other facilities.

Building sf -	34,691	$1.11 $/sf/yr Elec	$/sf/yr Gas - $0.27		mBtu/sf/yr
Building indices -	8.17 kWh/sf/yr		0.33 th/sf/yr		60.88
Federal Indices -	*13.90 kWh/sf/yr*		*0.48 th/sf/yr*		*95.44*

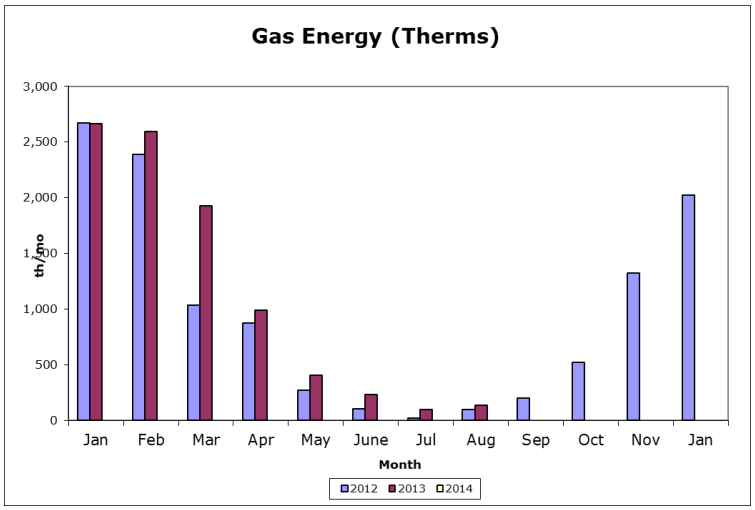
Electricity

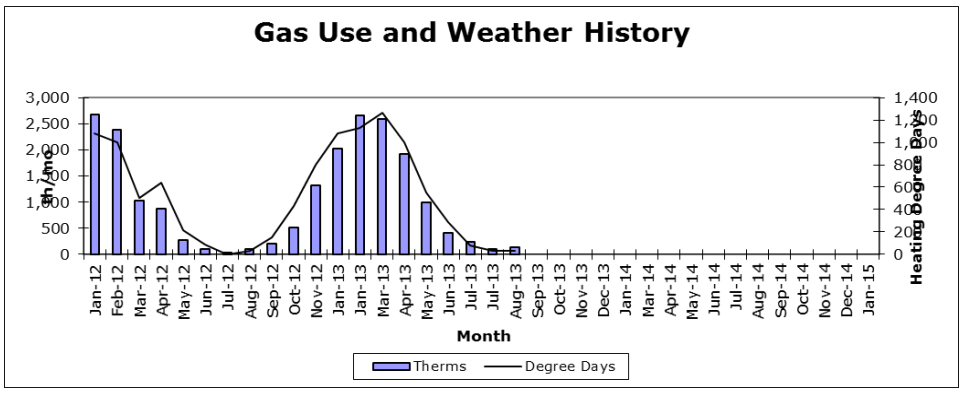
		Energy (kWh)			Demand, kW			Degree Days		Electricity
Year*	kWh/sf/yr	Weld Shop	Building	Total	Peak	Total	Cost	Heating	Cooling	$/kWh
2012	8.17	125,280	157,975	283,255	74	662	$38,361	0	0	$0.1354
2013	5.71	84,480	113,510	197,990	60	403	$27,206	0	0	$0.1374

While weather conditions appear very similar when similar time frames are compared, we know that employment was not. In 2012, the weld shop was being utilized more than normal by tradesmen seeking to increase their skill set in order to gain employment.



Gas usage of this facility appears to be consistent with the climate that the facility is located in. With the highest usage being in the winter months and then dropping to almost zero in the summer months. It is interesting to note that gas usage appears to have escalated for 2013. This can be attributed to the fact that there were more heating degree days in 2013 than there were in 2012.

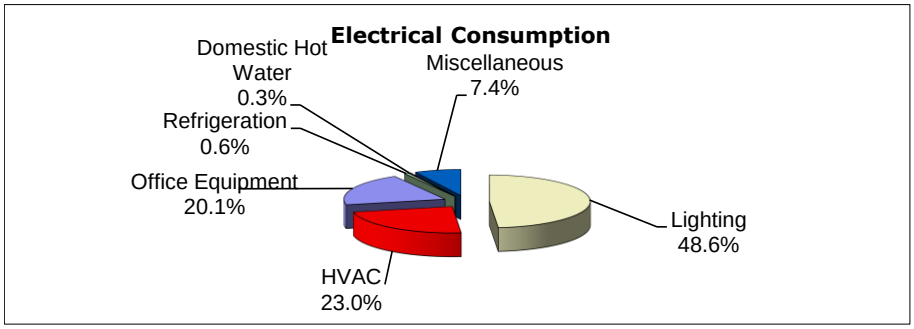


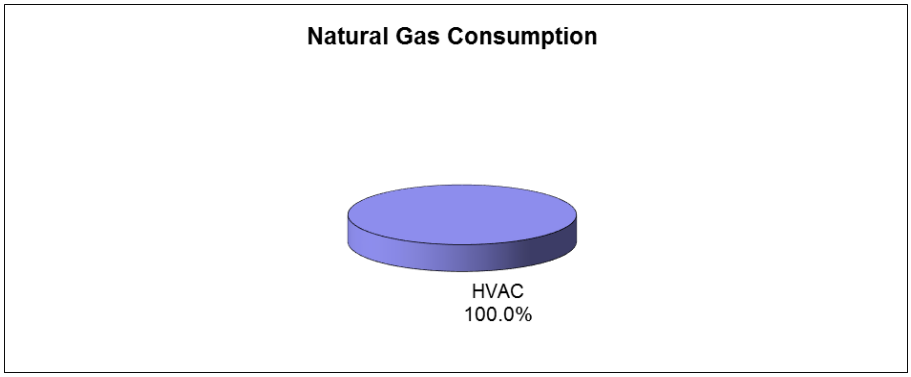


Without the availability of EnergyStar.gov due to the government shutdown, we are unable to obtain an energy star rating for this facility. This is a rating of how the facility performs as compared to other facilities of similar size and classification.

Overview of End Use Breakdown

Using a profile this is similar to other buildings in the Midwest, it can be seen where and how much energy is being utilized within the facility. However, this facility does not quite conform exactly to any one classification. Therefore it is important to note that the information is not entirely accurate. For a more precise end use break down, a more in depth study would be required. However, based upon our estimations we can see that HVAC and lighting account for a large portion of the electrical energy consumption. While HVAC accounts for all of the natural gas consumption.





Energy Audit and Recommended Savings Measure

There were several items discovered that we recommend Local Union Hall 601 consider implementing. For your convenience, these items have been broken down into three sections. Immediate implementation measures are measures which are low or no cost and easy to implement. Operations and Maintenance measures are measures that pertain to the facility's day to day operations and overall upkeep of the building. Capital planning measures are measures that will require financial planning due to the high cost of implementing. It is important to understand that these only recommendations and it is up to the facility manager to decide if they are to be implemented. It is also important to note that Payback only takes into account cost of material. Cost of labor was not considered because contractor costs may vary.

Immediate Implementation Measures

Measure	Potential savings (annually)	Payback (in years)
All computers in Power save mode	$150	Immediate
Occupancy Sensors	$761	1.3
LED Exit Lights	$25	4
Totals	**$936**	

Place all computers in power saving mode when not in use

When we performed our walk through we noticed several computers and monitors that were left on in the computer lab. However, we will only account for the computers in the office because the lab computers are seldom used. It is assumed to be 13. One for each employee. If you were to take into account breaks, lunches, and time away taking care of other tasks, a computer may only be used roughly 4 hours in an 8 hour day. If during this time all computers were set to power saving mode, a $150/yr savings could be realized. Even more would be possible if all computers were switched off when not in use.

Replace existing exit lights with LED

We also noticed several exit signs throughout the facility. While we were not able to verify, these are most likely compact fluorescent lights which use on average 7 watts of electricity. While it may not seem like much, the average LED uses 2.5 watts. Over a year's time, a savings of $25 for 5 signs could be realized. The cost of an average LED exit sign is $20 with a project cost of $100 and a 4 year payback. While this may not seem worthwhile, consider the fact that the basic LED exit sign lasts an average of 50

Occupancy Sensors

The night that we walked through, we noticed that a lot of the hallway lights were on with no one in the hall ways. These are the perfect areas to install an occupancy sensors. Turning the lights on only when occupied can save a tremendous amount of energy. If the facility were to install sensors to control the back and two side hallways a savings of $761 per hallway per year may be realized. Along with the rebate offered by Focus on Energy, this may be worth considering. Approximate cost is $1000 per hallway with a payback of 1.3 years.

Operations and Maintenance Measures for Energy Savings

Measure	Potential Savings	Payback (in years)	Rebate Available
Replace existing T8 lights With HPT8's	$1,094	5	$3 - $7 per fixture
Replace metal Halides	$39		$15 - $60 per fixture
Replace Parking Lot lights with LED	$878	2.9	$15-$60 per fixture
Replace Electric Water Heater with Gas	$78	6.4	$50 - $100 per unit
VFD's on Hot and chilled water pumps	$1,942	0.9	$50/HP or 30% of project
Totals	**$4,031**		

Replace existing T8 lights with HPT8's

This facility has quite a few fluorescent light fixtures. Replacing the ballast and bulbs with high performance units will reduce energy costs and provide a better quality of light. This is especially important in a classroom setting. While eventual replacement of all ballasts and bulbs is the ultimate goal, the facility may wish to do one room at a time. This will help spread out the cost. The rebates available for each fixture may be an added incentive for replacement. Approximate cost is $30 per fixture for material.

Replace or remove metal halides in brazing shop

We spotted these two lights in the brazing shop and were not quite sure of their purpose. Outright removal of these lights would be preferable which would result in a savings of $57. However, if the lighting is necessary, the facility should consider replacing them with HPT8 high bay fixtures. This would yield of savings of $39/yr. Approximate cost is $100 per fixture for material.

Replace Existing Parking lot lights with LED

Upon arriving at the building we noticed that the parking lot lights were all metal halide lamps. When we came out of the building we saw that only two per pole were on of the four that were up there. The facility would greatly benefit from replacing the heads on these lights with LED heads. Not only would they save electricity, they would also benefit from decreased maintenance of the lights.

Replace Electric Water Heater with Gas

While the current electric water heater looks newer, consideration for conversion to gas should be considered. A savings of $78 per year may be realized. The rebates may be an added incentive. Ideally, 2 tankless on demand water heaters are recommended. One to serve the employee kitchen and restrooms. The other to serve the public restrooms. This would eliminate the need for a recirculation pump that is on the current water heater as well has the energy used to maintain the heated water. Because of the low occupation of the building and the way it's used, a greater savings per year on tankless water heaters may be realized. Approximate cost is $500 for material.

VFD's on Hot and Chilled Water Pumps

When we saw the hot and chilled water pumps we saw a great potential for savings. The hot water pumps were running through a balance valve set at 50%. The chilled water pumps didn't have a balance valve that we saw but, there was a bypass in the system between supply and return. Both of these items result in wasted energy. Both systems could potentially yield almost a $1,000 savings each with the addition of a VFD for each system. The rebates for each VFD combined could potentially pay for most of the cost of one VFD. Approximate cost is $500 per VFD.

Capital Planning Measures

Measure	Potential Savings	Rebate Available
Reduction of Outside Air Intake	$9,067	$0.20 per CFM Controlled
Retro commission of facility	$1,734	
Set back temp 10 degrees	$524	
Set up temp 10 degrees	$2,414	
Chiller Replacement	$1,676	Based on size and efficiency
Totals	**$15,415**	

Reduction of Outside Air Intake

During our interview with the facility's manager, we were told that the outside air dampers were inoperative and they take in 100% outside air. Since this could not be verified, we approximated the value of outside air at 50% to 50% inside air. Reducing outside air intake for all 10 units to 25% could yield $9,067 per year. This number could change depending on the actual position of the dampers. However, when this is combined with setback/ setup of 10 degrees and only running the air handlers when needed, total savings could reach over $14,000 per year. If this upgrade is considered, replacement of the AHU's as well as their associated controls should be considered. The rebate available could be worth $60 per unit if utilized.

Setback/ Setup temperature 10 degrees

The facility manager noted that the setback/ setup controls of the facility were not used. This may need to be reconsidered. Setting back the temperature during the winter months in the building 10 degrees for 10 hours in the evening during the week and on the entire weekend, could potentially yield a savings of $524 per year. While setting up the temperature 10 degrees during the summer could yield $2,414. This takes into account both gas and electricity.

Retro commissioning of facility

Retro commissioning may seem like a redundant service in a building that is over 20 years old but, it actually can be quite helpful. This is an in depth study of the entire building to verify that each system is operating as it was designed. It also helps to identify systems that have deteriorated over time and bring those systems back to original design specifications. If the facility opts to utilize this recommendation, it is suggested that it be performed after all other upgrades have been completed. This will result in the most "bang for your buck".

Chiller Replacement

The current chiller is a 50 ton commercial 4 scroll compressor chiller. The facility's manager indicated that it may be oversized. Using a general "rule of thumb" of 1 ton of cooling for every 500 sq. ft. of floor space, we see that it may actually be undersized by a small margin. However, this can only be verified by the completion of a proper heat load calculation. Replacement with a comparable chiller would net $1,676 in energy savings. More savings may be realized if the chiller is indeed improperly sized. Another reason for replacement is that it uses R-22 refrigerant. According to the Montreal Protocol, R-22 will no longer be manufactured after January 2020. As of January 2015, the U. S. is to reduce its consumption of R-22 by 90%. The maintenance costs of this chiller are going to rise substantially in the coming years with the growing scarcity of R-22.

Conclusions

From what we see there is a large potential for savings in this building. Particularly in the HVAC system. By upgrading the controls on the existing air handlers, Local Union XXX could benefit from a savings $14,000 per year. Another $6,382 could be realized by instituting the rest of the recommended measures. This is a combined savings of over $20,000 per year or a 41% reduction in their energy bill. These measures will also result in the reduction of the environmental impact of the building as well as greater comfort of the occupants and users of this building. The use of high efficiency condensing boilers is an excellent start to Local Union XXX commitment to the future. It is important to continue on by implementing the suggested measures and with the rebates available for several of these projects, payback will be decreased thus making implementation even more appealing.

Measure	Potential Savings	Payback (in Yrs.)	Potential Rebate
Computer Power save	$150	Immediate	N/A
LED Exit Lights	$25	4	N/A
Set Back/ Set up 10 Degrees	$2,938		N/A
Replace T8 with HPT8	$1,094	5	$3
Occupancy Sensors	$761	1.3	$5
Replace Metal Halides	$39		$15
Replace Water Heater	$78	6.4	$50
VFD's on HVAC pumps	$1,942	0.9	$650
Reduction of OA	$9,067	1.6	$120
Retro Commission	$1,734		N/A
LED Parking lot lights	$878	2.9	$240
Chiller Replacement	$1,676		available
Totals	**$20,382**	**3.16**	**$1,083**

References

Wisconsin Focus on Energy – Focusonenergy.com

- Utility Data Spread Sheets
- Energy Conservation Measure Calculation Spreadsheets
- Energy Conservation Measure Incentives

BEST Center Curricula, Resources & Recordings

Academic Programs
Georgia Piedmont Technical College - Building Automation Systems
Milwaukee Area Technical College - Sustainable Facilities Operations
Laney College - Commercial HVAC Systems
City College San Francisco - Commercial Building Energy Analysis & Audits

Professional Development Materials, Presentations & Videos
National Institutes
Building Automation Systems Instructor Workshops
Webinars (e.g., BEST Talks)

Faculty Profile Videos
Reports & Case Studies
Marketing Resources

BEST
Building Efficiency for a Sustainable Tomorrow

NSF National Science Foundation