

Large Building Energy: Methods & Measurements Master Course Outline

Proposed Title: Large Building Energy: Methods & Measurements (NRG 163)

Credits: 4 credits: (44 contact hours)

Course Format: In-Person Lecture / Online Content – Hybrid

Grading Option: Decimal grade

Course Description:

The objective of this 4 Credit course is to prepare students for identifying energy efficiency opportunities and making recommendations on improving energy performance of medium and large commercial buildings. The course will introduce the methods and measurements used for commercial building energy audits and assessments.

Prerequisite: Completion of NRG 162 or Instructor Permission.

Course Rationale:

City of Seattle and several other municipalities require all non-residential and residential buildings over 20,000 sf to disclose annual energy use and track energy reduction towards zero net green house gas emissions by 2050. Such initiatives help building owners and facility managers to benchmark their buildings, understand the energy usage and identify potential energy efficiency measures by performing energy audits. This course is intended to prepare the student with foundational knowledge to collect the necessary data, analyze and recommend efficiency measures for the various building systems, components and HVAC operational characteristics. Students will be required to undertake envelope, lighting and HVAC equipment audits, use various field measurement tools, perform benchmarking and energy analysis required for all three levels of ASHRAE audits.

Topics to be covered:

- **Review EUI, ECI and Energy End Use** – review the data required and methods to calculate energy use intensity, energy cost index and disaggregate the energy use by energy end use
- **Energy Benchmarking** – collect and analyze utility billing data using EnergyStar Portfolio Manager or other tools
- **Energy Audit Process** – introduce the four stages of audit: (i) preliminary review/bench marking, (ii) site assessment/data collection; (iii) identification and analysis of efficiency opportunities and (iv) recommendations and reporting.
- **ASHRAE Audit Levels** – introduce the three levels of ASHRAE Audits
- **Walkthrough Audit** – introduce the purpose and process of walkthrough audit of building envelope, lighting and mechanical rooms and recording of observations
- **Collect Data** – introduce the use of data loggers, flow meters, light meters and other field audit tools for data collection

- **Analyze Data** – use spreadsheet based and other industry standard software tools to analyze the energy performance and identify efficiency opportunities
- **HVAC System Assessments** – understand the equipment performance characteristics and operation of heating, cooling, air-handling units, economizers, fan, pumps and motors
- **Building Operational Assessments** – understand the role of building automation systems, set up trends and analyze trend data to identify operational improvement opportunities
- **Payback Period Analysis** – identify sources to collect cost data and understand the methods for assessing payback periods for efficiency measures
- **Report Writing and Presentations** – understand the requirements for audit reports and presentation skills to communicate results of energy audits to building owners and stakeholders

Skill to be Mastered (objectives): (upon completion of this course students will...)

- Understand the basics of energy bench marking and energy end use
- Be able to collect utility billing data and analyze the energy use trends with weather data
- Understand the basics of energy auditing process and the standard ASHRAE energy audit levels
- Use field measurement tools such as flow meters, light meters, data loggers to collect field data for energy auditing
- Identify energy efficiency opportunities using walkthrough audit of building exterior, interior and mechanical rooms
- Understand the process of lighting audit by collecting lighting fixtures data, operational schedules and lighting controls and validating this
- Collect name plate data from mechanical equipment for analysis
- Understand the operation of economizers, terminal units, air handlers and central heating and cooling systems
- Understand the principals of building automation systems, ability to collect trend data and analyze them to identify operational faults/opportunities
- Acquire knowledge of energy efficiency technology options such as ECM motors, variable frequency drives and operational control strategies
- Undertake energy analysis and life cycle cost/payback period analysis using software tools
- Prepare written communication/final reports of energy audits

Outcomes to be measured (Student's completing this course will be tested on their competencies to...)

- Calculate annual EUI, ECI and benchmarking of a building energy use with utility billing data
- Identify end-use categories and match with fuel type to understand end-use breakdown of energy use

- Demonstrate the ability to inspect and identify envelope opportunities e.g weather stripping, condensation, air leakage, etc.
- Summarize lighting audit data collection and analysis for typical utility rebate program
- Describe the technology options for retrofit/replacement of HVAC equipment, fans, pumps and motors
- Calculate energy savings and payback periods for energy efficiency opportunities identified
- Create a final project report summarizing benchmarking, audit data and recommendations

Prerequisites (Prior Knowledge): (Students entering this course should have the following experience and competencies.)

- Be competent in the following math skill:
 - Conversion between fractions, decimals and percentages.
 - Solving single variable algebraic equations.
 - Solve for sides and angles of a right triangle, Pythagoreans theorem and Trigonometry
- Have an understanding of building science and energy calculations (including basics of heat transfer, thermal and indoor environment characteristics).
- Have completed NRG 102 and/or 162 prior to taking this course.
- Be able to operate a computer and use basic software for the development of documents.

Assessment (what you plan to asses and how)

Students will be required to prove competency in meeting each of the course objectives as listed above. The methods used to measure this competency will include:

- Worksheets and quizzes reviewing required reading and materials covered in course presentations.
- Three mini-course projects including field auditing of envelope, lighting and mechanical system identifying efficiency opportunities.
- A final project providing ASHRAE Level III audit report along with benchmarking and analysis.

Course Outline by Topic

Topic 0 – Course Introduction

Topic 1 – Review of Energy Use and Performance Metrics

Topic 2 – Energy Audit Process

Topic 3 – Building Walkthrough Audit

Topic 4 – Lighting Audit

Topic 5 – HVAC Equipment Audit – I: AHU Fans, Pumps and Motors

Topic 6 – HVAC Equipment Audit – II: Central and Plant Systems, Economizers

Topic 7 – Building Operations Audit – Building Automation Systems

Topic 8 – Deep Energy Retrofit Strategies

Topic 9 – Data Synthesis, Cost and Energy Analysis
Topic 10 – Energy Audit Recommendations and Reporting

Course Materials and References:

1. Procedures for Commercial Building Energy Audits, 2nd Edition, ASHRAE 2011
Available from: <https://www.ashrae.org/technical-resources/bookstore/procedures-for-commercial-building-energy-audits>
2. Northwest Energy Efficiency Alliance worksheet available at:
https://www.seattle.gov/Documents/Departments/Environment/ClimateChange/NEEA_MATRIX.xlsx
3. Pacific Northwest National Laboratory Retuning Resources – available at:
<https://buildingretuning.pnnl.gov/>
4. EPA ENERGY STAR Guidelines for Energy Management – available at:
<https://www.energystar.gov/sites/default/files/buildings/tools/Guidelines%20for%20Energy%20Management%206%202013.pdf>

Computer:

Students will be required to have access to a computer and be able to connect to the Internet. Further they will be required to navigate the classes the learning management system (canvas) to view presentations and complete course work and quizzes.

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