INDUSTRY DRIVEN REGIONAL COLLABORATIVE

COMMERCIAL BUILDING ENERGY ANALYSIS AND AUDITS PROGRAM OVERVIEW

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City College of San Francisco

Project Director: Wendy L. Miller, wlmiller@ccsf.edu

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COMMERCIAL BUILDING ENERGY AUDITING PROGRAM MATERIALS

BACKGROUND

In November 2011 the California Community College Chancellor's Office of Economic and Workforce Development awarded an Industry Driven Regional Collaborative grant to City College of San Francisco to develop responsive training curriculum in Commercial Building Energy Audits and Analysis. Working with industry experts, investor-owned utilities, regulators, professional organizations and regional colleges, we outlined a program that covered the broad range of skills required to work in this field. This content was divided into 15 modular courses designed for a community college level student. Although we do not produce Professional Engineers at the community college level, we can provide the foundational knowledge a student would need to take a deep dive into one or more of the subjects, or to pursue transfer to a baccalaureate engineering program. Content modules can be selected, re-combined, or offered in a more compressed format for incumbent workers, or those that have some background in construction, architecture, HVAC, building operations or mechanical engineering.

CONTRIBUTING SUBJECT MATTER EXPERTS:

Xin Ai, Advanced Technology Solar
Jim Caldwell, Workforce Incubator
Rachel Christianson, EEFG
Daryl DeJean, Emerging Technologies Inc.
Michelle Dionello, Arup Engineering
Brendan Havenar-Daughton, QuEST
Barry Hooper, San Francisco Department of Environment
Mark Jewell, EEFG
David Jump, QuEST
Jim Kelsey, kW Engineering
Irina Krispinovich, QuEST
Nicholas Kyriakopedi, Laney College
Peter Pollard, kW Engineering
Carlos Santamaria, Glenborough LLC and BOMA
Ken Sapp, ABM Energy Services
Colman Snaith, EMCOR Energy Services
Hitesh Soneji, CCSF Engineering Dept Chair
Ryan Stroupe, Pacific Energy Center
Lawrence Tachie, Acme Engineering and CCSF Engineering faculty

PROGRAM LEVEL LEARNING OUTCOMES

Upon completion of the program a student will be able to:

- Describe the basic concepts of energy auditing, including fundamentals of energy, energy measurement, energy conservation, and the policies driving the need for energy efficiency.
- Analyze building envelope, assess building systems, describe how building systems consume energy, and identify opportunities for energy efficiency.
- Employ appropriate tools for energy modeling, calculating energy use and savings estimates, and communicating empirical data.
- Describe utility rate structures and demand response strategies.
- Estimate energy savings and their financial impacts, and employ data to verify savings.
- Integrate business development skills and concepts to write an audit report that is a call to action and identifies the value proposition for the decision-maker.

PROPOSED SEQUENCE OF COURSES* FOR COMMERCIAL BUILDINGS ENERGY AUDITOR PROGRAM

Title	Hours	Units
ENRG 50 Intro to Commercial Buildings Audits	36	2
ENRG 51 MS Excel & Word for Energy Auditing	36	2
ENRG 52 Energy and Building Science Fundamentals	36	2
ENRG 53 Utility Rates, Benchmarking and Financial Analysis	36	2
Total Semester 1	144 hrs	8
ENRG 54 Lighting Systems and Controls	30	1.5
ENRG 55A HVAC 1 Fundamentals and Components	52	3
ENRG 56 Building Envelope Systems	30	1.5
ENRG 57 Miscellaneous Building Systems	18	1
ENRG 58 Demand Response for Energy Auditors	18	1
Total Semester 2	150 hrs	8
ENRG 55B HVAC 2 Systems and Efficiencies	52	3
ENRG 59 Simulation Methods and Code Compliance	36	2
ENRG 60 Professional Behavior for Energy Auditors	18	1
ENRG 61 Measurement Tools and Verification of Savings Calculations	36	2
Total Semester 3	142 hrs	8
ENRG 63 Field Experience with Reporting	105	4
ENRG 62 Audit Report Writing	36	2
Total Semester 4	141 hrs	6
PROGRAM TOTAL	**579 hrs**	**30**

**NOTE: Although these courses have not been submitted to the CCSF Curriculum Committee, all have been developed following the CCSF Curriculum Handbook and Technical Review Guidelines. Each contains the major sections required of community college curriculum: Course description, student learning outcomes, course content, instructional methodology (types of assignments and evaluation methods), and instructional resources such as textbooks or websites.*

COURSE DESCRIPTIONS

ENRG 50 Intro to Commercial Buildings Audits, *36 hours*

Description: Overview of the energy auditing process for commercial buildings. Topics include various levels of audits, defining scope of work, preliminary assessment of building performance data, collection and assessment of building system operations, analysis of data, developing recommendations, report preparation and presentation.

Major Learning Outcomes:

Upon completion of this course a student will be able to:

- Describe the various levels and phases of work for commercial building audits.
- Describe and classify the types of data collected for use in a commercial building audit.
- Describe field safety considerations and techniques necessary for on-site building assessments.
- Analyze data in order to identify opportunities to reduce energy consumption and improve building operational efficiency, and formulate action recommendations.
- Estimate financial implications of recommended upgrades.
- Integrate findings and recommendations into a written report.

ENRG 51 MS Excel & Word for Energy Auditors, *36 hours*

Description: Overview of Microsoft Excel as used for common engineering applications, with a focus on energy savings calculations. It covers Excel basics, such as navigation techniques, key-pad short cuts, graphing, and calculations. Advanced topics include regressions, pivot tables, lookup, dates and macros.

Major Learning Outcomes:

Upon completion of this course a student will be able to:

- Demonstrate fundamental use of spreadsheet basics.
- Create and interpret graphs.
- Illustrate the use of Excel's built-in functions and the functions commonly used by engineers.
- Interpret simple regression analysis directly from graph data using various trend lines.
- Create and apply macros and pivot tables on existing data.

ENRG 52 Energy and Building Science Fundamentals, *36 hours*

Description: Fundamental concepts for understanding energy use in commercial buildings. Principles of energy, heat transfer, measurement and unit conversion, phase change, psychrometrics. Balance point and emissivity, delta flows, solar geometry. Energy efficiency improvement strategies.

Major Learning Outcomes:

Upon completion of this course a student will be able to:

- Summarize the basic concepts of energy, including the first and second laws of thermodynamics, work, and power.
- Measure electricity, heat, pressure, and light, and calculate unit conversions to determine energy use in buildings over time.
- Analyze environmental conditions using the psychrometric chart and processes, and relate observations of variances in the environment to energy use in buildings.
- Describe and compare energy concepts including heat transfer, change of state or phase change, balance point, emissivity, and delta flows.
- Describe concepts of solar geometry and relate them to building science.

ENRG 53 Utility Rates, Benchmarking & Financial Analysis, *36 hours*

Description: Utility rate types and charges. Building benchmarking tools such as EnergyStar Portfolio Manager and LBNL's Energy IQ. Methods for estimating costs, and calculating the financial benefits of recommended energy efficiency projects.

Major Learning Outcomes:

Upon completion of this course a student will be able to:

- Compare tariff and rate schedules used by utilities to determine customer energy bills.
- Use multiple tools to analyze billing data for commercial buildings.
- Assess the impact of building type, climate and occupancy patterns and tenant use on commercial building energy use.
- Use benchmarking tools to compare the Energy Use Intensity of buildings of similar type and climate, and illustrate typical energy use patterns of specific facility types.
- Determine the cost of various energy efficiency measures, and calculate the value of them using various metrics.

ENRG 54 Lighting Systems & Controls, *30 hours*

Description: Fundamentals of lighting systems and controls for energy auditors. Concepts of lighting, terminology, measurement tools, identifying energy efficiency opportunities, codes, standards.

Major Learning Outcomes:

Upon completion of this course a student will be able to:

- Summarize terminology, physics and principles of lighting.
- Identify and compare various types of lighting systems, including field identification and interpretation of nameplate data.
- Measure illuminance and lighting intensity.
- Describe the theory and operations of various lighting control systems.
- Evaluate energy use by various types of lighting systems and identify opportunities for energy efficiency measures.
- Calculate energy savings of energy efficiency measures and estimate their financial impact.
- Apply relevant local, state and national codes, standards and regulations relevant to lighting system recommendations.

ENRG 55A HVAC 1, Fundamentals & Components, *52 hours*

Description: Fundamentals and concepts of HVAC with emphasis on types of equipment and conveyance. Principles of work, power and energy. Refrigeration cycle, psychrometric chart, load calculations, nameplate identification, media.

Major Learning Outcomes:

Upon completion of this course a student will be able to:

- Describe the principles and concepts of work, power, and energy.
- Describe the basic principles of thermodynamics and heat transfer.
- Measure and calculate conversion of units, such as temperature, pressure, power, British Thermal Units (BTU), etc.
- Analyze and interpret room conditions using the psychrometric chart and software such as Trace 700 or e-Quest.
- Estimate various types of heating and cooling loads as applied to buildings, rooms, and mechanical systems.
- Define the purpose of various heating, cooling, and conveyance equipment.
- Identify various heating, cooling, and conveyance equipment in the field.
- Interpret name plate data of various heating, cooling, and conveyance equipment.

ENRG 55B HVAC 2, Systems & Efficiencies, *52 hours*

Description: Configured HVAC systems types, system controls and identification of energy efficiency or conservation measures.

Major Learning Outcomes:

Upon completion of this course a student will be able to:

- Describe and compare various types of air side systems such as single duct, dual duct, multi-zone, psychrometrics, terminal units, etc.
- Describe and compare various types of water side systems such as steam, condenser water, hydronic, cooling and heating sources.
- Describe the fundamentals of various controls of HVAC systems.
- Evaluate energy conservation or efficiency measures of HVAC systems.
- Calculate the energy efficiency or conservation coefficients such COP, EER and/or SEER.
- Examine and evaluate various energy efficiency or conservation measures as applied to HVAC systems.
- Calculate the amount of energy saved by implementing energy efficiency measures on both air side and water side systems.

ENRG 56 Building Envelope Systems, *30 hours*

Description: Fundamentals of building envelope systems and how they can be used to control heat, light, sound, moisture, air movement. Benefits, challenges and applications of low-impact sustainable strategies for buildings.

Major Learning Outcomes:

Upon completion of this course a student will be able to:

- Describe and distinguish the elements of the building envelope, including roof, walls, and glazing.
- Describe and identify various building materials used in constructing commercial buildings.
- Estimate the U-value, R-factor and C-value of various insulation materials.
- Interpret relevant codes and code compliance related to existing buildings.
- Describe the processes of air infiltration and natural ventilation into a building.
- Describe various glazing types and relate them to thermal effects.
- Compare and contrast various passive heating and cooling systems.
- Evaluate the benefits and challenges of implementing various sustainability strategies.

ENRG 57 Miscellaneous Building Systems, *18 hours*

Description: Overview of types of facilities with high-energy use equipment, descriptions of equipment, plug load, vampire loads. Common energy efficiency opportunities.

Major Learning Outcomes:

Upon completion of this course a student will be able to:

- Describe the types of facilities that contain high energy-use equipment, and evaluate why these are of interest to commercial building auditors.
- Summarize the types of equipment in commercial kitchens, describe energy efficiency opportunities within commercial kitchens, and assess the challenges to implementing many of them.
- Summarize the types of equipment in grocery stores, describe the energy efficiency opportunities within grocery stores, and assess the challenges to implementing many of them.
- Summarize the types of equipment in offices, describe the energy efficiency opportunities within offices, and assess the challenges to implementing many of them.
- Categorize equipment that contributes to vampire loads, and assess energy efficiency opportunities.

ENRG 58 Demand Response for Energy Auditors, *18 hours*

Description: 5% of California generation is only utilized for 40 hours over a year. The power plants represented in this 5% are the dirtiest and most expensive in the state. We can eliminate the need for this generation through the use of demand response (DR) and load management. This class explores the applicability of various DR strategies including global temperature adjustment, global dimming for lights, pre-cooling and load control devices. DR rates and incentive types will be covered. Other topics include thermal storage and other load shifting systems, AutoDR, persistence and commissioning of these systems.

Major Learning Outcomes:

Upon completion of this course a student will be able to:

- Assess the importance of load management and demand response in limiting peak load across the electrical grid.
- Calculate and analyze load factor for various facilities as part of an effort to determine the impact of demand response or load shifting strategies.
- Synthesize information on the variables that inform load management and demand response projects including utility rates, climate, facility type, facility usage patterns and occupant satisfaction.
- Evaluate specific facilities for the potential application of various load management and demand response measures.
- Integrate back-up generators and alternative work-force schedules into demand response strategies, and consider the challenges these measures introduce.
- Assess the value of automating demand response strategies to speed up response time and eliminate human errors.

ENRG 59 Simulation Methods & Code Compliance, *36 hours*

Description: California's energy and sustainability codes represent cost-effective levels of building performance and are a critical reference for energy auditors. This course explores the Building Energy Code (Title 24, section 6), Appliance Code (Title 20), and the Green Building Code (Title 24, section 11). The class will include modules on simulation tools that can be used for code compliance, analysis of the potential impact for specific EE and DR measures, verification of energy savings efforts. Simulation programs to be addressed include eQUEST, EnergyPro and Ecotect. Students will model specific EE measures or whole facilities with these programs as part of in-class exercises and homework assignments.

Major Learning Outcomes:

Upon completion of this course a student will be able to:

- Describe the history of commercial energy efficiency regulation in California and related codes.
- Describe the components of the Building Energy Efficiency Standards (Title 24, Section 6), the Appliance Code (Title 20), and the Green Building Code (Title 24, Part 11), and the building simulation requirements of each.
- Compare various Building Energy Modeling Programs (BEMS), including Energy Pro, eQUEST, and Ecotect.
- Create a building model using a BEMS such as eQUEST, and employ that model to measure and evaluate various energy efficiency and demand response measures.

ENRG 60 Professional Behavior for Energy Auditors, *18 hours*

Description: Professional business behavior and communications for commercial building energy auditors. Includes written, telephonic and face-to-face communications, scheduling and conducting site visits with building owners/managers and their employees, basic report writing and presentations.

Major Learning Outcomes:

Upon completion of this course a student will be able to:

- Appropriately communicate ideas verbally and in writing to both professional and technical personnel.
- Research and present information clearly and professionally to clients and local agencies before and after site visits.
- Compile and organize information for energy audits.
- Identify, categorize, and prioritize energy efficiency measures and projects for implementation by facility managers, operators, and custodians.
- Manage time and organize work effectively.

ENRG 61 Measurement Tools & Verification of Savings Calculations, *36 hours*

Description: Measurement and verification (M&V) is a quality assurance process for energy efficiency measures that have been implemented. Course covers how M&V relates to audit process, accepted standards, M&V planning, measurement boundaries, data collection tools and methods, savings calculations.

Major Learning Outcomes:

Upon completion of this course a student will be able to:

- Describe the role of measurement and verification in the commercial building audit process.
- Distinguish between different measurement boundaries, and describe the appropriate selection criteria for each.
- Identify sources of data and appropriate measurement instruments.
- Assess and apply different energy savings analysis methods.
- Calculate actual energy savings based on data.

ENRG 62 Energy Audit Report Writing, *36 hours*

Description: Capstone course for commercial buildings energy audit program. Concurrent enrollment with ENRG 63 Field Work in Commercial Energy Audit. Writing compelling and accurate technical report of audit findings for non-technical audience. Elements, formats, templates, structure, graphics.

Major Learning Outcomes:

Upon completion of this course a student will be able to:

- Assess the purpose of the audit report, scope of work, and level of detail required for the report.
- Organize information and create a plan for report writing.
- Manage time effectively to meet client and employer needs.
- Summarize audit findings and recommendations clearly and concisely.
- Utilize tables, charts, and graphics to illustrate information and improve client understanding of findings.
- Formulate prioritized recommendations that evaluate energy efficiency measure (EEM) recommendations in terms of energy savings and financial costs/ benefits to the client.

ENRG 63 Fieldwork in Commercial Energy Auditing, *105 hours*

Description: Capstone course for commercial buildings energy audit program. Supervised field work experience or internship for a minimum 5 hours/week, plus weekly conferences with supervisor or faculty lead. Concurrent enrollment with ENRG 62 Audit Report Writing.

Major Learning Outcomes:

Upon completion of this course a student will be able to:

- Create and manage effective professional relationships with clients and their employees, including promptness, responsibility and courtesy.
- Plan and organize audit activities, including pre-audit information collection, site visit(s), and interviews.
- Inspect and catalog various equipment at the client's facility, including heating, cooling, lighting, process and other system equipment.
- Evaluate energy efficiency opportunities, calculate potential energy savings, and formulate recommendations for implementation.
- Organize and set up power point presentation of findings to clients and team members.
- Select appropriate standard terminology and format for technical report writing.