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Advancing Building Energy Retrofit Industry through Engaged Scholarship

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ABSTRACT

This paper outlines the result of an innovative program to develop a competency-based curriculum and a work process to engage students in energy assessment of small commercial buildings in their community. Throughout the resulting course, "Leadership in Building Energy Efficiency (LBEE)," students were trained to gather buildings' energy-related data and make recommendations for potential courses of action. The program facilitated energy assessment for 45 commercial buildings and supported the development of a retrofit plan with financing in place for nearly 30 of these projects. The purpose of this collaborative program was to advance building energy efficiency through the introduction of new methods and processes leading to financially viable energy retrofits of small commercial buildings. The program focused on assisting small restaurants, grocery stores and other food sales/services that are low-profit- margin and usually lack the ability to manage and finance energy efficiency improvements. As a result of this program, students got engaged in making long-term improvements in their communities. Additionally, they gained the real-world skills necessary to develop and execute energy retrofit projects for other customer segments as part of their careers. The program is broadening and scaling up to include other building use types and aims to be part of the development pipeline for energy retrofit projects in a way that develops students' capabilities, increases the knowledge of building owners and operators, and reduces the development costs of energy service firms and third-party financers.

Key words: Engineering curriculum, Experiential learning, Flipped classroom

INTRODUCTION

In the United States, residential and commercial buildings consume over 70% of the electrical power generated, 40% of primary energy, and are responsible for 40% of CO2 emissions from combustion (EPA 2016; EIA 2018; Pérez-Lombard, Ortiz, and Pout 2008). Once constructed, buildings remain in use for many decades. For example, in 2012 the median age of commercial buildings in the US was 32 years old (CBECS 2015). The retrofit of buildings to improve energy performance represents a substantial opportunity in the construction market with the potential to reduce energy demand, create jobs, and achieve environmental benefits. Small and medium-sized buildings account for 10% of US primary energy use but are typically unserved by the energy retrofit industry. Significant factors restrain efforts to pursue small commercial building energy efficiency. Building owners and tenants often lack the funds or authority to invest in retrofit projects. Stakeholders may lack the necessary information to recognize the benefits of retrofit projects. These factors are compounded by limited market capability to develop and aggregate small commercial building retrofit projects. This research seeks to advance building energy efficiency through the introduction of new methods and processes leading to financially viable energy retrofits of small commercial buildings with an emphasis on restaurants and convenience stores.

The first innovation in this effort was the design of a competency-based curriculum to prepare students for conducting building energy assessments. An engaged scholarship approach was then introduced to the business development process to lower the cost of developing energy retrofit projects.

The retrofit of small commercial buildings on a large scale offers a significant opportunity to reduce energy consumption and associated greenhouse gas emissions, spur economic development in the form of construction activity, lower utility costs for small businesses, and improve the health and well-being of building occupants. Furthermore, throughout this program students gained the real-world skills necessary to develop and execute projects for other related businesses as part of their careers. This engaged scholarship approach is transferable to other engineering disciplines and justifies further investment in coursework development that prepares students to make long-term impacts in their communities.

BACKGROUND

There is an increased demand, driven by policy initiatives, regulatory requirements, and technology advancements, for a workforce with advanced competencies in commercial building operations, maintenance, and energy-related technologies. In the early 1970s, McClelland identified competencies as significant predictors of employee performance and success. A competency is an assortment of knowledge, skills, abilities (collectively KSAs), behaviors, and personal characteristics that encompasses mental, intellectual, cognitive, social, emotional, attitudinal, and physical characteristics necessary for success in a given role, job, or position (Boyatzis 1982; McClelland 1976). McClelland regarded competency models as an assessment tool that can help develop behaviorally based interview protocols; clarify hiring requirements in terms of finding the right fit; equip staff with complete information regarding succession into specific positions; inform employers about the necessary development strategies; and finally, educate job seekers to increase their employability. Competency models are also regarded as an asset for human resources to assist professional development of employees, both at entry points into a position and moving up or over to other positions (McClelland 1994; Boyatzis 1982). To meet the needs of a high-growth sector such as commercial building energy efficiency, business and industry leaders as well as educators, trainers, career counsellors, and job seekers must understand the competencies necessary for workplace success. The US Department of Energy has worked closely with the commercial building industry and other key stakeholders to address these needs by developing national guidelines to improve the quality and consistency of commercial building workforce and energy-related jobs (CBEI n.d.). One product of this work was the creation of Job Task Analyses (JTAs) for four key job titles in the advanced commercial buildings workforce: Energy Auditor, Building Commissioning Professional, Building Operations Professional, and Energy Manager. Another outcome of this effort was the development of a competency model for each the positions (Figure 1). Note that the competency model has been available to users since May 2015 on the Competency Model Clearinghouse website (https://www.careeronestop.org/CompetencyModel/competency-models/Advanced-Commercial.aspx). This work includes information from the Competency Model Clearinghouse, a website sponsored by the US Department of Labor, Employment and Training Administration (USDOL, ETA), used under the CC BY 4.0 license.

A competency model is a visual representation of the competencies for an entire industry or occupation often represented through illustrations that map competencies in a hierarchical manner (Campion et al. 2011; Cao and Thomas 2013). Levels in the model correlate with the likely arenas in which competencies are cultivated—from personal traits developed through life experiences to those learned in training, and onward and upward through increasingly focused work experiences. An industry competency model can serve as a resource to help articulate the workforce needs. The model can be used to understand the competencies required of an industry workforce and how they match job requirements with industry recognized skills. The model can also illuminate competencies gaps within industries where short-term training programs can be developed to address them or where existing programs can be modified (Ennis 2013). The tiers of the model are divided into blocks representing the KSAs essential for successful

Figure 1. Advanced Commercial Buildings Workforce (ACBW) Competency Mode.

performance in the industry or occupation represented by the model. Each competency is described by key behaviors or examples of the critical work functions or technical content common to the industry.

Every occupation requires a different mix of KSAs and is performed using a variety of activities and tasks. The top tier describes the occupation-specific knowledge, skills, and technical competencies for each of the job titles: Building Operations Professional, Energy Auditor, Building Commissioning Professional, and Energy Manager. For example, building energy auditing can include a wide array of processes and tasks across building systems that are often completed by highly experienced professionals. Table 1. Sample List of Occupation Specific

Table 1. Sample List of Occupation Specific Competencies for Energy Auditor.

	Knowledge	Skills
Energy Auditor	• Building physics • Building pressurization • Sampling protocols and procedures • Type of energy audits (level 1, 2, or 3, etc.) • Typical energy analysis methodologies • Typical energy usage by building type • Typical percentage of end usage by occupancy type	• Understand available data types for weather (bin data, hourly data, TMY, etc.) • Ability to determine tools needed for an audit • Ability to interpret thermography • Programming skills

Competencies for Energy Auditor. is a sampled list of occupation specific competencies for energy auditors, the entire list can be accessed on the Careeronestop website (CMC n.d.).

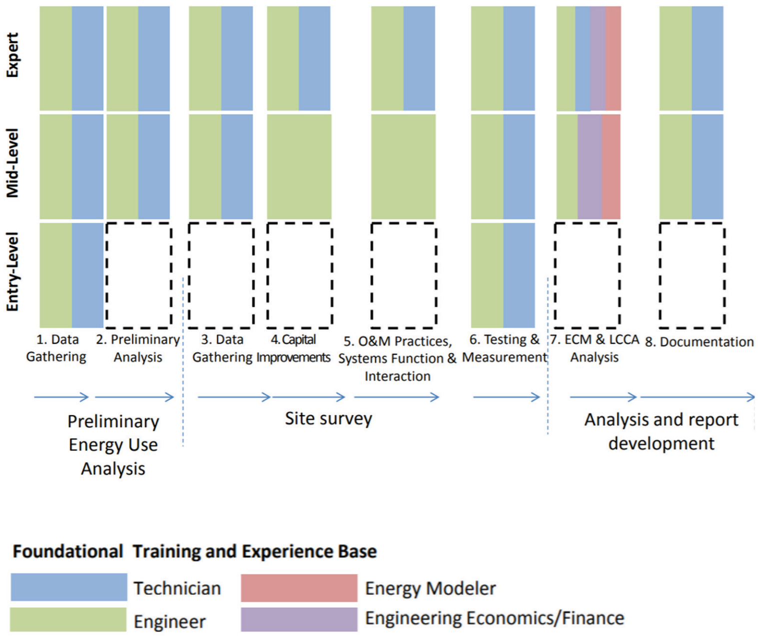
Building energy characterization commonly referred to as “energy auditing” or “energy assessment” refers to the actions taken to understand and describe the factors contributing to building energy performance. While energy auditing provides information on energy conservation strategies, current methods are largely focused on financial savings and packages of measures with the best return on investment (Fuller et al. 2010; Ingle et al. 2012). Furthermore, in current practices, investment is often wasted on collecting detailed data, instrumentation, writing long and technical reports, detailed energy models and saving analyses for projects that do not result in actual retrofits.

The American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) defines three tiers of energy audits that reflect a continuum of increasing effort and investment (Deru 2011): Level 1 Audits focus on site and preliminary assessments to identify no-cost/low-cost energy-saving strategies and the potential for larger opportunities through brief inspections of buildings and assessment of energy bills. Generally offered at no cost, Level 1 Audits are often performed as a means to securing fee-based energy analysis work. Level 2 Audits focus on more detailed energy surveys and analysis, which provide more information on energy use in buildings and potential energy savings. Level 3 Audits include the design of retrofit packages and economic analyses to inform detailed recommendations and potential financial return on investment for major energy-saving strategies.

The capability to detect potential energy improvement opportunities through observation and engagement with building owners/occupants is key in the first stages of building energy characterization. Table 2. Foundational Training and Experience Base in Energy Audit Process shows the training and experience that is required for performing a Level 1 audit compared to Level 3. For example, data gathering can be accomplished by less experienced and even entry-level energy professionals while a mid-level or an expert energy modeler is needed to conduct a life-cycle analysis.

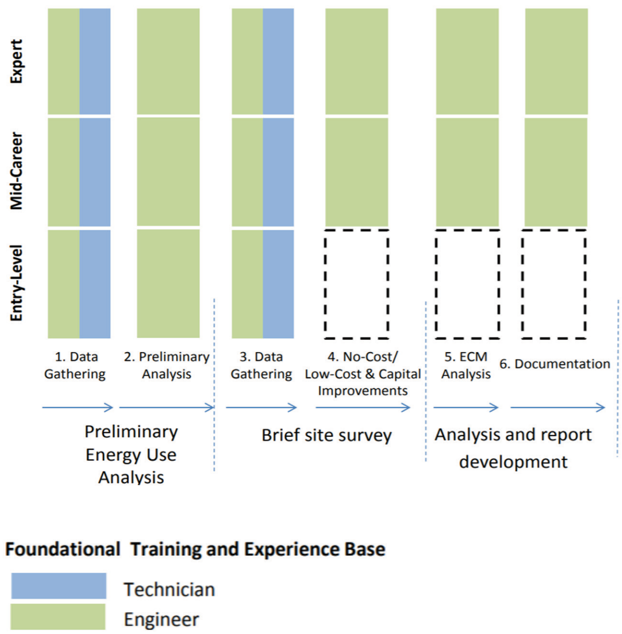
Table 2. Foundational Training and Experience Base in Energy Audit Process

Level 1 Audit: Walk Through Analysis



Source: (CBEI, n.d.)

Level 3 Audit: Detailed Analysis of Capital – Intensive Modifications



Source: (CBEI, n.d.)

COURSE DESIGN AND DEVELOPMENT

According to research, project-based learning, where students are active participants, is one of the most effective ways to learn engineering design (Dym et al. 2005; Dutson et al. 1997; Smith et al. 2005). Simultaneously, project-based learning models that engage students in building energy efficiency have emerged as a potential strategy to build broad capacity in building energy systems. Further, in programs that are engaging students in building energy assessment, it has been observed that students have a unique potential to connect and build trusting relationships with building owners (Wu et al. 2016). Additional studies have shown that engaging students is a powerful strategy in the pursuit of a sustainable future (Dale and Newman 2005; Feldbaum 2009; Brundiers, Wiek, and Redman 2010). In this section, the initial activities to deploy a competency model in the design of a project based curriculum are presented.

The "Leadership in Building Energy Efficiency (LBEE)" course objectives are targeted for a 400-level or graduate course experience. Upon completion of the course, students will be able to (1) demonstrate knowledge of typical building systems that impact energy use, (2) gather data pertaining to energy use through observation and field measurements, (3) analyze potential quantitative energy savings resulting from recommendations, and (4) communicate results of data collection and analysis to targeted audience.

Further definition of the course objectives in an engaged scholarship context includes the description of "performance competencies" that require judgment on the role of students between simply completing a task and completing the task well and in a way that leads to client satisfaction. These "performance competencies" include the ability to (1) gather appropriate information through communication and observation; (2) work effectively with tools needed for an energy assessment; (3) accurately analyze and interpret data (utility bills, thermographs, etc.); and (4) author high quality reports that are realistic, credible, and verifiable and communicating the results with the client.

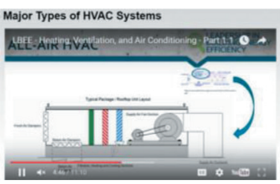
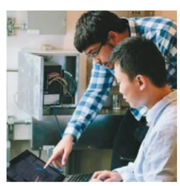
In order to accomplish these objectives, the course focuses on the identification and implementation of no- and low-cost energy efficiency measures in buildings, referred to as building re-tuning (BRT) or a Level 1 audit as defined by ASHRAE standards (PNNL n.d.). Specifically, the training is intended to prepare students for a subset of the occupation- and industry-related tasks for energy auditors (as defined in the ACBW competency model shown in Figure 1). The following activities comprise the BRT process:

1. Performing targeted outreach and client acquisition to identify candidates for building energy assessment.

2. Conducting the pre-qualification survey to gather background information (e.g., utility bills, size of building, its function, etc.).
3. Analyzing the utility data before building walkthrough.
4. Conducting walkthroughs, making observations, and taking all necessary measurements with the use of hand tools and/or auditing equipment.
5. Analyzing the gathered information to identify areas of concern.
6. Making necessary recommendations to the client in a way that will lead to action.
7. Documenting all data and writing a report that effectively communicates energy-saving opportunities to building owners.

Offered in the Architectural Engineering Department at The Pennsylvania State University (Penn State) since Fall 2014, the LBEE course is a hybrid class that uses the flipped classroom model. In a flipped classroom, the course content for a given module is delivered electronically prior to class each week, with the expectation that students will review and learn the content independently in advance of class. The modules introduce the topics of energy efficiency management in major focus areas: lighting, building envelope, hot water/steam systems, HVAC, compressed air, plug loads, building automation system, and indoor environment quality. Each module is designed to introduce students to the topic, check their learning as they move through the content, and deliver activities to reinforce and assess their learning. Class time is then available for demonstrations of measurement tools, hands-on training, in-class discussion around weekly topics, on-site building data collection, report writing, and project presentations (See Table 3. LBEE Course Structure.).

Table 3. LBEE Course Structure.

Short video lectures—viewed by students before the class	In-class time	During walkthroughs	Group project—after walkthrough
• Identify energy saving opportunities in small commercial buildings	• Discussions and Q&A about video lectures • Visual inspection of building systems, using campus building as a teaching tool • Learning how to work with different tools	• Conduct building energy assessments	• Generate energy assessment reports • Share findings with building owners
			

A WORK PROCESS FOR STUDENT-LED ENERGY ASSESSMENT

In 2014, the Pennsylvania Department of Environmental Protection (PA DEP) funded a collaborative effort designed to demonstrate a scalable approach to facilitating building energy assessments that would lead directly to energy retrofit proposals and installations in small-sized commercial facilities. The first innovation of this initiative was "lowering the cost of energy retrofit" by utilizing an engaged scholarship approach. A new entity was envisioned to pursue proposed strategies and to serve as a coordinating body across the research, education, outreach, and business transactions that make up the work process. This entity, named Energy Outreach and Assessment Center (EOAC), was created to house training and management functions of the program as well as incubation space for the collaborating team members.

The three major project partners in the first year of the program were Penn State, contractor Private Energy Partners, LLC (PEP), and the Philadelphia Energy Authority (PEA). Penn State played a primary role in designing the program and documenting the process, conducting student training, project data management, and data review/validation/makeup deficiencies to ensure accurate data transfer to PEP. PEP assessed buildings for deep retrofit, provided the engineering for detailed multi-system measure retrofit proposals, developed a supplier base to sell high quality but affordably priced equipment into the program, identified high quality and affordable implementation partners, and managed communications with clients about the grant and other financing partner possibilities. The PEA role was to provide city connections and support as the primary liaison with different agencies and utility companies in Philadelphia such as Philadelphia Electric Company (PECO), Philadelphia Gas Works (PGW), and the Philadelphia Water Department (PWD). PEA also contributed to marketing and messaging, translated flyers into other languages, arranged for the team to procure utility data, participated in the development of the proposal template, and reviewed final retrofit proposals.

Most students came from one of three educational institutions: Penn State, Temple University, or Delaware Technical Community College. Two different methods of training students to conduct energy assessments were demonstrated. One method offered the LBEE course as a senior-level academic three-credit course (currently AE-498) in summer semesters. The second method was the creation of an intensive, non-credit "bootcamp" based on the LBEE course material and was offered in January 2017 to nine community college and four-year engineering students.

Students in the three-credit hour course the non-credit bootcamp-style course, were expected to conduct building energy assessments after the initial client engagement. The lifecycle of an individual project involves the initial client engagement, student-led building energy assessment, energy economic savings analysis, and retrofit proposal development. Figure 2 presents the flow of

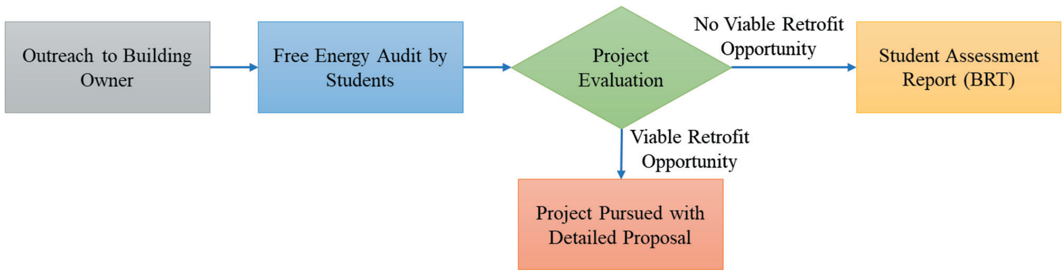


Figure 2. Flow of Projects from Initial Outreach to Tenants and Retrofit Proposal Development.

an individual project from initial client engagement, through building energy assessment, energy-economic savings analysis, and retrofit proposal development.

Building owners were contacted by EOAC staff and the results from recruiters' initial observations, a short pre-qualification survey, and follow-up phone calls were documented in a shared tracking sheet. Those that met the pre-qualification criteria listed in Table 4. Criteria for Project Evaluation. were scheduled to receive an on-site energy assessment. To lower the cost of the customer acquisition, EOAC employed less experienced (entry-level) students who were trained to collect vital data about building conditions, energy use, and the limitations of building tenants/owners to accommodate energy upgrades. Each building was evaluated in terms of savings opportunities and alignment with regional financial incentives. Projects with favorable conditions for deep energy retrofit according to the criteria in Table 4. Criteria for Project Evaluation. received a detailed audit which identified and priced upgrades to create a retrofit plan.

Table 4. Criteria for Project Evaluation.

Pre-Qualification Criteria	Criteria for Deep Retrofit
1. Confirm that business type was small food sales/services 2. Confirm client willingness and engagement 3. Access to 12 months of utility bills	1. Old equipment, issues with repairs, and/or desire for replacements that would yield in more than 20% savings 2. The ownership status (Ask whether they own or lease the building) 3. Confirm client willingness to invest time and money for upgrading their buildings

DISCUSSION OF IMPACT FOR STAKEHOLDERS

This section describes the long-term impact of this engaged scholarship approach for stakeholders of the energy retrofit industry. These stakeholders include building owners/occupants, energy service companies, students as future professionals, educators, and sustainability in general—defined as the "triple bottom line"—environment, society, economics. To discern and organize different beneficiaries in energy retrofit projects, a framework proposed by Sanford was used in the program evaluation process (Sanford 2011). In this framework, there are five categories of stakeholder. The first and foundational stakeholder is the customer or consumer. The second stakeholder, co-creators, is comprised of the people and organizations who contribute to the creation of a product or service, from raw material suppliers to employees and contractors. The third stakeholder is Earth systems, also referred to as ecosystem services, the original source and infrastructure without which human activities would be impossible (sun, wind, water). The fourth stakeholder is community, the human inhabitants of all the places with which a business needs to partner in order to source its materials and workers, manufacture its goods, sell its products or services, and recycle or store its waste. The fifth stakeholder is the investor, without which the company's business would be difficult or impossible to realize. Drawing from this framework, the five stakeholder groups of the building energy retrofit industry are presented in Table 5. Stakeholders of Buildings' Energy Retrofit Industry..

Over the program period, several focus groups were conducted with project team members who identified clients, collected data, authored reports and proposals, and ultimately managed retrofit projects (See Figure 3 for more details on the structure of the focus groups).

The focus groups aimed to ensure a reciprocal value exchange and a balanced contribution in the network of stakeholders. The added value for different stakeholders that was observed and captured by project team members is summarized in Figure 4.

A total of 28 student assessors were trained and hired as interns in the first year of the program: 10 in Summer 2016, 9 in January 2017, and 9 in Summer 2017. Internships are low-cost and provide career experience. Additionally, there is a demand from the market to hire trained students and create (green) jobs. These types of internships are aligned with community college goals and potentially

Table 5. Stakeholders of Buildings' Energy Retrofit Industry.

Stakeholder	
Customer	Building Owner/Manager; Occupants/Tenants; Building Operators
Co-Creators	Energy Service Companies; Service Providers; Contractors; Learning Communities (growing networks of trainers, trainees, and researchers who are interested and work in this area, learning from each other's experience); Supply Chain Partners
Earth Systems	Living systems are often underrepresented members of stakeholder groups. Including them here allows us to honor the fact that buildings and the environment exchange energy and resources daily and will allow us to think about the long-term sustainability of the whole system.
Investors	Energy Investment Funds; Building Owners, Business Development Professionals
Community	Neighborhoods; Utility Companies; Municipalities; Energy Authorities; Association of Specialty Organizations/Businesses; Community Economic Development Associations

Figure 3. Focus Groups for Program Evaluation.

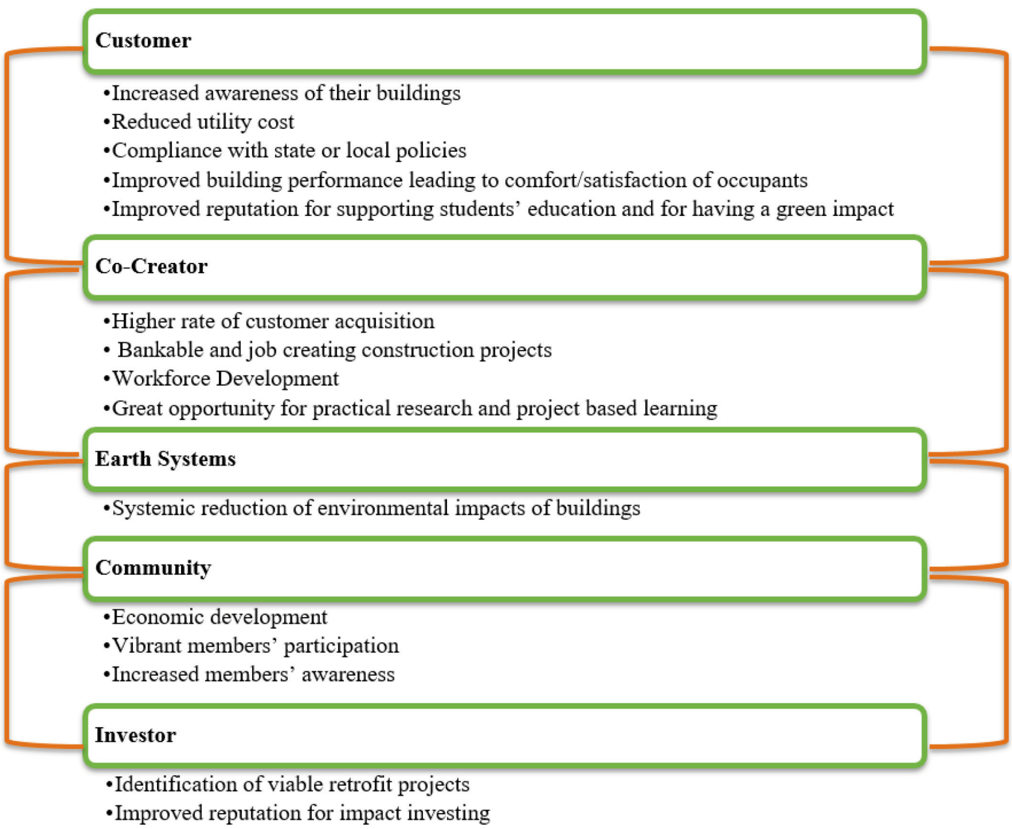


Figure 4. Value Exchange between Building Energy Stakeholders.

with other programs that are designed to strengthen the career and workforce readiness of students. Moreover, many clients like the idea of helping students further their education by letting them conduct an energy assessment.

During the first year of the program, 116 businesses in Philadelphia were contacted by EOAC staff. Fifty-seven businesses were interested in the program and were asked to provide 12 months of their utility bills. Forty-five businesses out of fifty-seven interested clients received a free building energy assessment. The assessment reports increase the awareness of the building owners about the energy systems in their buildings and help with the identification of viable retrofit projects.

Finally, 29 of the conducted assessments were converted to deep retrofit proposals with an estimated minimum annual energy savings of 878,000 kWh. These proposals are potential construction projects that are bankable and can create job opportunities in the community. If implemented, building owners can benefit from the savings on their utility bills and from the improved comfort/satisfaction of occupants. Moreover, designers, builders, manufacturers, and policy makers can experience systemic economic, environmental, and social system effects of a vibrant and vital energy retrofit industry.

DISCUSSIONS OF IMPACT ON STUDENT COMPETENCIES

To investigate the effectiveness of the program, in this section we discuss the strengths and weaknesses of this innovative approach regarding students' competency in conducting energy assessment. In addition to the general grading system that is part of the course design for ensuring learning outcomes are met, in this study students were engaged in weekly project group meetings. This could empower students to play an active role in improving the learning outcomes and helping instructors to design more efficient and productive future teaching materials. Based on the results of students' self-assessment and observations of project team over the course of program, the following lessons were learned:

1. Semester or summer internships are not long enough for the students to maximize their contribution and return the investment in training them. We recommend that future implementations of a student-led energy assessment program are structured around 12-month long internships. This duration should provide students adequate time to reach proficiency and contribute value to a program designed to foster energy retrofits. Additionally, we recommend similar programs are structured to pair new student assessors with experienced student assessors, allowing the experienced students to contribute to the training of the subsequent cohort of assessors.
2. For students, there are always some limitations on personal effectiveness competencies (Tier 1 in Figure 1). It was difficult and cumbersome to schedule assessments for student interns who

were also enrolled in classes and only working part-time. Penn State decided to only deploy pairs of assessors in the field, which restricted the number of assessments that could be conducted each week.

3. All students found themselves confident in doing all preliminary energy use analysis. As all participants had engineering and technology backgrounds that provided them with sufficient skill to easily deal with data, their high level of confidence in conducting these tasks was expected. This expectation needs to be factored into the design of teaching materials for those students who lack the academic competencies (Tier 2 in Figure 1. Advanced Commercial Buildings Workforce (ACBW) Competency Mode.). After evaluating the final building energy assessment reports written by students in the first class; however, it was found that achieving writing competencies is time intensive. Consequently, an automated report writing tool was developed as a result and has been used to save time and to increase the quality of the work.
4. All students could gain a satisfactory level of confidence working with tools such as a light-meter, infrared camera, ultrasonic acoustic detector, and combustion multi-meter, and make savings calculations based on the results recorded through those devices. Therefore, it is an attainable task to provide students with the occupation-specific requirements by teaching them how to use BRT-related tools and expecting them to conduct the corresponding calculation and analysis comfortably after doing two to three walkthroughs. Students could easily gain confidence in making meaningful observations, e.g., locating daylight harvesting opportunities, finding issues with thermostats location, and other no-cost/low-cost opportunities. Again, it needs to be noted that levels of confidence gained, and their duration might vary for each student, based on their educational background.
5. All students seem to be lacking the requisite confidence to find issues related to the Building Automation System (BAS), which indicates the need for more attention and more targeted education. One possible cause for this lack of confidence could be that the specific walkthroughs provided students with limited opportunities to experience and learn in areas such as HVAC and lighting automation systems, packaged units and indoor air quality, and most of the majority of case studies were buildings without BAS. Therefore, if students are expected to be able to perform independently and exhibit meaningful contribution in those areas, a more in-depth investigation needs to be made on the extent of their educational preparation to equip them with enough theoretical knowledge, as well as designing more targeted walkthroughs to provide them with the appropriate milieu to exercise their knowledge and gain reasonable level of technical competencies (Tier 4 and 5 in Figure 1). In this program, students were asked to take pictures of the equipment including the model number to later look them up online or ask more detailed questions from our industry partners.

6. The paper-based data gathering method is primitive and inefficient. Existing commercial audit tools did not appear suitable for the program without extensive modification. Data entry and data transfer from the data collection spreadsheet to the retrofit proposal was time consuming and there is a need for streamlining this process. A seamless and customized tool that avoids data reentry could increase efficiency and help contain proposal preparation costs.

CONCLUSIONS

Human resources and talent management professionals, drawing on McClelland's identification of competencies as significant predictors of employee success and performance, utilize competencies to refine their processes of attracting, recruiting, assessing, selecting, placing, developing, training, evaluating, and rewarding employees. In addition, human resources management professionals have used competency models to align organizational goals with the existing talents of its workers, organize the business needs, direct strategic plans, and drive the mission of a company. Competency models are not an "end product," but are developed as a resource for multiple uses, including developing workforce planning, conducting labor analyses, communicating the needs of the industry, guiding career development, establishing career pathways, informing curriculum and instructional developers, and highlighting requirements for certifications and licensure.

In this study, the ACBW Competency Model was used to identify the skills and knowledge sought by potential employers in energy retrofit industry. Additionally, this study presents a practical use of this model in design of training programs for building energy assessment. During the first year of the program, 116 businesses in Philadelphia were contacted and the resulted in 45 on-site energy assessments; 29 of the conducted assessments were converted to deep retrofit proposals with estimated minimum annual energy savings of 878,000 kWh. The results of this study combined with student performance monitoring over several semesters indicate students rapidly gained the confidence to conducting independent walkthroughs, which helped meet energy conservation and saving goals of their local utility program. Additionally, this study identified program highlights and learnings that can be leverage for future efforts:

- To meet the needs of a high-growth sector such as commercial building energy efficiency, business and industry leaders, educators, trainers, career counsellors, and job seekers must understand the competencies necessary for workplace success.
- A clear definition of the KSAs and competencies required for various professionals in the building industry is efficaciously presented through a competency building block model.
- In the engineering curriculum, a strong emphasis on learning through application can be beneficial to students by developing competencies that are valuable in the workforce.

- Competency models are an effective instrument for targeted and effective investments in education and training that is responsive to the demand for a skilled and qualified workforce. Competency-based training in the commercial buildings workforce can lead to faster career progression and advance building energy retrofit industry.
- Engineering students can be trained to gather building energy use data and analyze them to identify no- and low-cost energy conservation opportunities. This can be beneficial for stakeholders of the energy retrofit industry and the sustainability in general, defined as the "triple bottom line"—environment, society, economics.

These results justify further investment in coursework that teaches and prepares students to make long-term impacts in their communities. Development of custom applications and tools to enable the accurate and efficient collection of on-site building data and generate high quality reports is also an area worth investing time and money. Further research is needed to explore the integration of advanced tools and analytical methods that can also support the elevation of this approach to a graduate level course leading to the integration of student research projects focused on energy efficiency in buildings.

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