TEXAS ENGINEERING EXTENSION SERVICE

TEXAS A&M ENGINEERING

A Member of The Texas A&M University System

Final Scientific/Technical Report

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Consortium/Team Members: N/A

Recovery Act: Training Program Development for Commercial Building Equipment Technicians

DOE Award DE-EE0003856

TEEX TRAIN • SERVE • RESPOND

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Abstract

The overall goal of this project has been to develop curricula, certification requirements, and accreditation standards for training on energy efficient practices and technologies for commercial building technicians. These training products will advance industry expertise towards net-zero energy commercial building goals and will result in a substantial reduction in energy use. The ultimate objective is to develop a workforce that can bring existing commercial buildings up to their energy performance potential and ensure that new commercial buildings do not fall below their expected optimal level of performance.

Commercial building equipment technicians participating in this training program will learn how to best operate commercial buildings to ensure they reach their expected energy performance level. The training is a combination of classroom, online and on-site lessons. The Texas Engineering Extension Service (TEEX) developed curricula using subject matter and adult learning experts to ensure the training meets certification requirements and accreditation standards for training these technicians. The training targets a specific climate zone to meets the needs, specialized expertise, and perspectives of the commercial building equipment technicians in that zone.

The combination of efficient operations and advanced design will improve the internal built environment of a commercial building by increasing comfort and safety, while reducing energy use and environmental impact. Properly trained technicians will ensure equipment operates at design specifications. A second impact is a more highly trained workforce that is better equipped to obtain employment.

Organizations that contributed to the development of the training program include TEEX and the Texas Engineering Experiment Station (TEES) (both members of The Texas A&M University System). TEES is also a member of the Building Commissioning Association.

This report includes a description of the project accomplishments, including the course development phases, tasks associated with each phase, and detailed list of the course materials developed. A summary of each year's activities is also included.

Introduction

Currently, most commissioning and maintenance oversight is performed at a degreed engineer level, which makes it expensive and inefficient. The current challenge is to find properly trained technicians to maintain buildings at the highest possible level of energy efficiency at a reasonable cost. The goal of the *Energy Efficiency for Commercial Building Technicians* training program has been to develop a skilled workforce that will bring existing commercial buildings up to their energy performance potential and ensure that new buildings do not fall below the optimal level of performance. In addition to creating a more highly trained workforce that is better equipped to obtain employment, this training helps reduce energy consumption.

Buildings use 42% of the total energy consumed in the United States today. Of that amount, 20% is used in commercial buildings. Reducing energy use can have several benefits, including saved dollars, efficient equipment operation, increased service life, and reduced maintenance. Much of the high cost of energy use is due to factors that are quickly ascertained, such as poorly operating or aging equipment, inadequate building insulation, and excessive infiltration through doors and windows. Many of these factors can be addressed through low- to no-cost options. In addition, more sophisticated changes, such as incorporating building automation systems and alternative energy sources, can further reduce costs. The commercial building technician is on the front line of the effort to determine inefficient energy use and offer corrective solutions. This course is designed to provide commercial building technicians with the knowledge, skills, and abilities to assess, implement, and maintain energy-efficient building operation.

The course is delivered through online, classroom, and hands-on activities. Participants complete the interactive online training prior to the classroom component of the course. The online portion includes an immersive online game to make participants aware of a building's energy use, possible inefficiencies, and potential solutions. After completing the online component, participants attend the classroom component, which consists of lectures, small group activities, and hands-on activities. The hands-on activities include the operation of relevant measurement instruments and a building tour, in which participants assess the building for inefficient energy use and offer corrective solutions.

Accomplishments

The objectives for developing the training program were divided into three phases, with specific tasks under each. TEEX met the overall goal through meeting the following phase objectives and the phase's associated tasks.

Phase I—Management and Integration

Complete a project management plan and integration plan and complete a curricula deficiency/developmental needs analysis.

- Task 1 – Develop a project management plan.

TEEX developed a plan which included the project description and objectives, as well as the projected impact of the project. We also included a risk management plan detailing the possible risks to the project and mitigation plans to address each risk. A log detailed each milestone and the criteria used to determine the successful completion of each milestone. The dates were determined by the project timeline, which was broken down by phase, stage, and then task. The plan also included a funding and costing profile for both years of the development project. The project management plan was submitted to the DOE project manager on September 7, 2010. He requested modifications to the plan, which were incorporated (and are include in the above description), and the plan was resubmitted and accepted on September 30, 2010.

- Task 2 – Develop an integration plan.

The integration plan provided the proposed topic, subtopics, and teaching points for each unit of instruction. The integration was completed on October 1, 2010 and included as part of the program plan.

- Task 3 – Conduct a curricula deficiency/developmental needs analysis.

The results of TEEX's curricula deficiency/developmental needs analysis indicated that while building equipment technicians can receive training in energy efficiency on many

topics, there are serious deficiencies. Training is often piecemeal, covering only one or two aspects of efficient energy performance. Training that offers a more comprehensive approach often fails to address the needs of technicians, focusing instead on engineering professionals. There is also a lack of comprehensive training that targets the hot and dry, hot and humid, and temperate and humid climate zones. The curricula deficiency/developmental needs analysis was completed on October 15, 2010, incorporated into the program plan, and delivered to the DOE project manager on October 22, 2010.

Phase II – Development and Consolidation

Develop curricula and consolidate training materials.

- Task 4 – Develop curricula.

Curricula development was completed on June 1, 2012 using a five-stage development process.

- Stage I – Front-End Analysis (completed February 1, 2011)

Step 1: Needs Assessment – Determine gaps between current and desired outcome, prioritize gaps based on agreed-upon criteria, and determine which gaps are instructional needs and most appropriate for design and development of instruction.

Step 2: Task Analysis – Identify the prerequisites, job functions, and tasks within job functions. Determine if tasks are procedural, process, cognitive, etc.

Step 3: Course Goals and Objectives – Enhance curriculum construction using Bloom's taxonomy in developing the required level of performance needed to adequately address the knowledge, skills and abilities to be learned in the course of instruction. The course goal, along with the terminal and enabling objectives, serves as the foundation of the curriculum.

Step 4: Detailed Course Outline – Organize content into a detailed, logically sequenced outline by grouping objectives according to learning levels (i.e., Bloom's taxonomy) and

sequenced according to a logical progression.

Step 5: Media Selection – Select delivery for blended learning, instructor-led training, video teleconferencing, electronic performance support system, computer-based training, web-based training or synchronous web-based training focused on the target audience, as well as the course goal and objectives.

- Stage II – Design (completed July 15, 2011)

Step 1: Course Design Document – Develop a roadmap for the course design phase; it provides the course framework and documents the detailed expectations and outcomes.

Step 2: Evaluation Plan – Establish an evaluation plan using Kirkpatrick's levels of evaluation, incorporating levels 1 and 2 in all courses through feedback and pre-/post-testing and levels 3 and 4 for performance-based curriculum.

- Stage III – Development (completed March 9, 2012)

Step 1: Templates – Develop content that meets the terminal and enabling objectives for the module resulting in a standard modular design. Content is developed with input from SMEs, training development experts and, when possible, stakeholders to include the potential end-users of the training and is revised, edited, and published by technical writers utilizing state-of-the-art software.

Step 2: Multimedia – Develop visually-rich curriculum incorporating graphs, tables, graphics, photos, and any required software applications to aid in the creation of content. Online course is alpha tested.

- Stage IV – Implementation (completed May 11, 2012)

Step 1: Testing/Rehearsal – Internally test and deploy content. Online course is beta tested.

Step 2: Training Delivery – Deliver content in the prescribed manner. Staff audits the course.

- Stage V – Evaluation (completed June 1, 2012)

  This stage ensures the content, course materials, and feedback function as designed. Participants complete pre- and post-tests, after action reviews, and other feedback for use on curriculum revisions.

- Task 5 – Consolidate training materials.

Course content was formatted into a clear and comprehensive program that encompasses all subject matter in the course. The consolidated training materials were finalized as part of the development process on June 1, 2012. The following items were delivered to the DOE project manager on a USB drive on July 12, 2012:

1. Promotional video—Short video developed to promote the course. It is intended to be posted to online video sharing services and to be shown as a loop at conferences and similar events.
2. Course materials
   - Android app
     - Code package—Directory that contains the source files use to create the buildingTech.apk application.
     - buildingTech.apk—Final software package, ready to be installed on an Android tablet. Currently, the application only works on devices with the Android operating system.
   - Course surveys

        - Follow-up survey—Survey, hosted on SurveyMonkey.com and distributed via email approximately six months after the participant has completed the course, that will assess whether the participant's behavior has changed as a result of the course (Kirkpatrick level 3 evaluation). Results will be collected and analyzed to help TEEX determine what has been effective and what needs to be improved.
        - TEEX satisfaction survey—Standard TEEX satisfaction survey, which will collect responses on the participant's immediate satisfaction with the course (Kirkpatrick level 1 evaluation). Results will be collected and analyzed to help TEEX determine what has been effective, and what needs to be improved.
    - Online course—Standalone version of the online component of the course. The online component will need to be completed before the students can attend the classroom component of the course. The online course starts with a pre-test. The pre-test complements the post-test, given at the end of the course. The scores of the pre-test and post-test will be compared and used to assess the participant's learning as a result of the course (Kirkpatrick level 2 evaluation). The course can be viewed by clicking "Launch_Story.exe." Please note that, because the course is designed to operate within a web-based learning management system, occasional errors may appear when run from a local drive. These can be ignored with no consequence to the course.
    - PowerPoints—Presentations (and associated files) that will be used in the classroom to assist the instructor in delivering the course.
    - Printed material
        - Module 1 Participant Activity Blueprints—Blueprints that are printed and distributed to the students to assist in a participant activity. More detail can be found in the instructor guide.

- Module 5 Walkthrough Blueprints—Blueprints that are printed and distributed to the students to assist in a participant activity. More detail can be found in the instructor guide.
- Instructor Guide—Guide that the instructor can use when teaching the class.
- Knowledge Test—Final exam, which the students will need to pass in order to receive credit for the course. This also serves as the post-test, a complement to the pre-test in the online course. The scores of the pre-test and post-test will be compared and used to assess the participant's learning as a result of the course (Kirkpatrick level 2 evaluation).
- Knowledge Test Key—Copy of the exam that contains the answer key.
- Participant Manual—Manual given to participants when they attend the course.
- Energy Management Tables—Tables that contain information about acceptable light levels. This sheet will be placed next to the light meter so that participants can properly determine appropriate light levels during the building assessment.
- Walkthrough Activity—Sheet, printed in pads of 50 sheets, provides a place for participants to handwrite notes during the building assessment.

Phase III – Certification, Commercialization, and Sustainment

Complete certification/accreditation plan and complete commercialization and sustainability plan.

- Task 6 – Develop a certification/accreditation plan.

A certification plan was developed in which TEEX describes how it achieve accreditation for the course. The team will use existing relationships with certification and accreditation organizations and submit this training program to appropriate organizations for certification approval. Likewise, contacts with engineering and trade associations will be solicited to obtain necessary credentials for certifying coursework completion. Receiving input for

course content and testing creates industry buy-in from partners, and ensures the continued improvement and relevancy of course material. Affiliations with community colleges throughout the country allow for coursework matriculation into existing vocational and associate degree programs.

The certification/accreditation plan was completed on July 11, 2012 and submitted to the DOE program manager as part of the commercialization plan.

- Task 7 – Develop a commercialization and sustainability plan.

A commercialization and sustainability plan was developed in which TEEX describes how it will use its current reputation and industry contacts to commercialize the course. As a statewide recognized industry leader in Heating, Ventilation, and Air Conditioning (HVAC) training, TEEX will market this course by expanding on its current market reach regionally (within the hot-humid zone) through the TEEX website, using direct marketing to collected HVAC email and other targeted mailing lists, promoting the course at conferences and trade shows, and aggressively using various social media avenues (such as Facebook, Twitter, and web blogs) to raise awareness of the course. In addition, TEEX will target HVAC-related associations and facility maintenance organizations, building on existing relationships and developing new ones to market this course. The TEEX marketing team will c produce visually interesting electronic designs that will be launched to targeted email contact lists and create high-quality printed marketing fliers to be widely distributed. A promotional video can be viewed at http://www.youtube.com/watch?v=iDZsQKis0rA&list=PLFFB4F90D0AD62202&index=1&feature=plpp_video.

The commercialization and sustainability plan was completed on July 12, 2012 and submitted to the DOE program manager as part of the commercialization plan.

Year One Summary:
July 13, 2010 through July 12, 2011

TEEX was notified of the award through a letter dated June 22, 2010 and began the initial planning for the project, including completing and submitting the "Environmental Questionnaire" (as required by the National Environmental Policy Act) and the "Representation of Limited Rights Data" form. TEEX received the actual award on July 19, 2010 and prepared a Project Management Plan (PMP). After an initial review of the PMP, the actual start date was shifted from July 13, 2010 to September 1, 2010. This allowed for time to negotiate sub-awards and have the DOE project manager review the updated PMP. However, the period of performance as stated on the award remained the same and TEEX adjusted the timeline to complete all tasks within the award period.

During the first quarter of performance, the initial draft of the sub-award was completed and sent to the sub-recipient for signature. An initial meeting to discuss project timelines, deliverables, and management structure was held with the lead instructional design specialist and the subject matter experts from the TEES and TEEX. In addition to completing and obtaining approval of the PMP, TEEX completed the integration plan and began the curriculum needs analysis. All milestones, reports, and deliverables for the second quarter of the project were achieved/delivered on time, including the following:

- National Energy Technology Laboratory (NETL)/DOE kickoff meeting (completed October 4, 2010)
- Task #2 – Integration plan (completed October 10, 2010)
- Task #3 – Curricula deficiency/developmental needs analysis (completed October 15, 2010)
- Deliverable #1 – Program plan (completed October 22, 2010)
- Quarterly status report (completed October 28, 2010)
- DOE go-no-go decision (completed November 5, 2010)
- Needs analysis (completed December 3, 2010)

- Task analysis (completed December 17, 2010)
- Course goals and objectives (completed December 31, 2010)

In addition, as requested, the results of the Phase II needs/task analysis were submitted for review on December 20, 2010. During the second quarter, TEEX collaborated with other awardees of NETL's Commercial Building Equipment Technicians training program. TEEX initiated and scheduled two conference calls with the Northwest Energy Efficiency Council (NEEC), Gas Technology Institute (GTI), and International Union of Operating Engineers (IUOE). The first conference call was conducted on November 2, 2010, during which the attendees discussed the DOE expectation that the Technician Training Program grantees would interact in the development of the Job Task Analysis/Knowledge, Skills, and Abilities (JTA/KSA) studies developed by their programs. This would ensure that the building technician training programs would be in line with Energy Efficiency and Renewable Energy (EERE) workforce development objectives, specifically the requirements to agree on standard terminology, coordinate gap analyses, and agree on a standard reporting format. As a result of this discussion, TEEX and NEEC shared their individually developed JTA/KSAs with the rest of the group for comments and discussion during the second conference call, which was held on January 5, 2011.

All reports and tasks for the third quarter of the project were achieved/delivered on time including:

Phase II, Stage I – Front end analysis

- Quarterly status report (completed on January 21, 2011)
- Detailed course outline (completed on February 4, 2011)
- Delivery media selection (completed on February 11, 2011)
- Success criteria – TEEX Stage I approval (completed on February 11, 2011)

This stage was completed by the principle investigator with assistance from the subject matter experts and an instructional design specialist. Also during the third quarter, TEEX continued to collaborate with the other Technician Training Program awardees. TEEX scheduled and

participated in a conference call with NEEC, GTI, and IUOE on January 5, 2011. The call focused on JTA/KSA studies. Discussion points included the following:

- TEEX's specific section on safety and whether a separate section was necessary
- Target audience
- Core/common areas
- Possible core document
- Workforce terminology (building operator/technician/operating engineer)
- Anticipation of the National Renewable Energy Laboratory's (NREL) release of its JTA/KSAs
- Sharing the TEEX survey with rest of group
- Progress of each group member
- TEEX setting up a collaborative website to share information

The design stage (Stage II of Phase II) began February 21, 2011 and required the full-time expertise of at least two instructional design specialists, one leading the design for the online component and one leading the design for the classroom and on-site components. This stage, as well as the remaining stages of Phase II, also included significant work from graphic designers, technical writers, and subject matter experts. This phase of the project constituted the majority of the expenditures in both budget periods.

All reports and tasks for the fourth quarter of the project were achieved and delivered on time. Fourth quarter activities included the continuation of Phase II development and consolidation activities. By the end of this quarter, the design stage, consisting of the development of the Curriculum Development Documents (CDD), was 95% complete. The documents included detailed lesson plans, as well as the storyboard for the online portion of the training. In addition, the first draft content for five of the seven modules was completed, with significant progress toward completing the content for the last two modules. Several of the interactions for the online portion of the training were also developed during the quarter.

Year Two Summary:
July 13, 2011 through July 12, 2012

All reports and tasks for the first quarter were achieved and delivered on time. This quarter's activities included the continuation of Phase II development and consolidation activities. The design stage, consisting of the development of the CDD was completed and submitted on July 15, 2011. Work on the development stage continued. The reorganized course consisted of eight modules, four online and four instructor-led. Drafts of all eight modules were completed. The instructional design specialists and subject matter experts refined and expanded content for both the online and instructor-led components and they continued to develop interactions and activities. Discussions concerning the certification/accreditation plan and commercialization and sustainment plan, listed under Phase III: Certification, Commercialization, and Sustainment, were initiated. The project timeline was adjusted to reflect the need for more time in the development phase, which did not affect the original project completion date of July 12, 2012.

All reports and tasks for the second quarter were achieved and delivered on time. This quarter's activities included progress in the development stage of Phase II. The templates for both the online and instructor-led portions of the course were completed. All modules were further refined and expanded. The subject matter experts and instructional designers toured and reserved the facility for the classroom and on-site portions for the internal pilot/alpha and external pilot/beta.

TEEX subject matter experts submitted comments on NREL's proposed JTAs for operating engineers/building technicians during the public comment period. Main comments included the following:

- Proposed JTA focuses on large buildings, where small- and mid-sized buildings will also fall under the JTA.
- Proposed JTA lacked discussion of building envelope issues, which directly affect energy performance.

- Proposed JTA lacked discussion of maintenance needs of several technologies that the building technician would likely encounter, including direct expansion air conditioning, furnaces, and refrigeration.
- Proposed JTA takes an approach that seems to expect the technician to be a generalist, competent in several areas, when it is more likely that the technician will specialize.

During the comment periods for subject matter experts, one of the team's subject matter experts, a technician with 20+ years of experience, submitted comments on the JTA for operating engineers/building technicians. The TEEX team also organized a teleconference on November 10, 2011 to discuss how the Technician Training Program awardees were incorporating the NREL JTAs into their technician training programs. The teleconference was attended by representatives from all four teams (TEEX, NEEC, GTI, and IUOE), as well as Dan Nardozzi of NETL and Danny Studer of NREL.

TEEX contacted companies who have contracts with the US General Services Administration (GSA), who would fall under the Federal Building Personnel Training Act (FBPTA) of 2010, for participation in the external pilot/beta of TEEX's building technician training course. TEEX also presented a summary of its program during a conference call organized for the Greater Philadelphia Innovation Cluster (now the Energy Efficient Buildings Hub), and offered its PowerPoint presentation for distribution to the other attendees.

All reports and tasks for the third quarter were achieved and delivered on time. This quarter's activities included the completion of the development stage of Phase II. The online portion of the course was completed and alpha tested the last week of March. The draft curriculum for the classroom and on-site components of the course was completed and published in preparation for the internal pilot scheduled for the first week of April. Program participants were confirmed and the beta test for the online portion was scheduled for late April. The internal pilot/alpha test was scheduled for first week in May and the facility was confirmed. In addition, a meeting was held with TEEX's program director and marketing director to initiate plans for developing the commercialization and sustainability plan.

All reports and tasks for the fourth quarter of the project were achieved and delivered on time, with the exception of DOE Stage IV approval, which was moved on the timeline to be submitted with Deliverable 3. This quarter's activities included the completion of the implementation and evaluation stages of Phase II. TEEX piloted the classroom component internally during the first week of this quarter. The instructional design specialist and subject matter experts assimilated and incorporated comments into both the online and classroom components. Plans for the online beta test and external pilot were finalized, and attendees, who came from the educational, commercial, and military sectors, were confirmed.

The beta test of the online version was conducted from April 23 to April 27 and the external classroom pilot was conducted from April 30 to May 4. An after-action review was held with the curriculum coordinator, instructional designer, and subject matter experts. They assimilated and incorporated attendee comments into both the online and classroom components. Revised training materials were consolidated in preparation for the final edit. The program director and marketing director developed drafts of the commercialization and sustainability plan and circulated the plan for comments and revisions in preparation for submitting Deliverable 3.

The commercialization plan, as well as the completed curriculum, was delivered to the DOE program manager on July 12, 2012, and the project was successfully completed.

The course description and registration information can be found at http://www.teex.org/teex.cfm?pageid=training&area=teex&templateid=14&Division=EU&Course=RAC160.