

EERE Award Number: EE0007727

Recipient Name: Clemson University

Project Title: Energy efficiency for the growing South
Carolina manufacturing industries

Principal Investigator: Michael Carbajales-Dale

Acknowledgement: This material is based upon work supported by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) under the Advanced Manufacturing Office Award Number DE-EE0007727.

Disclaimer: This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

Clemson University
Energy efficiency for the growing South Carolina manufacturing industries

Executive Summary Final Report (Budget Periods: 2017-2022)

A. Project Objectives

The overall goals of the proposed project were to establish a DOE Industrial Assessment Center with Clemson University as the main center and to cement the Clemson IAC as the "go to" resource for energy efficiency expertise and assistance to manufacturing businesses in the state of South Carolina. The Clemson IAC included a satellite support center through partnership with the SCE&G Energy Innovation Center at the Clemson University Restoration Institute (CURI) in North Charleston, SC. The Clemson IAC was the first IAC based in the state with the goal to serve the entire state. The Clemson IAC provided SMEs with no-cost energy assessments, trained the next generation of energy-savvy engineers, and provided outreach to non-participating SMEs.

Project objectives were structured into five 12-month Budget Periods. In the first Budget Period, the primary objective was to establish methods and materials for Clemson IAC assessments, training, and outreach. In the remaining Budget Periods, the primary objectives were to perform assessments, train students, and pursue outreach to hard-to-reach SMEs that did not participate in energy assessments.

Expected outcomes in the first Budget Period included the development of standard procedures for performing energy assessments, including data acquisition, processing, and communication both within the team and in assessment reports prepared for SMEs. Outcomes related to student training in the first Budget Period included detailed curriculum and internship plans for students pursuing the DOE IAC Certificate and energy-related Clemson University certificates. Outcomes in the first Budget Period also included the development of outreach materials and plans for outreach events. In Budget Periods 2 through 5, major expected outcomes are trained students and completed energy assessments and reports for SMEs. Decision points and Go-No Go criteria for the end of each Budget Period, presented in more detail below, are based on the number of students in training and the number of energy assessments performed.

B. Technical Scope Summary

In the second Budget Period, the scope of work is to plan and host the first annual meeting. Recruitment of SMEs has continued to meet our required target of assessments. Unfortunately, with the uncertainty in funding and the departure of Jay Devkota, our Assistant Director, this target is unlikely to be met and will need to be revised down from 15 to 10. Training of students has remained a priority, with developed training materials being implemented into a course targeted at IAC interns. Follow-up implementation surveys for SMEs that have completed assessments has been initiated and will continue. Further outreach activities are planned for the start of the next budget period.

C. Performed and Remaining Tasks

Tasks remaining from Budget Period 1: IAC Operations Approach and Training Program Development

Task 1.0: Kickoff, Recruiting, and Reporting

Task Summary: This task established communication and collaboration among Clemson IAC participants in order to effectively accomplish all project objectives and reporting requirements. Task 1 also includes the first annual meeting of participating faculty, staff, students, industry partners, and advisory board members and completion of the first year's annual report.

Milestone 1.3 First annual meeting (Q4)

Milestone 1.4 First annual report (Q4)

Completed Tasks:

#	Milestone Title or Brief Description	Milestone Complete Dates	% Complete	Milestone Progress Notes
1.3	First annual meeting	11/14/17	100%	Meeting of PIs and advisory board was held at CEPCI offices in Columbia SC.
1.4	First annual report	11/14/17	100%	Status report presented to advisory board and PIs at annual meeting

Task 2.0: Training and Curriculum Development

Task Summary: The PIs will develop the Tier 1 basic training module, schedule its integration into basic training classes, and ensure that the training program will provide the DOE IAC certificate, which includes completing a minimum of two semesters or summers with the IAC, a minimum of six plant assessments, a demonstrable ability in a minimum of 8 of the core skills with a complete and accurate record in the IAC student registry. Recruitment of students in Task 1 is important to having at least five students in basic training in Year 1.

Milestone 2.1 Complete training materials and in-class syllabi (Q2)

Completed and Ongoing task

#	Milestone Title or Brief Description	Milestone Complete Dates	% Complete	Milestone Progress Notes
2.1	Complete training materials and in-class syllabi	01/11/2018	100%	We have developed our own training modules to train our interns and faculty on energy assessments. This training was instituted into a one credit-hour Clemson Creative Inquiry class: Industrial Assessments specifically targeted for current and prospective IAC interns.

Task 3.0: Outreach Development

Task Summary: The IAC team will develop outreach materials (best practices, case studies, and guidance on energy savings measures) targeting manufacturing SMEs not directly served by an IAC assessment. Information sheets or flyers will be developed to target the top 5 major industry sectors in South Carolina as well as a general flyer appropriate for any industry. The outreach director will lead the development of outreach materials and coordinate the outreach activities.

Milestone 3.1 Complete outreach materials (Q3)

Completed and Ongoing task

#	Milestone Title or Brief Description	Milestone Complete Dates	% Complete	Milestone Progress Notes
3.1	Complete outreach materials	11/15/2017	100%	We have designed our Clemson IAC trifold brochure to distribute to our partners, clients and the community to inform on energy saving techniques. These were distributed to 900 companies across the state who were identified according to IAC eligibility criteria.

Budget Period 2 (repeated through BP3-5):

Task 1.0: Kickoff, Recruiting and Reporting

Task Summary: This task establishes communication and collaboration among Clemson IAC participants in order to effectively accomplish all project objectives and reporting requirements. The team will hold an inaugural kickoff/planning meeting as soon as the project is awarded in which the participating PI's will introduce the goals and management structure of the Clemson IAC to our participating faculty, staff, students, and industry partners. The primary purpose of this meeting is to i) establish our Tier 1 training and Tier 2 internship program, ii) establish the SME and student recruitment strategy, iii) establish the assessment protocols, and iv) begin planning for the development of outreach materials and events. The advisory board will also participate in this meeting. This task continues through Year 1 to recruit SMEs and begin scheduling assessments. The Assistant Director (AD) will collaborate with the participating partners to recruit and gain commitments from a minimum of three SMEs by mid-year. Task 1 also includes the first annual meeting of participating faculty, staff, students, industry partners, and advisory board members, to be held near the end of Year 1, and completion the first year's annual report.

Milestone 1.1 Plan and hold kickoff meeting (Q1)

Milestone 1.2 Initial SME recruitment. SMART deliverable: Four (4) SMEs recruited and scheduled for assessments (Q2)

Milestone 1.3 Second annual meeting (Q4)

Milestone 1.4 Second annual report (Q4)

Completed Tasks:

#	Milestone Title or Brief Description	Milestone Complete Dates	% Complete	Milestone Progress Notes
1.1	Kickoff meeting	10/13/17	100%	Meeting of PIs to discuss work load during BP2.
1.2	SME recruitment	01/11/18	100%	Fourth SME scheduled
1.3	Second annual meeting	07/09/18	100%	Second annual meeting will be scheduled for August at CEPCI offices in Columbia, SC
1.4	Second annual report	07/09/18	100%	Report will be presented at second annual meeting

Task 2.0: Training and Curriculum Development

Task Summary: The PIs will develop the Tier 1 basic training module, schedule its integration into basic training classes, and ensure that the training program will provide the DOE IAC certificate, which includes completing a minimum of two semesters or summers with the IAC, a minimum of 15 plant assessments, a demonstrable ability in a minimum of 8 of the core skills with a complete and accurate record in the IAC student registry. Recruitment of students in Task 1 is important to having at least twelve students in basic training in Year 2.

Milestone 2.1 Complete training materials and in-class syllabi (Q2)

#	Milestone Title or Brief Description	Milestone Complete Dates	% Complete	Milestone Progress Notes
2.1	Training materials and in-class syllabi	01/22/18	100%	We have developed our own training modules to train our interns and faculty on energy assessments. This training was instituted into a one credit-hour Clemson Creative Inquiry class: Industrial Assessments specifically targeted for current and prospective IAC interns.

Task 3.0: Outreach Development

Task Summary: The IAC team will develop outreach materials (best practices, case studies, and guidance on energy savings measures) targeting manufacturing SMEs not directly served by an IAC assessment. Information sheets or flyers will be developed to target the top 5 major industry sectors in South Carolina as well as a general flyer appropriate for any industry. The outreach director will lead the development of outreach materials and coordinate the outreach activities.

Outreach activities included:

-

Milestone 3.1 Complete outreach materials (Q3)

Completed and Ongoing task

#	Milestone Title or Brief Description	Milestone Complete Dates	% Complete	Milestone Progress Notes
3.1	Complete outreach materials	07/09/18	100%	<p>1. We have designed our Clemson IAC trifold brochure to distribute to our partners, clients and the community to inform on energy saving techniques. These were distributed to 900 companies across the state who were identified according to IAC eligibility criteria.</p> <p>2. Additionally, we engaged with a marketing class who provided feedback on promotional materials, website, and workflow. Their recommendations will be instituted during BP3.</p>

Task 4.0: Assessment Development

Task Summary: The IAC team will develop protocols for energy assessments and reports to be used by Assessment Teams in their work for SMEs. Energy experts (i.e. faculty and IAC staff) leading teams of no more than five students will assess and report their findings. The AD will develop follow-up protocols and surveys to collect SME implementation data and also coordinate with Task 1 to complete DOE database reporting. In Year 2, at least fifteen SME energy assessments will be performed and the experiences used to improve and refine the protocols.

Over its lifetime, Clemson IAC conducted 61 assessments, including 277 recommendations (an average of 4.5 recommendations per assessment) for a total of \$5.72M in recommended cost savings estimated to save around 0.82 TBtu of energy per year and 60,000 metric tonnes of CO₂ emissions per year. These recommendations were all captured in reports uploaded to the IAC program website.

Of these recommendations to date, 116 have been implemented (an implementation rate of 42%) for total annual savings of \$1.7M per year. Assuming these savings have persisted, would have generated \$5M in savings to SMEs throughout the state. Accompanying these financial savings would be 90,000 metric tonnes of CO₂ emissions reduction. These savings will continue to benefit the SMEs and the state into the future.

Milestone 4.1 Complete energy assessment protocols and perform at least 10 assessments (Q4)

This milestone was achieved for budget periods 2019-2021.

Task 5.0: Special Projects

Task Summary: Conduct other tasks or special projects as needed, consistent with the objectives above, and as determined by DOE to be advantageous to the program and in furtherance of IAC Program goals. A graduate student will be supported to conduct Special Projects. In addition, the Creative Inquiry (CI) teams will also support innovations in energy audits, which will contribute to the Special Projects task.

Clemson IAC has been involved in a project with Clemson Energy Visualization and Analysis Center (CEVAC) to develop a utility-use tracking and analysis platform based on Microsoft Power BI. This platform has been developed further and implemented with several SMEs who have had assessments from Clemson IAC.

Milestone 5.1 Report on special projects (Q4)

Budget Period 2 Go/No-Go Decision Point: The Clemson IAC will have a minimum of 12 students in training and will have completed a minimum of 10 SME energy assessments.

Budget Periods 3 – 5 will contain similar tasks as noted in BP2 above but will be negotiated at continuation.

Clemson IAC hired and trained 64 undergraduate and graduate students during the project period. Many of these students have gone on to work either in industry (such as Apple, Amazon, Tenneco, and Eastman) or for energy service and consulting companies (such as P3, Advoco, Burns & McDonnell, and Kimley-Horn) where they continue to use the critical skills they learned with us to drive change for energy efficiency and sustainability.

D. Project Management and Reporting

Clemson-IAC will follow the required federal quarterly reporting schedule (within 30 days after the end of a calendar year quarter) to complete and submit quarterly project progress reports in each of the Project Periods. Reports will be completed, using IAC Program Field Manager's website and online tool. A PDF file of the report will also be uploaded at the DOE designated website (i.e., EERE site for IAC program).

All required reports have been completed on the IAC website and uploaded to EERE-PMC website.