AC 2007-125: PROMOTING AWARENESS OF INDUSTRIAL ENERGY EFFICIENCY AND WASTE REDUCTION IN UNIVERSITY STUDENTS POPULATION

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Promoting Awareness of Industrial Energy Efficiency
And Waste Reduction in the University Students Population
Introduction

This paper describes how a systematic effort is being carried out at the University of Missouri-Columbia, to promote student awareness of best practices in energy efficiency, reusable energy, waste reduction and productivity improvements. In particular, it illustrates how the activities of a newly established Missouri Industrial Assessment Center (U.S. Department of Energy, IAC Program) in the College of Engineering can be logically integrated with both graduate and undergraduate engineering education in this regard.

Missouri Industrial Assessment Center

With the backing of the U.S. Department of Energy, and in partnership with the Missouri State Department of Natural Resources (MoDNR), the State Department of Economic Development, the University of Missouri Extension, and the Missouri Manufacturing Extension Partnership (MEP) center, The University of Missouri-Columbia (MU) College of Engineering has established the Missouri Industrial Assessment Center (Missouri IAC, see: http://iac.missouri.edu). The aim of Missouri IAC is to promote best practices in energy efficiency, reusable energy, waste reduction and productivity improvement through integration of activities involving the University of Missouri, the state agencies, the MU Extension, and the major utilities in the state. The primary objectives of the Missouri IAC are to:

Provide students with practical experience and training in energy engineering, by:
- Providing practical, hands-on training of industrial energy, waste and productivity assessment skills to the Missouri IAC student-affiliates
- Establishing online materials aimed at increasing awareness of industrial energy use and efficiency, and promoting such awareness by incorporating these materials into existing engineering courses
- Developing courses and curriculum focusing on energy efficiency and conservation, waste reduction, and energy assessment
- Promoting awareness of energy efficiency, waste reduction and renewable energy in the general university student population through transfer programs and student organization

Help small- to medium-sized manufacturers improve energy efficiency, minimize waste and improve productivity, by:
- Conducting energy audits for eligible industrial organizations in the state of Missouri
- Providing guidance to industrial organizations following the energy audits in order to help meet cost-saving goals
- Promoting interdisciplinary assessment teams of faculty, students and state energy managers and engineers

Integrate the IAC program into existing programs and create innovative approaches to delivering IAC, educational and regional outreach services, by:
- Promoting best practice in industry by conducting regional outreach seminars
- Working with the partners to establish Missouri IAC as the center of resources and services in industrial energy efficiency for industries in Missouri
Utilizing the synergy resulting from its partnerships with MU Extension and the Missouri MEP program, jointly to offer and deliver a more comprehensive range of business services and solutions to small and medium manufacturers, to help them achieve Lean Production in terms of both operational productivity and energy consumption.

Developing a computer-aided energy audit book, initially as a training and auditing tool for students, but potentially also a tool that can be made available to the general manufacturing organizations to promote best practice.

Missouri IAC organizational structure

Since early 2005, we began a number of initiatives that lay a strong foundation for the organization and operation of the Missouri IAC. The overall center structure is summarized in Figure 1. Integration of activities between the Center and its partners are logical and seamless, for the mission of each can be directly supported or supplemented by those of the other:

- **State Agencies**: Due to the importance of the Center to the economy, the competitiveness and the stability of the manufacturers in the state, both Missouri Department of Natural Resources and Department of Economic Development offer their full support for the Center, committing resources to support the center, including administrative effort, technical assistance staff, and specialist equipments. Through working side-by-side on the various initiatives, the MU team and the state energy managers and engineers have developed a very fruitful working relationship.

- **Manufacturing Extension Partners (MEP) program**: In concert with the U.S. Department of Commerce National Institute of Standards and Technology (NIST), Missouri Enterprise is part of a nation-wide network of seventy-four MEP centers. With a cadre of field engineers and consultants to serve all Missouri small and medium manufacturers, its success is measured in client impact that can be directly enhanced by the mission of the
Center. In return, the center benefit significantly from Missouri Enterprise’s wide network of industrial clients in the state.

- **MU Extension**: MU Business Development Programs are housed within the MU College of Engineering and UM Extension and work with partner host institutions across the state to provide Missouri’s prospective and existing small business owners the educational and technical assistance resources they need to remain competitive. Using individualized counseling and instructional resources, the network will promote the services and best practices with the Center.

- **Industry Partnerships**: Associated Industries of Missouri is a non-profit organization that represents Missouri’s industrial base. Since 1919, Associated Industries has helped Missouri businesses succeed at business by offering training and educational opportunities; providing a variety of valuable resources to its members at a reasonable cost. AIM represents Missouri’s industries and will be a key to reaching industries and promoting best practices to Missouri industries.

- **State-Wide and Local Utilities**: As part of the Ameren Corporation (a Future 500 energy company), AmerenUE is Missouri’s largest electric utility, and provides energy services to approximately 1.1 million customers across the eastern half of Missouri. It serves 65 Missouri counties and 500 towns. From the company’s perspective, the Center is: “a good fit with energy efficiency concepts we have proposed as part of our integrated resource plan filing with the Missouri Public Service Commission.”

- **Student Organization**: Affiliated with the proposed Center, the MU Student Society of Energy Conservation if formed: “To promote energy awareness, conservation, and efficiency. To promote renewable and clean energy systems. To educate ourselves and the public about energy conservation…” The Society will collaborate with, and compliment to the Center activities in a number of areas.

Strategically, this network of partnership work together to utilize the resultant synergy to help establish Missouri IAC as the center of resources and services for industrial energy efficiency and waste reduction in the State of Missouri and, to certain extent, its immediate surrounding areas. Specifically:

- **Education, training and promotion**: The state energy managers and engineers have made use of their experiences to help train the Center students. The industrial partners interject a “voice of the manufacturing client/customer” into the process of initiating, reviewing and making recommendations to the curriculum development effort to be carried out by the Center, to assure that the results meet the needs of industry and the community. The MU Extension also utilize its educational and training network to help the center’s training effort, including facilitating a series of energy seminars across the state. The MU Student Society of Energy Conservation helps promoting awareness of energy efficiency and waste reduction through presentations, seminars, and workshops, for the university and school (high/middle) student population in the region, and through its newsletters and articles.
• **Outreach**: Jointly, the partnership deliver a more comprehensive range of business services and solutions to small and medium manufacturers. The Center, the MU Business Development Programs, and Missouri Enterprise together will offer a complete range of services to help clients to become more competitive through achieving lean production and energy efficiency and waste minimization. As a mechanism to facilitate this effort, we provide links to each others website and provide the necessary web materials.

Student involvement

Up to date, both undergraduate and graduate students have been successfully involved with the Center’s work - graduate classes through group projects, and senior undergraduate classes through Capstone projects. In addition to engineering, students majoring in physics, biochemistry and management have also been involved in the effort. These students have tackled, or get involved in, many activities such as:

• Training about industrial energy audits, jointly supervised and facilitated by the Center management, and the Energy Center of MoDNR. Figure 2 shows our group of graduate and undergraduate students going through the introductory training in audit procedures and in infrared thermograph.

![Fig. 2 Training of students at MoDNR Energy Center. Clockwise from top: group of trainees; a state energy engineer explaining the features of an energy efficient building; seminar on audit procedures given by a state energy engineer; training on use of infra-red camera.](image)

• Promotion of awareness, including the development of informational brochure on energy and productivity efficiency and waste reduction, which has been sent to a large number of industrial organizations in the state.
• Demographical analysis of industrial organizations in the state in regard to energy consumption, and development of a database containing the key information and the key statistics which have been very valuable in our campaign of awareness promotion.

• Development of a computer-aided energy audit book, initially as training and auditing tool for IAC students, but potentially also a tool that can be made available to the general manufacturing organizations to promote best practice.

• Experts/Expertise Base. This database lists and provides links to details of faculties with interests and experiences in various areas of energy efficiency and conservation, from all the major universities within the State of Missouri. The experts are grouped according to their area of expertise and their institution, and database is searchable accordingly to provide contact details and more detailed information. Through a link this database is incorporated within our computer-aided audit workbook, making it a useful on-line tool if any additional and/or specialist help is required by a client during an energy audit.

• Formation of the MU Student Energy Conservation Society, intended to help in promoting awareness of energy efficiency and IAC activities, both within the student population and in the community at large.

Curriculum Development

An undergraduate elective course is being developed. This aims to help students understand and adopt more energy efficient and environmentally friendly technologies, new materials and manufacturing processes that generate energy savings while improving productivity. We will design and develop three innovative options: 1) a three-credit-hour senior undergraduate/first year graduate course: *Analysis and Design of Energy Efficient Industrial Systems*, that is supported by an online version; 2) a derivative of this course to be offered to practicing engineers through MU Extension and MU Continuing Education; and 3) a performance support system to provide advice to companies regarding energy audits.

*Analysis and Design of Energy Efficient Industrial Systems* will be a problem-centered course that supports the kind of diagnosis-solution problem solving required to perform a competent energy audit. The justification for a problem-centered course is that analysis and design of energy-efficient industrial systems requires a combination of two skill sets: technical knowledge of the systems and problem-solving ability\(^1\). A problem-centered course provides an intensive, interactive and experiential learning environment that is more effective for the students to gain such skills\(^2\). Once the problem domains are identified, three problems per domain will be developed for web-based delivery. For each problem, the online course will comprehensively present the problem and provide background conceptual materials. Students are required to analyze the problems and identify the possible solutions. Following this approach, the proposed course will include sets of problems (e.g., insulation, heating system, machinery system, and lighting system). Each problem will include a problem representation, a multi-layered conceptual model of the systems being analyzed, a computer-aided workbook, and a case library of similar analyses. Relevant technical knowledge in the course will include topics such as: introduction to
energy management, fundamentals of industrial systems analysis and design, heat transfer, fluid mechanics and electrical science, boilers, furnaces, motors, lighting, HVAC, compressed gases, electrical energy management, insulation use and design, waste reduction, performance of building envelopes, alternative energy sources, energy policy and codes, economic analysis, energy auditing, and national energy security and reliability. In essence, this learning-through-doing approach exemplifies a number of contemporary learning theories, including anchored instruction, case-based reasoning, and problem-based learning. Students in the course will also be exposed to the Missouri IAC activities through industrial visits, seminars and presentations.

The course to be delivered through MU Extension and MU Continuing Education to practitioners in the field will be a self-instructional course that de-emphasizes the conceptual components of this course, focusing instead on the processes and similar cases in order to familiarize the practitioners with the mechanisms of energy analysis. In addition, the online performance support system will help an industrial organization if and when an energy audit is appropriate. Using an expert system, it will guide a company through an analysis process to support the decision-making involved.
As an aid to teaching, training and auditing, a computer-aided audit workbook has been developed to provide a complete guide to the processes, tasks and outcomes of an energy audit (see Figure 3). From the initial audit planning to the final recommendation and follow-up, the workbook utilizes a front-end flowchart to specify the steps and tasks involved, and then logically integrate all the relevant entities such as instructions (Figure 3, a), data collecting tools, procedures of analysis and calculation, and worksheets to support task execution and project management (Figure 3, b, c). Other notable features include links to other resources (Figure 3, a), the experts/expertise database (Figure 3, e), and a specially developed worksheet for calculating organization-wide energy consumption (Figure 3, d). With the completion of the necessary steps, the workbook provides templates for generating final recommendations and report (Figure 3, f). In essence, it is a unified project tool that organizes and links instructional materials, worksheets, analytical tools, and resources in a logical and task-centered manner.

We plan to utilize the database of the U.S. Department of Energy’s IAC program ([www.iac.rugters.edu/database](http://www.iac.rugters.edu/database)) to develop a number of audit cases. In a simulated environment involving these cases, student teams will be asked to use the audit book to go through the audit process, covering all the necessary skills such as site evaluation, data analysis, recommendation recognition, and report preparation. Results will be compared with those from the real situation, and the process repeated until lessons are learned. This will be used for the initial training of new recruitments and skill improvement for the more experienced center students. Its value as an initial training tool has already been proven when used by our current undergraduate projects groups to develop the understanding of the contents and procedures of an energy audit. Additionally, it can also be used as an on-site tool for energy, as follows: 1) a copy of this workbook will be made for each of the audit client and taken to the site, 2) the audit team will follow the procedures as specified, populate the relevant worksheets, and carry out analysis and calculations, and generate recommendations as the audit progresses, 3) when complete, the populated workbook will provide comprehensive documentation of the audit, including data, analysis and report. We intend to further develop the structure, contents and functionality of this tool during the project period.

Conclusion

Our approach, based on an extensive network of stakeholders, has proven to be very beneficial to all concerned. In this case, outreach, research and educational activities are truly and seamlessly integrated.

Through these efforts, we now have a platform and network that provide our students with excellent learning and training opportunities about industrial energy efficiency both within the university and in the community, benefitting from the expertise, experiences and resources brought in by the university faculty, the government agencies and the industries. According to one of our graduates: “My experience working with the MU energy project has always been one of the most eye-catching items on my CV”.

It is hoped that such efforts will help generate energy-efficiency savvy graduates who in the future will contribute positively to a healthy economy and environment.
References
