Industrial Energy Management Curriculum

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Implementation of an energy management curriculum involves cooperative efforts among students, faculty, and local industry engineers. Two successful initiatives have occurred. The first focuses upon committing an entire class to one industrial site. On site instruction regarding thermodynamics, system analyses, mass transfer, plant operations and energy economics is followed by focused data collection and analyses. Students become cognizant of real world engineering and are expected to contribute toward improved site energy management. The host industry supports community/university relations, previews cooperative education students, and occasionally, adopts class generated cost avoidance ideas.

An alternative program occurs when one time visits are arranged at several industries throughout a one semester course. A site walk-through, with both faculty and plant engineers as guides, is coordinated with instruction in engineering science, economics and utility distribution and plant operations. Typically, a site visitation occurs over two to three hours including orientation and post walk-through questioning. A working team of students presents a professional analysis in class at a later date. Site engineers support the effort through operations descriptions, data acquisition and are invited to critique the presentations.

Both curriculums are manageable over one semester. In the United States a typical three semester credit hour course necessitates 48 contact hours over 16 weeks. Class size for both programs has been limited to 20, but at least 12 are needed to propagate a team concept.

The primary curriculum focuses upon one industrial site. The facility conference room is used for staging, instruction, data analyses, and for the final presentation. Plant engineers typically enroll and area managers judge the final presentations. The facility also provides safety training and escort personnel if there are no enrolled employees. The university professor provides class management, lectures regarding thermodynamics, energy utilization and management, plant operations, guides data acquisition and analyses, and maintains liaison between the students and plant personnel. The professor also follows-up to assure the university recognizes the industry for its contribution and community conscience. The professor works with the students to ensure analytical integrity and helps develop the professional presentation. The course is graded via the "you get paid (earning A) or you get fired (earning F)" concept: the students are led to understand contemporary industrial survival does not tolerate mediocrity.

This course is best offered over three hours one night per week for 16 weeks. This program satisfies contact hour requirements and allows for reasonably in-depth data collection and analyses. Also, most plant engineers work first shifts and can accommodate a 6-9PM program. The weekly format also allows for combining lectures, examples, guest expertise with data acquisition and analyses. The last 30 minutes of each class are reserved for an open forum encompassing questions, conjecture, and planning. All students participate in the weekly forums and are encouraged to contribute to all team areas.

Students are divided into teams. Each addresses a different facet of energy management. If team composition exceeds four or five, efficiency suffers due to overlapping assignments and the problem of weekly remote coordination. Team leadership is not assigned. It occurs as a natural personality phenomenon. Someone always takes charge. The leader assumes responsibility for contacting students during the week to assure reasonable progress. Many team members have day jobs so coordination requires additional effort. This facet allows students to undergo self evaluation. Future industrial managers recognize their innate ability. Also, engineers who embrace applied science but shun responsibility beyond analytical minutia recognize their best method for effective contribution. Without at least three members a team dynamic fails to occur and the professor becomes de facto leader. This situation is shunned because it thwarts the educational process. Mathematical applications can be easily addressed in the classroom. When confronted with the cacophonous, grimy, economic reality, students learn to use science to understand production systems. On the factory floor all variables save one are not generally given. As the students overcome problems and analyses despite gaps in readily available data, the meaning of engineering education takes hold. Solving meaningful problems amid the din is the best experience. Figure 1 depicts the syllabus for Industrial Energy Management. The current text is Plant Engineers and Managers Guide to Energy Conservation by Albert Thumann, P. E., C.E.M.

Four teams are optimum: team one develops the energy management data base and utilization algorithms: team two addresses electricity distribution and utilization: team three addresses fossil fuel utilization: team four addresses compressed air and water utilization. With luck enough plant engineers have enrolled to assign one to each team.

Creation of the database depends upon available information. Statistically significant regressional analyses require three years' data at steady production rates. Also, plant management may prefer that comparisons stem from a particular base year. Whichever methodology occurs, the data base is intended as a management tool from which regressional analyses will offer three insights. First, based upon the most significant variable, usually unit production, unit energy cost can be predicted. Depending upon standard deviations, once all monthly data are input and analyzed, management will have a comparative measure of monthly efficiency. Second, incremental energy utilization rates allow for systematic or equipment life cycle analyses. The comparative rates facilitate preventive maintenance. Finally, regressional analyses allow for identification of the significance of each variable (e.g., number of heating degree days as an impact upon natural gas cost). Anomalies and trends can also be identified, ad infinitum, depending upon managements' interest. Inexpensive PC data base programs are used for development and maintenance of the energy management system.

Team two is responsible for analyzing distribution, identification and inventory of large motors ("large" is plant subjective), and if possible, determining which systems are demand centers. Throughout the course, team two focuses upon plant wide electric demand structure in an attempt to identify mitigating circumstances. For example, observation of three adjacent reactors indicates a six-hour cycle of which three hours per reactor cycle are devoted to electric heating. Team two performs a time/energy study to determine potential cost avoidance from cycling electric heating. Team two also analyzes historic power factors to determine the impact of capacitors. If possible, team two conducts a survey entitled "What's on? How come?" to determine if systems are idle but energized during off shifts.

Team three addresses fossil fuel utilization. Large energy consumers are targeted regarding heat transfer operating parameters. Individual furnaces, boilers, kilns, etc. can be segregated within the EMS data base if necessary. Product temperature, furnace temperature and moisture content, actual versus specifications, are typical considerations. Opportunities for primary and secondary heat recovery are investigated. Also, most plants do not consider space heating as either a significant cost center or an area for energy management. Management at many one story facilities are surprised when apprised of roof snow melting cost and the large temperature difference between the ceiling and the floor.

Team four analyzes compressed air and water. If the facility uses steam, team four is responsible for quantifying leaks and identifying malfunctioning traps. Also, compressed air leakage is prevalent and a ready source for cost avoidance due to normal operational philosophy of installation, activation, and assuming the system operates efficiently forever. Team four analyzes potable and wastewater volumes and treatment costs.

When one specific industry cannot be targeted, the class is arranged around walk through tours alternating with a lecture and analyses. Course timing is similar. Figure 2 represents a typical program.

This plan limits analyses to obvious opportunities. However, students are encouraged to independently contact visited facilities in order to acquire additional data. Students are assigned to groups of three or four. The host engineer is contacted by the professor to arrange for the tour. He or she is advised that some students might call in advance for process one line diagrams or other data. During the walk through tours, the assigned group takes note of energy management opportunities with the help of other students and the course instructor. The group is responsible for synthesizing a preliminary report, presented in class the next week, and also, for collecting additional data during the term. The final reports are oral and written relating to potential initiatives. The written reports are passed along to plant engineering.

All students participate during the post visit discussions. Throughout the term additional ideas arise as students become exposed to each new phase of energy management. Grading for this configuration is also subject to the "A" or "F" format. Engineers from visited plants are invited to attend final reports.

Both formats have met with student and industrial approval. The former configuration provides detailed assistance to plant engineering and management, the foremost being implementation of a useful energy management system. Also, the former configuration allows for detailed in-plant system analyses which have led to specific improvements. Each method has led to specific proposals which have been implemented. Typically, space heating, leakage and secondary heat recovery opportunities occur at all sites. Also, electric demand shedding opportunities are universal but at most sites conflict with production scheduling. The energy management class provides students education in real time and the affected industries engineering help mostly addressing unexpected opportunities.

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INDUSTRIAL ENERGY MANAGEMENT

All classes will meet at XYZ Corporation.
Classes occur from 6PM through 9PM Tuesday.
Text: Plant Engineers and Managers Guide to Energy Conservation, 6th ed.
Albert Thumann, P.E., C.E.M., The Fairmont Press, Inc, 1996

NOTE: There will be a round table discussion of current activities during the last 30 minutes of each weekly meeting.

Topical Outline

Week 1: Introduction: Group assignments TEXT: CH.1
Lecture: Plant Operations (by a participating engineer)

Week 2: Plant tour TEXT: CH. 3 & 6
Lecture: Principles of Heat & Mass Transfer

Week 3: Lecture: Energy Management Systems (EMS): Configuration and Maintenance TEXT: CH. 10 & 11
Guest Lecture: Mr/Ms from the local utility: TEXT: CH.4
Plant tour by groups for specific responsibilities

Week 4: Lecture: EMS System Design and Operation TEXT: CH. 14
Guest Lecture: Mr/Ms from the natural gas supplier

week 5: Lecture: Energy Economics TEXT : CH. 2
Groups begin systematic surveys and data acquisitions

Week 6: Lecture: Electric System Distribution & Management (includes Case Studies {CS}) TEXT: CH. 15
Group data acquisition & surveys

Week 7: Lecture: Fossil Fuel Systems & {CS} TEXT: CH. 5
Group data acquisition & surveys

Week 8: Lecture: Water Distribution & Treatment & {CS}
Group data acquisition & surveys

Week 9: Lecture: Compressed Air Systems & {CS} TEXT: CH. 12
Group data acquisition & surveys

Week 10: Lecture: Space Heating & Cooling TEXT: CH. 7 & 8
Group Progress Reports
Group data acquisition & surveys

Week 11: Group data acquisition & surveys

Week 12: Group data acquisition & surveys

Week 13: Group data acquisition & surveys

Week 14: Group Progress Reports
Lecture: Professional Presentations & Communication
Final data acquisition

Week 15: Final Report Rehearsal

Week 16: Final Presentations

Figure 1

INDUSTRIAL ENERGY MANAGEMENT

All classes will meet at the classroom or designated Corporation.
Classes occur from 6PM through 9PM Tuesday.

Text: Plant Engineers and Managers Guide to Energy Conservation, 6th ed.
Albert Thumann, P.E., C.E.M., Fairmont Press, Inc. 1996

Topical **Outline**

Week 1: Introduction: Group assignments — TEXT: CH.1 & 3
Lecture: Plant Operations

Week 2: Lecture: Principles of Heat & Mass Transfer — TEXT: CH.6 & 10

Week 3: Meet at ABC Corporation. Group 1 responsibility

Week 4: Lecture: Energy Management Systems (EMS) — TEXT: CH.4 & 11
Guest Lecture: Mr/Ms from the local utility
Round table led by Group 1

Week 5: Meet at XYZ Corporation. Group 2 responsibility

Week 6: Lecture: Energy Economics — TEXT: CH.2
Guest Lecture: Mr/Ms from the local gas distribution Co.
Round table led by Group 2

Week 7: Meet at DEF Corporation. Group 3 responsibility

Week 8: Lecture: Electric System Distribution & Management TEXT: CH.15
Round table led by Group 3

Week 9: Meet at uvw Corporation. Group 4 responsibility

Week 10: Lecture: Fossil fuels/heating and cooling — TEXT: CH.6 & 7
Round table led by Group 4

Week 11: Meet at RST Corporation. Group 5 responsibility

Week 12: Lecture: Water Distribution & Compressed Air Systems TEXT: CH.8
Round table led by group 5

Week 13: Meet at GHI Corporation. Group 6 responsibility

Week 14: Lecture: Professional Presentations & Communication TEXT: CH.12
Round table led by Group 6

Week 15: Final Reports: Groups 1, 2 & 3

Week 16: Final Reports: Groups 4, 5 & 6

Figure 2