# Industrial Collaboration to Develop an Energy Assessment Course

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## Abstract

A new graduate course is addressing the growing demand for employees that can solve energy-related problems, assess mechanical and electrical energy systems, and make a business case for implementing energy-related improvements. The course stresses hands-on application by using USDOE software, touring local industries, and performing onsite energy assessment projects. The course was developed in collaboration with a local fortune 500 company, known for powerful engines, and includes lectures from the companies' pool of global training experts.

## Introduction

IUPUI Engineering Technology department has had success in developing graduate programs by addressing niche markets such as Motorsports Engineering and Facilities Management. Within Facilities Management we look for "Bright Outlook Occupations" to inform elective development. [1] One example is the Energy Auditor Occupation which had a 2017 Median Wage of $70,010 and growth potential as shown nationally and in Indiana in Table 1:

**Table 1: Projected Employment for Energy Auditor [2]**

| National | Employment | | Percent Change | Projected Annual Job Openings* |
|---|---|---|---|---|
| | 2016 | 2026 | | |
| United States | 1,023,900 | 1,114,300 | 9% | 104,200 |

| State | Employment | | Percent Change | Projected Annual Job Openings* |
|---|---|---|---|---|
| | 2016 | 2026 | | |
| Indiana | 13,680 | 15,090 | +10% | 1,420 |

Energy Auditors has been identified as a "Bright Outlook Occupation" because it meets one of the following criteria:

- "Projected to **grow faster than average** (employment increase of 10% or more) over the period 2016-2026
- Projected to **have 100,000 or more job openings** over the period 2016-2026." [3]

This data provided a point of discussion for dialog with local industry, which led to a collaboration with Cummins. [4]

Cummins developed a corporate energy focus in 2006 and already had a developed training program for their employees. [5] They were interested in learning from our faculty, a certified energy auditor with USDOE funding in the energy efficiency area, and willing to share their training program and international experience and perspective. Our faculty attended a training event, shared energy audit equipment, and discussed best practices for collecting data from industrial systems.

## Course Overview

The new course, ECET-53800: Energy Management, is an interdisciplinary course that addresses the demand for multi-skilled engineers by blending electrical and mechanical content that focuses on applications in industrial systems in manufacturing facilities and commercial buildings. It is facilitated by one faculty member that teaches in Electrical Engineering Technology, Mechanical Engineering Technology, and Mechanical Engineering. The course is delivered online, in a one semester (sixteen week) sequence, with weekly assignment deadlines.

## Course Design

The course introduces practical procedures to reveal energy, productivity, and waste reduction options in order to operate and maintain commercial buildings with a focus to minimize operating costs while maintaining good environmental stewardship. The content is divided into ten modules with ten lectures provided by Cummins team of international trainers and eight supplemental lectures provided by faculty. The ten Cummins lectures are:

1) Energy Assessment Process.
2) Power Management.
3) Lighting.
4) Building Envelope.
5) Heating & Cooling.
6) Machinery & Equipment.
7) Fuel Usage.
8) Energy Recovery.
9) Environmental Treasure Hunts/Environmental Audits.
10) Energy Management Systems – ISO 50001

These modules were designed for a broad variety of employees, not just engineers, so the supplemental lectures expand the technical content and provide real-world examples that are used for discussion or assignments.

**Module Details**

Module 1 looks at how to approach an energy audit at a facility. The module presents the Cummins Energy Review Tool, which is used for ISO 50001 implementation to create an Energy Balance and monitor performance. It occurs over a two week period and is assessed by having students summarize the energy audit process, analyze and compare example audit recommendations.

Module 2 explains how to measure and monitor energy performance and why it is important. It also covers how to set up a controlled shutdown process for a facility in order to avoid wasted energy when production is stopped for breaks or extended periods. This module is slotted for one week, see example content in Figure 1 and an example assignment in Figure 2:

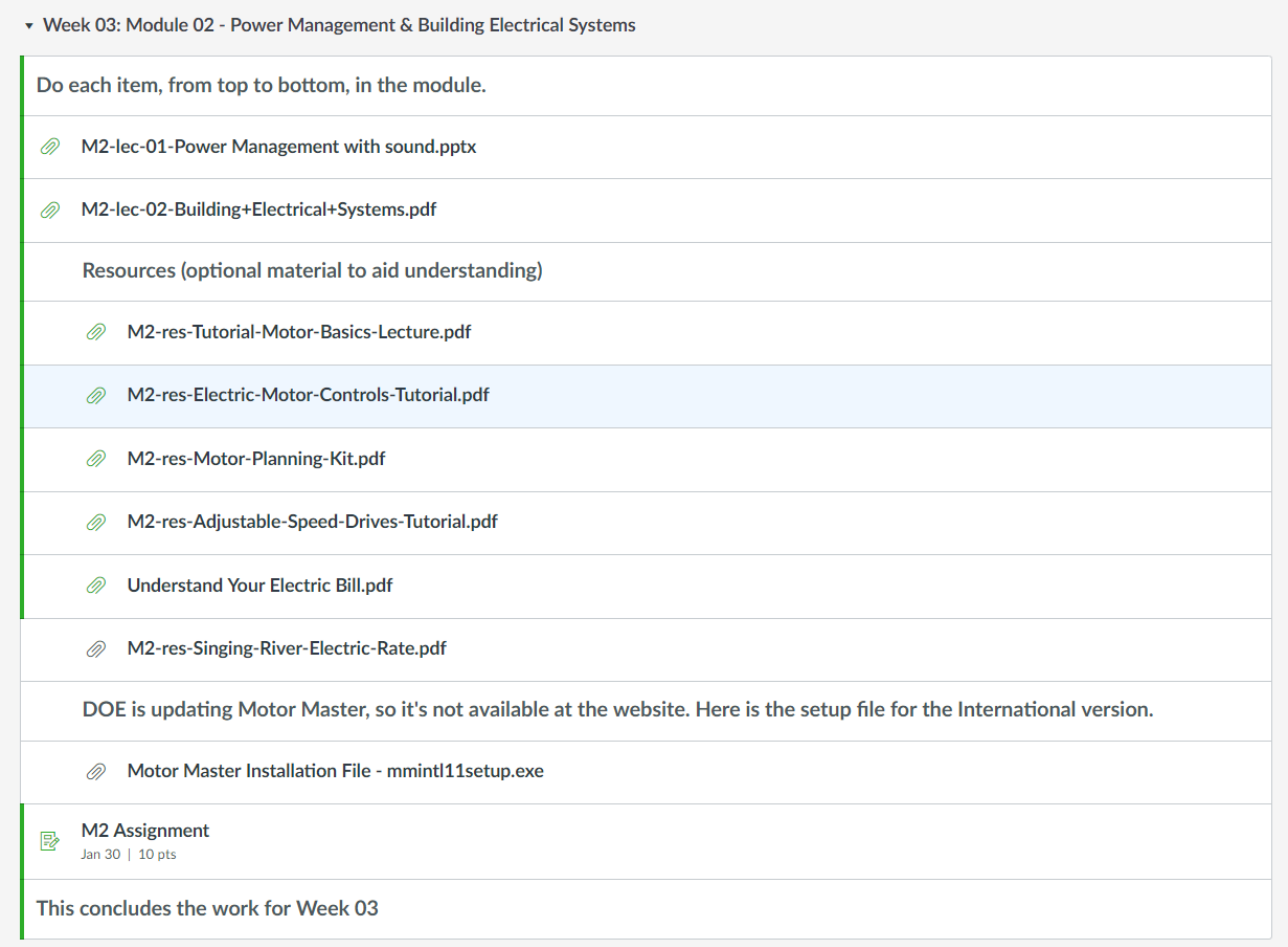


*Figure 1: Module 02 -Power Management*

Note that the "-res-" designations are used to indicate optional resource material, material that is considered known from an undergraduate level material perspective but may not have been covered by other majors granted access to the MS Technology degree program.

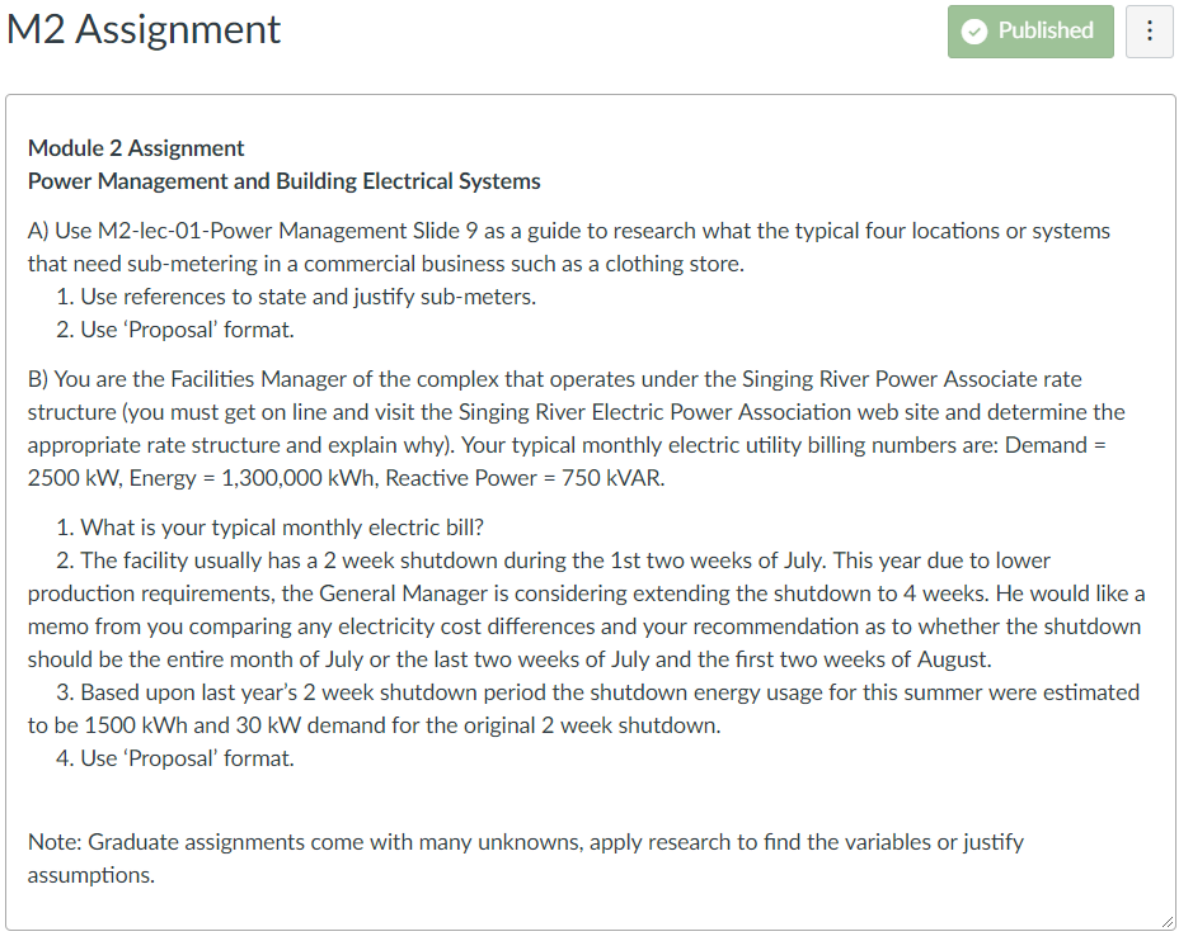


*Figure 2: Module 02 Assignment*

Note that some assignment details are intentionally left out, to simulate real-world situations where data or background information is missing, which forces judgment and allows for the assessment of reasoning.

Module 3 discusses various lighting terminology, lamp types, and features and how to identify lighting control strategies for an organization. It focuses on identifying, analyzing, and cost comparing different lighting technologies. It is presented over a two week period and is assessed with a proposal that describes the current system, current energy usage, proposes a new technology, calculates proposed energy usage, calculates energy and cost savings and presents a business and engineering case for the change. The assignment style is repeated in other modules but the systems change to match the module title.

Module 4 was designed to enable students to identify components of a building envelope, understand heat transfer and its effects on annual operating energy loads and how to improve the

thermal performance of a building. It also discusses how systems interact, specifically how daylight harvesting (a lighting recommendation) impacts the building envelope system and how to analyze the cost-effectiveness of interacting systems. It is presented and assessed in one week.

Module 5 discusses facility heating and cooling loads. It presents an overview of traditional HVAC systems and encourages the research of new technology and how to calculate energy and cost savings. This module is presented over three weeks and includes breakout lectures over AC systems, chiller systems, cooling towers, and air handling systems. There are so many topics that I developed three assignments; one is required homework and the other two can be done as bonus assignments.

Module 6 discusses machinery and equipment related to motors, compressed air, and hydraulics. It explains the relationship between production levels and energy use, analyses the financial cost/benefits of a successful motor management program, constructs a systematic approach to improving a compressed air system, and discusses best practice ways to improve the efficiency of hydraulic systems and other production equipment. It and the remaining modules are presented and assessed in one week.

Module 7 discusses fuel (natural gas) usage. Topics include how to read NG utility bills, how to compare energy and cost across utilities, types of systems that use fuel, and best practice examples to reduce usage and cost. Combustion processes and steam versus hot water systems are focused on and a real-world boiler system is used for the assessment.

Module 8 discusses the most common methods and tools to recover energy. It also discusses locations or processes that could benefit from the waste heat recovered and the current energy recovery technology. Additionally, we discuss energy storage and combined heat and power systems.

Module 9 establishes the method to audit a facility, identify environmental improvement projects and how to prioritize them within the organization. This module uses three resources developed by Cummins; an environmental treasure hunt guideline document, a scoring matrix, and a project hopper with information used to populate the matrix.

Module 10 examines the Energy Management Systems (EnMS) –ISO 50001 standard released in 2011 that allows an organization to build a management system to monitor, measure and improve energy performance. The content focuses on the Plan, Do, Check, Act (PDCA) system and discusses the continuous improvement methodology.

**Assignments**

All assignments are individual and use real-world situations and/or data. The focus is on reasoning and justification skills and how potential audiences impact the information and methods of communication. A sample schedule of the topics and assignments are shown in Figure 3.

**ECET-53800 Energy Management**

| Week | Reading | Topic | Module Deliverable - due @ Noon on date shown |
|---|---|---|---|
| 1<br>1/9 | Text: Chapter 1 | M1 - Welcome and Energy Assessment Process | M1 Assignment - due 1/17 |
| 2<br>1/16 | Text Chapter 8 | M2 - Power Management and Building Electrical Systems | M2 Assignment - due 1/24 |
| 3<br>1/23 | | | |
| 4<br>1/30 | Text Chapter 7 | M3 - Lighting Systems | M3 Assignment - due 2/7 |
| 5<br>2/6 | | | |
| 6<br>2/13 | Text Chapter 10 | M4 - Building Envelope | M4 Assignment - due 2/21 |
| 7<br>2/20 | Text: Chapter 2 | M5 - Heating And Cooling | M5-1 Assignment - due 3/7 * |
| 8<br>2/27 | Text Chapter 4 & Text Chapter 5 | M5 - Heating And Cooling | M5-2 Assignment - due 3/7 * |
| 9<br>3/6 | Text Chapter 6 | M5 - Heating And Cooling | M5-3 Assignment - due 3/7 * |
| 10<br>3/13 | **No Class** | **Happy Spring Break** | |
| 11<br>3/20 | | M6 - Machinery and Equipment | M6 Assignment - due 3/28 |
| 12<br>3/27 | Text: Chapter 3 | M7 - Fuel Usage | M7 Assignment - due 4/4 |
| 13<br>4/3 | | M8 - Energy Recovery | M8 Assignment - due 4/11 |
| 14<br>4/10 | | M9 - Environmental Treasure Hunts | M9 Assignment - due 4/18 |
| 15<br>4/17 | | M10 - Energy Management Systems - ISO 50001 | M10 Assignment - due 4/25 |
| 16<br>4/24 | | | |
| 17 | No Final Exam | | |
| | * choose one, other two are bonus opportunities | | |

*Figure 3: Course Schedule*

## Results

The initial course enrolled seven graduate students. The course grades ranged from 83.01-94.69%. One student commented "The class was challenging and I believe I learned a lot, but mostly from online research and the textbook. I didn't find the Cummins Lectures particularly good. They were more like a "lunch & learn" talks that I attend at my office." Another commented "The presentations from Cummins were a nice addition but material within the presentations seemed introductory. The presentations from the professor were much better." Finally, the course evaluation question "Overall, I learned a great deal from this class" resulted in a 3.5/4 mean score.

## Conclusion

An analysis from the student's comments, scores, and course evaluation indicate that the course was successful in educating the students about the processes, calculations, and reporting involved in energy management. Although the level of content (from the Cummins lectures) was not at a graduate level, the additional content from the professor covered the gap. The Cummins content was useful in providing a real-world context and real-world examples. Overall I believe the collaboration was useful because it provided a global perspective to energy management concerns, it provided lecture content from several professionals from around the world, and it provided several real-world examples from global Cummins facilities. However, to date, it hasn't led to additional collaboration, internship opportunities, or enhanced employment opportunities for our students.

**Bibliography**

[1] US Department of Labor: Wages & Employment Trends. 2017. Available at https://www.onetonline.org/link/summary/13-1199.0. Accessed March 2018.

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[5] Industry Week: How Cummins Became an Engine of Energy Efficiency. 2017. Available at https://www.industryweek.com/leadership/how-cummins-became-engine-energy-efficiency?NL=IW-001&Issue=IW-001_20180828_IW-001_470&sfvc4enews=42&cl=article_2&utm_rid=CPG03000008061415&utm_campaign=28848&utm_medium=email&elq2=b2a4945953434217aacde4aa0f09f9eb. Accessed August 2018.

**Biography**

Dr. David W. Goodman is an Associate Professor in Electrical and Computer Engineering Technology in the Purdue School of Engineering and Technology at Indiana University-Purdue University Indianapolis (IUPUI) and teaches capstone, energy efficiency, and renewable energy courses in Electrical and Computer Engineering Technology, Mechanical Engineering Technology, and Mechanical Engineering. He is also Assistant Director of the Department of Energy funded Industrial Assessment Center and trains about a dozen students each year to conduct energy and waste audits at small and mid-sized facilities. David's areas of expertise include electrical power systems, relay protection, computer control systems, solar thermal systems, and informal energy education. He has eight years of electrical engineering experience at General Electric and Owens-Illinois, plus two years as an electronics technician at Emerson Radio. He is also a member of ASEE, ASES, AEE, ASHRAE, ASME, and NAPE.