On-Campus Comparison of Energy Saving Technologies for Vending Machines

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Abstract

As part of the Wisconsin's Focus on Energy Program, the Milwaukee School of Engineering (MSOE) investigated two possible technologies to save energy involving vending machines. MSOE is interested in this research for two reasons: involvement of our students in emerging technologies to save energy and to provide a service to our community. Two soda vending machines were installed in the student lounge of the Science Building, each equipped with a different energy-saving device. The first device tested was a Vending Miser™. This device detects motion outside the machine, and if no activity is sensed, this device turns off the vending machine after a compressor cycle is completed. If activity is sensed in front of the machine, or if the device calculates that the compressor should run to keep the soda cool, the vending machine is turned back on. The other technology tested uses electroluminescent (EL) panels in place of the traditional fluorescent lights. Surprisingly, lighting accounts for approximately half of the energy used by a typical soda vending machine. The results of this comparison were provided to Focus on Energy to determine if additional funding of either technology was warranted. The results were also published on a student-developed web page. Since the study was performed with students, in a high traffic area, this research was a wonderful vehicle to increase student interest in the energy efficiency area. This paper documents the two technologies, the students' response to the different technology, the methods used to compare the technologies, and the development of the web page. In addition, suggestions for further work in the area are made, and lessons learned on this project are discussed. It was found that while the amount of energy saved is small for an individual machine, Wisconsin alone has over 75,000 of these machines, so the total energy savings can be substantial.

Introduction

Genesis of Wisconsin's Focus on Energy Program

Focus on Energy (www.focusonenergy.org) is a public-private partnership offering energy information and services to energy utility customers throughout Wisconsin. These services are delivered by a group of firms contracted by the Wisconsin Department of Administration's Division of Energy. The goals of this program are to encourage energy efficiency and use of renewable energy, enhance the environment, and ensure the future supply of energy for Wisconsin[1 2]. As part of this work, Focus on Energy does the testing of energy saving devices.

Milwaukee School of Engineering (MSOE) Involvement

MSOE (www.msoe.edu) is involved with Focus on Energy at two levels. MSOE is the primary contractor for the Business Programs segment of Focus on Energy. As such, it handles the administrative aspects of the program and the awarding of contracts to subcontractors. Along with other entities, MSOE faculty and student teams can bid on Focus on Energy projects.

This paper focuses on the teaching opportunities and the student involvement in one such project. It is planned that subsequent papers, addressed to business and industrial audiences, will focus on the technical aspects of the project, and future energy savings for individual installations.

Figure 1. Vending Machine Installation

Electroluminescent (EL) Panels

EL panels consist of a thin flexible semiconductor material that use electroluminescence to light the front of the vending machine. A photon of visible light is emitted when the semiconductor

material is subjected to an electric field. The material can provide uniform lighting across the surface of the panel or it can be designed to illuminate individual sections selectively or sequentially. The vending machine in Figure 1 uses this technology. It was designed by CM-GLO (www.cmglo.com) of Watertown, Wisconsin. From the outside, unless the animated lighting is activated, it looks the same as a typical vending machine.

VendingMiser™ Controller

The VendingMiser™ (U.S. Patent No. 6,243,626) is an energy-reducing device that can be connected to any vending machine. The VendingMiser™, designed by the Bayview Technology Group (www.bayviewtech.com), uses a passive infrared sensor. The VendingMiser™ shuts the machine down when the area surrounding the machine is unoccupied. The device automatically reenergizes the vending machine when the surrounding area becomes reoccupied. The VendingMiser™ also monitors the ambient temperature for the duration the machine is powered down. The device automatically runs the compressor at specific times, independent of occupancy, to keep the product being sold at an appropriate temperature. The VendingMiser™ will never power down the vending machine while the compressor is running. The device is shown in Figure 2.

Figure 2. VendingMiser™

Pedagogical Goals

Student interest in the study of electrical power technologies has been waning for many years.[3] The Electrical Engineering curriculum[4] at MSOE includes a required course on electric machines and power, but many other universities have dropped such courses. This project, with its presence on the web and its location in a heavily traveled lounge on campus, has increased the student exposure to the power area. Helping the environment and saving energy is also attractive to many students. Plaques explaining the technologies and possible energy savings were installed adjacent to both vending machines. In addition, the power electronics associated with the EL panel has provided an interesting case study on power quality.

Government/Industry Goals

This review and demonstration project was initiated to identify the practicality of both, or either, of the energy-saving technologies by analyzing performance data (average current, voltage, kW-Hrs) and determining potential cost savings. The project is also intended to be an educational showplace for energy saving technologies through its web site and location within the university. At the conclusion of the project, a technical paper will be published on the results and findings of the research effort. During the life of the project, interested individuals are able to visit to the web site to view operating data for both machines over a several week period.

Public Benefits

The public will benefit from a cleaner environment when less energy is used. The VendingMiser™ manufacturer claims that one of their devices will reduce greenhouse gas emissions by 2200 lbs. of CO_2 each year[5]. (Based on occupancy and the Environmental Information Administration's national average of carbon emissions and electricity generation.) The technologies developed by Bayview Technologies and CM-GLO could help businesses and institutions save money by reducing the energy use of the vending machine on their property.

Project History

In the summer of 2002, Focus on Energy agreed to conduct power consumption testing on the EL panel technology and the Vending Miser™. CM-GLO Company had approached Focus on Energy, along with MSOE, regarding their new technology involving the use of EL panels for vending machines. As previously stated, the panel replaces the fluorescent lights normally found in vending machines. According to CM-GLO representatives, EL panels could potentially reduce by 90% of the power required for illumination in a conventional vending machine.

As part of an earlier project, Focus on Energy had purchased 200 VendingMisers™ for use in public buildings. In the justification for this project, Focus on Energy had stated that an average vending machine in Wisconsin uses approximately 3,500 kWh of electricity each year, which would amount to approximately $210 in utility costs.

CM-GLO designed and delivered an animated front panel for a Vendo (www.vendoco.com) soda-dispensing machine. This particular panel was designed with sequential lighting – first the

logo, then the bottle, and finally, a splash behind the bottle is lit. Past market data showed that animated vending machines sell more product than panels that stay lit. CM-GLO also made available, through the local distributor Seven-Up/Dr. Pepper Bottling Co. (www.juicewi.biz), a machine for testing the VendingMiser™. The VendingMiser™ device was made available by the Focus on Energy program.

It was decided during a meeting between Focus on Energy and CM-GLO representatives that the energy consumption testing done on a vending machine equipped with an EL panel would be compared to energy testing done on a vending machine equipped with the VendingMiser™. The testing would determine the power consumption characteristics for each machine. The data would also be compared to the data supplied by the vending machine manufacturers' (Vendo) machine power consumption data.

It was agreed by all parties that the testing would be conducted on the MSOE campus in the Allen-Bradley Hall of Science in downtown Milwaukee, WI. This facility is a three-floor building that runs daytime and nighttime classes, as well as houses offices for faculty and staff. A first floor lounge, Lee's Lounge, is a large room consisting of tables, sofas and vending machines of all types. There are only two soda machines in the lounge. Each machine sells the identical brands of soda at the identical price of $0.65. The machines are standing side-by-side, one being equipped with the EL panel and the other with the VendingMiser™. The equipment used for the testing was supplied by Focus on Energy.

The first prototype of the EL technology was installed into a vending machine by CM-GLO and delivered to the MSOE campus on September 1, 2002. An identical vending machine, with standard fluorescent lighting was delivered at the same time. The two machines were installed side by side in the Lee's Lounge. The testing was to reveal the total power consumption of the vending machine equipped with the EL Panel and compare it to the total power consumption of the vending machine equipped with the VendingMiser™. The data was to be collected for a continuous period of a month. The second part of the research was to show the power usage of each power-consuming element of a vending machine with an EL panel. A distinction was to be made between the power consumption of the EL panel by itself versus the power consumption of the refrigeration section.

Publicity

This project has been the subject of news articles and web pages. The project was one of two Focus on Energy projects featured in the Fall 2002 issue of *Dimensions*, MSOE's magazine[6] for Alumni and the general public. In addition to the MSOE web site, Focus on Energy has posted a press release covering their involvement with these technologies on their web site. This publicity prompted a visit from Dr. James Mapp, the Energy Star coordinator for the Sate of Wisconsin.

Student Impressions

This project was a great introduction to power testing for the students directly involved. The ideas behind both energy saving devices, the EL panel and the VendingMiser™, were basic enough that the students were able to focus on the power consumption testing and basic research

skills. The research skills gained by the students include traditional technology research and database research; power testing, research timing and organization (when to and how long to spend on a particular subject), analyzing and organizing collected data, and making general correlations from the collected data.

While most of the students, faculty, and staff were supportive of this research, it must be noted that the machine equipped with the EL panel was viewed unfavorably by some of the students and staff. Apparently, some people had lost their change in the machine. It is difficult to predict how much money was lost to the vending machine, or if the lost change was related to power quality issues with the EL panel. At least three different people approached members of the research team with this complaint, and a note was posted by the machine regarding the faulty coin return.

Also, several persons complained about the dimness of the EL panel. Some of the students were unsure whether or not the vending machine was powered on. This issue is being address by CM-GLO. The existing panel has a diffuser that reduces the light output. The diffuser is not needed with the EL panel. In a separate issue, faculty and students had commented on the high-pitched noise the vending machine with the EL panel made.

While not a complete success with the consuming public, the EL panels and VendingMiser™ device have been successful teaching tools as examples in several electrical engineering courses taught by Dr. Wrate and Dr. Steve Williams at MSOE. Additionally, the student research team members learned a significant amount about energy efficiency and measurement techniques. This was the first technical project for both students.

Web Page Development

Dr. Wrate and Jeremy Poling originally developed the web site for this project (www.msoe.edu/orgs/focus/vending.html). It was designed to display the results from the vending machines on a daily basis. Each daily page has the date at the top of the page followed by a chart comparing the total kWh used by each machine to the estimated kWh as published by Vendo. The remainder of the page displays graphs of the current and voltage for each machine for that day. In this way, the visitors to the site are able to visualize the amount of energy used by each machine. The web site also includes a page designed to demonstrate the cost savings per day per machine. On this page there is also an analysis on how much savings would theoretically occur if a vending machine was equipped with both a VendingMiser™ and an EL panel. This calculation is purely theoretical, and has not been verified through testing.

The web site visitor can choose to go to a web page displaying pictures of the vending machines, or they can view the project history page. The overall objective of the web site is to publish all of the data logged from the two vending machines. This site is intended to provide all the data collected, so that students and other researchers could utilize the data for their work in this area. It was not intended that this web site provide a definitive analysis of the economics of these devices. Therefore, the site contains no recommendations for the purchase of either device.

Measurement Techniques

To assist companies to perform their own internal energy audits, and due to the large amount of internal energy and power testing done, Focus on Energy has put together a Tool Lending Library. The library allows researchers to check out instruments such as power meters and data loggers, infrared thermometers, ultrasonic leak detectors, combustion analyzers, light meters, pressure transducers, and indoor air quality monitors. For this particular project, the data loggers and power meters were borrowed from the Lending Library. The existing electrical power measurement equipment in the Focus on Energy Tool Lending Library consists of two different models: data loggers and recording power meters.

The first devices provided by the Lending Library were the data loggers. These devices measure current and temperature only. After conferring with Focus on Energy staff, it was decided that current measurements alone might be sufficient to provide the necessary comparison. The clamp-on current probes for the devices have several ranges. When used in this research, two ranges were necessary (5 A and 25 A). When a current close to 5 A was flowing into one of the vending machines, and two probes at different ranges were on the power cord, the difference between two readings was approximately 1 ampere! When checked against a different measurement device, a Fluke 43 power meter with a Hall-effect current probe, a difference of greater than 1 A was found! The device's calibration feature was tried, but it was not successful. (The User's Manual contains only a brief, one-paragraph description of the feature, and no further information could be found on the company web site.)

Because the of problem described, and since true power could not be measured with the first device, the research team then switched to the recording power meters. At first glance, the calibration sheet provided with the devices would seem to imply that both the voltage and current inputs to the device were calibrated. This was only partially true. The current calibration appeared impressive, with less than a 0.01% error. But then the team noted the meters used for the calibration: an HP Multimeter and 0-20 V, 0-3 A DC Supply. Therefore, the value of approximately 150 A listed on the calibration sheet is only a relative value based on the current scaling used! Rather than using currents, a voltage at the Phoenix terminals of the device was used. The actual current sensor, a split-core CT, was not included in the error. The accuracy of a split core CT is such that the 0.01% error stated would be insignificant. (Uncertainties with split core CTs are usually 1% or greater.) Because of this, tolerances on the data are not given on the web site, and hard numbers on possible cost savings are not provided. On suggestion made by them team to Focus on Energy for future work was to compare the devices used by the Lending Library to NIST traceable devices.

Representative Data

The graph in Figure 3 shows the current drawn by the vending machine fed through the VendingMiser™ for a typical day. The VendingMiser™ turned off the vending machine for only a short time during the night. Students frequent the lounge for most of the night during the term, so the VendingMiser™ does not turn off the vending machine very often. The energy used that day was 7.684 kW-Hr.

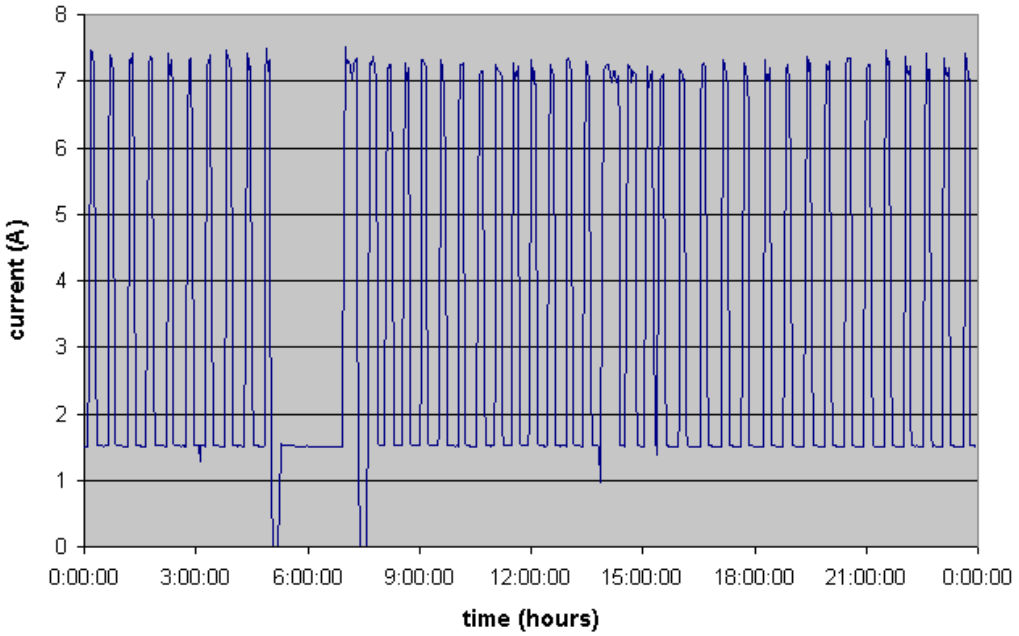

Figure 3. VendingMiser™ equipped machine current for typical day (November 13, 2002)

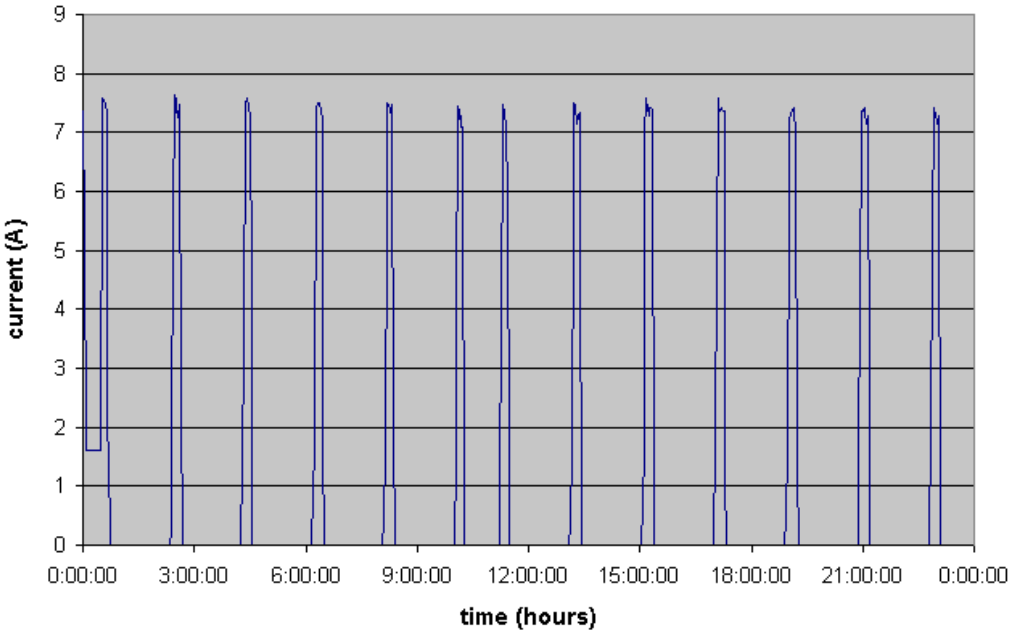

Figure 4. VendingMiser™ equipped machine current for Saturday of Thanksgiving Break (November 28, 2002)

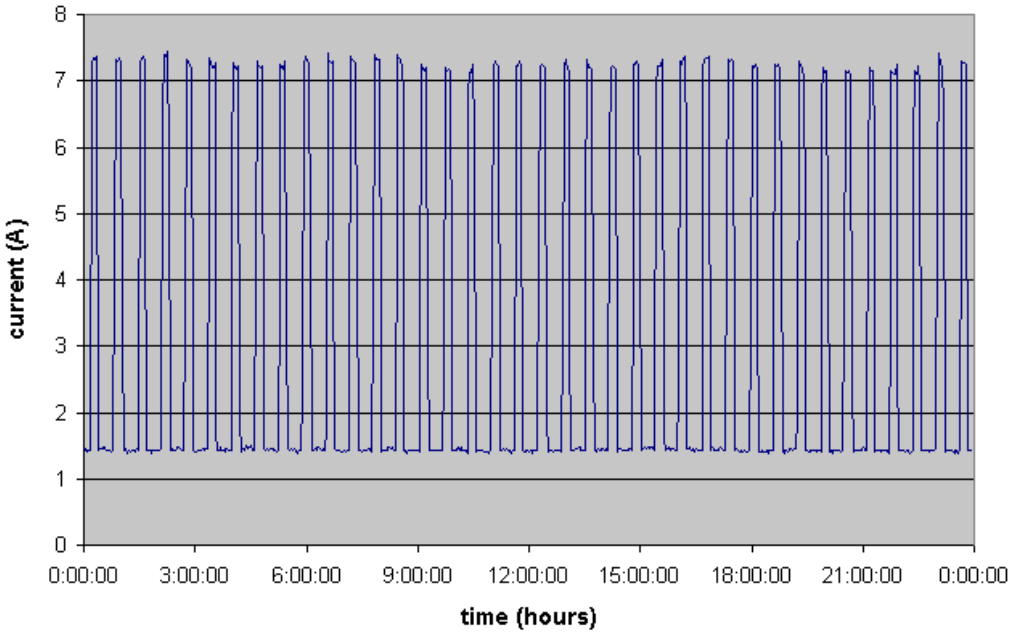

Figure 6. EL panel machine current for Saturday of Thanksgiving Break (November 28, 2002)

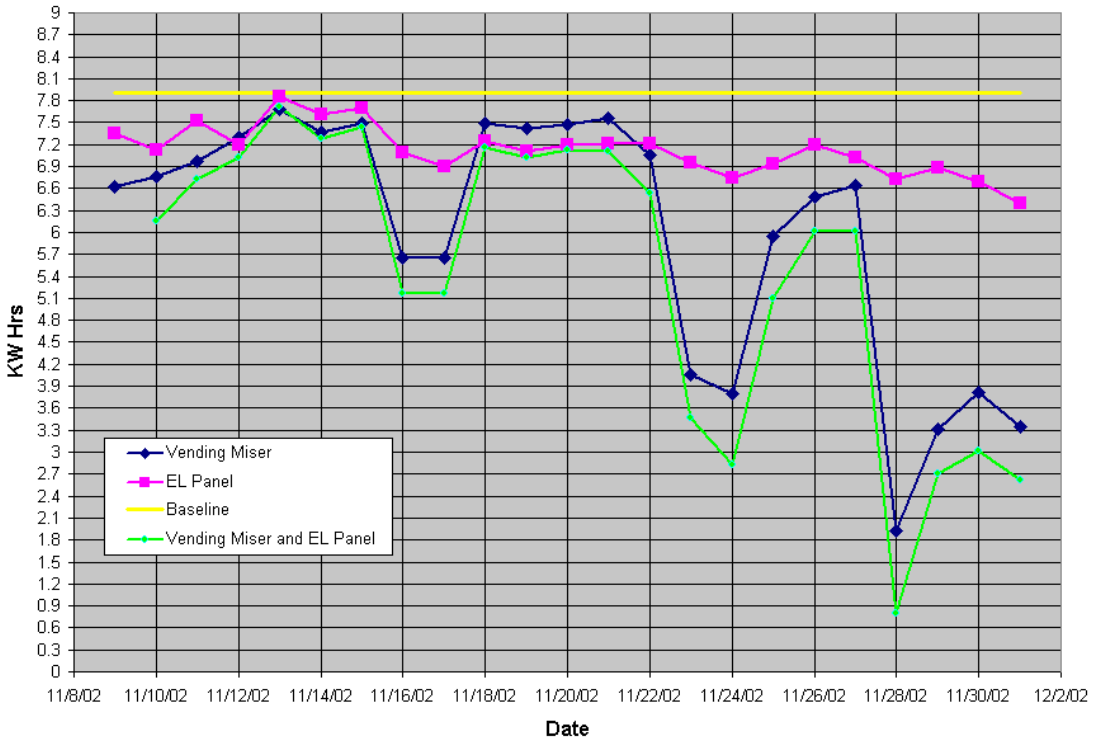

Figure 5. Energy use comparison

The effect of the VendingMiser™ is clearly seen in Figure 4. This figure is a graph of the current drawn by the vending machine on Thursday of Thanksgiving Break. Obviously, no

students, staff, or faculty went through the lounge that day. The energy used that day was 1.930 kW-Hrs.

Figure 5 represents the current drawn by the vending machine equipped with the EL panel for the Saturday of Thanksgiving break. The energy used that day was 6.731 kW-Hrs. This graph is a typical for the EL panel. There is no real distinction between each day.

A comparison is made in Figure 6, demonstrating the energy used by each machine for the duration of the study. The yellow line in the graph is the baseline of the comparison as published by Vendo, 7.9 kW-Hrs per day. The green line represents theoretical data, if a machine were to be equipped with both a VendingMiser™ and an EL panel.

Conclusions

While the authors are not certain weather either of these technologies are economically viable, one thing is certain, Wisconsin is attempting to deal with proactively with its energy concerns. One extremely positive aspect of this project has been the web site. It allowed unfiltered data to be presented to students, fellow researchers, governmental decision makers, and the general public. As an example of governmental involvement the web site has created, the research team has been able to meet with the Energy Star coordinator for the State of Wisconsin.

At this point, the authors are uncertain whether further investments by Focus on Energy are warranted. A complete economic analysis must be performed in order to determine the commercial viability of either technology. In addition, power quality concerns with the EL panel and possible effects on product quality with prolonged off cycles with the VendingMiser™ must be investigated further.

A major lesson learned by both the students and the faculty involved was the lack of standards for power consumption testing of devices and the questionably quality of the some power testing equipment.

Acknowledgment

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Biographies

GLENN WRATE was the Principle Investigator for this project. Dr. Wrate is an Associate Professor and the Director of the Master of Science in Engineering Program at the Milwaukee School of Engineering. He graduated with a Doctorate of Philosophy in Electrical Engineering from the Michigan Technological University in 1996. He is a registered Professional Engineer in the State of California.

EMILY BLAKEMORE was the Graduate Research Assistant on this project. Ms. Blakemore graduated from Indiana University with a Bachelor of Science in Mathematics and is currently a student in the Master of Science in Engineering Program at the Milwaukee School of Engineering. She was in charge of collecting the data and publishing the data to the website.

JEREMY POLING was the Undergraduate Research Assistant on this project. He is completing his Bachelor of Science in Architectural Engineering at the Milwaukee School of Engineering. Jeremy contributed much of the initial set-up of the data loggers for the vending machines.

LEE GREGUSKE was the Contract Administrator for the project. Mr. Greguske is a technology manager for Focus on Energy,. Lee oversaw the research and made sure the objectives of the test plan were being completed properly and in a reasonable amount of time.