# Vending Machine Energy Consumption and VendingMiser Evaluation

Submitted to:

TAMU Energy Office

By:

John Ritter
Joel Hugghins

Energy Systems Laboratory
Texas A&M University System

October 31, 2000

## Executive Summary

The Texas A&M campus has approximately 263 soda vending machines operated by the local Coca Cola distributor. Machines at the Coca Cola Bryan warehouse and a new machine located at the Energy Systems Riverside lab were analyzed to determine the energy consumption for each machine and for the individual electrical components within the machine. The machines selected were representative of the machines used on the A&M campus, and were in working order. From this testing, it was determined that the 263 campus machines consume an estimated 3546 kilowatt-hours per year, with a demand of 106 kilowatts, incurring about $34,000 per year in electrical costs. It was also found that the newer machines offer little energy savings over similar older models, and that the lighting systems account for 40% of the electrical cost for the vending machines.

VendingMiser an economy maximizing hardware was also evaluated over the course of the study. The energy savings from the use of VendingMiser would be significantly less for the few vending machines in buildings occupied during regular business hours; however, the majority of vending machines on campus are in continually occupied areas, resulting only in a slight energy reduction.

This report details the following prioritized recommendations and the estimated savings for each recommendation. Refer to the complete report for clarification.

1. Disconnect vending machine lights.
    - $11,252 and 375,072 kWh annual savings.
2. Use of economy maximizing hardware, such as VendingMiser.
    - The greatest energy savings from the use of a VendingMiser on the Texas A&M campus for an individual machine is $64 per year, with a payback around 2.6 years.
    - Most vending machines are in continually occupied areas and would not achieve the energy savings indicated above, so the use of the VendingMiser is not recommended.

## Introduction

As an effort to decrease the amount of non-critical energy used on the Texas A&M campus, and to assist Dixie Narco in evaluating the efficiency of their vending machines, the Texas A&M Energy Systems Laboratory investigated the power consumption of soda vending machines on the Texas A&M campus. Several vending machines were evaluated to determine the power consumption for the individual components, and the whole machine. Recommendations were made from the results. The VendingMiser device was also tested to evaluate the potential energy savings of this device.

The typical vending machine consists of a compressor, compressor fan, circulation fan to circulate cold air throughout the machine, fluorescent lighting system, and electronics, which are illustrated in Figure 1 below. The compressor also has a cooling fan that operates when the compressor is running. This report will refer to the compressor and its fan as the condenser section.

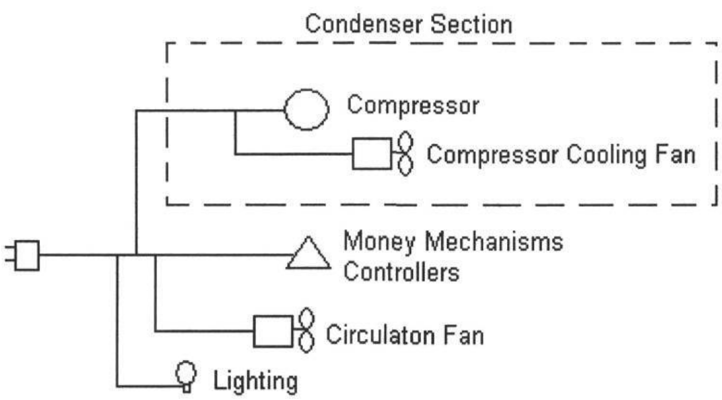


Figure 1. Simplified electrical schematic of typical vending machine.

The VendingMiser is an electronic device with a passive infrared sensor that completely shuts down a vending machine when the device has sensed the surrounding area has gone vacant for a set period of time, and re-powers the machine when the area has become occupied. The device has two independent settings that are set by the user: inactivity timeout and vacancy delay time.

The inactivity timeout is set by the user to a fuzzy logic or fixed setting. The fuzzy logic program will shut down the machine after the surrounding area has been vacant for 30 to 90 minutes. The fuzzy logic program learns the occupancy patterns of the area and adjusts the timeout accordingly. The fixed setting will shut down the machine a fixed basis of 15 minutes after the area goes vacant.

The vacancy delay time will be re-power the vending machine for approximately 20 minutes every 2, 4, 8 or 12 hours as set by the user during periods that the surrounding area is vacant.

## Test Procedure

*Vending Machine Energy Consumption Evaluation:*

With the assistance of the local Coca Cola distributor and the Dixie Narco vending machine company, five vending machines similar to those on the Texas A&M campus were measured for their energy consumption. The machines evaluated are listed below in Table 1.

Table 1. Vending Machines Evaluated.

| Make | Model | Refrigerent Type | Vends |
|---|---|---|---|
| Dixie Narco | 440 | R12 | Can |
| Dixie Narco | 501E | R134 | Bottle & Can |
| Dixie Narco | 600 | R12 | Bottle & Can |
| Royal | 448 | R12 | Can |
| Royal | 768 | R134 | Bottle & Can |

The DN 501E is a new machine sent to the Energy Systems Lab for evaluation by Dixie Narco. The other machines were machines used on the A&M campus for several years, which were recently decommissioned to the local Coca Cola warehouse.

Each machine listed above was connected to a metering device and a portable data logging unit for the purpose of measuring (1) the line voltage, (2) the current (Amp) draw for up to four of the metered components, and (3) the calculated power consumption of the metered components. All the fields listed above were measured in real time and logged in single minute increments for a time span of at least 20 hours. Tracking these continuous data points generates power profiles that reveal the typical behavior of these machines in normal conditions.

After sufficient data was collected on all the various devices, a scaling-up procedure was used to estimate vending machine energy consumption for the whole campus. The Energy Systems Lab obtained a current vending machine count of 263 machines on the A&M campus from the local Coca Cola distributor. The machines tested represented the general assortment of machines on the campus, and in order to simplify the scale-up, the machines tested were considered to be the average representation of the machines found on campus. The data from all the machines tested were averaged together, and then multiplied by 263 to obtain the total campus estimates. Estimates of deviation are given to provide for potential upper and lower boundaries of power use.

*VendingMiser Evaluation:*

The new Dixie Narco 501E vending machine located at the Energy Systems Riverside lab was used to evaluate the VendingMiser. As shown later in this report, it was determined that the Dixie Narco 501E has an electrical demand that is about average for vending machines on the Texas A&M campus.

The Energy Systems Riverside lab is occupied for 9 hours per day during the workweek and minimally during the weekends. However, the occupation of the Energy Systems lab varies from having a high occupation when tests are being conducted, to very little occupation when the employees are in the field.

Extensive power consumption data was collected from the vending machine, and this data was used to determine the power consumption without the VendingMiser. All testing was conducted on an empty machine, where the additional energy required for cooling the vended product was assumed to be small over the testing period of one complete week (7 days).

The VendingMiser was connected to the machine, as well as an electrical energy-logging unit to monitor power consumption of the machine. The VendingMiser was placed on the side of the machine allowing the device to detect occupants as they passed the machine to the lab office, which is typically occupied when the lab is open. The device was then set to the desired setting according to Table 2 below, and allowed to run for 7 days (one week, including weekends), before the data was collected, and settings changed.

Table 2. Test Parameters.

| Week | Vacancy Delay (hours) | Inactivity Timeout (minutes) |
|---|---|---|
| 1 | 2 | 15 Fixed |
| 2 | 2 | 30-90 Logic |
| 3 | 4 | 15 Fixed |
| 4 | 4 | 30-90 Logic |
| 5 | 8 | 15 Fixed |
| 6 | 12 | 15 Fixed |
| 7 | 12 | 30-90 Logic |

The 8 hour vacancy delay and 30-90 minute logic setting was tested, but due to corrupt data on the file, this test setting was excluded from our analysis, where the missing data did not affect the results.

## Results

*Vending Machine Energy Consumption Evaluation*:

The data from the various machines was analyzed to determine the cycle times, base and peak loads, power breakdown for the electrical components, and the estimated subsequent annual energy consumption of the machines.

Cycle time was determined by measuring the time elapsed from one compressor energization to the next and found to be approximately 5 minutes on and 10 minutes off on average for the vending machines tested.

The base load was found by observing typical measured lows in power usage when the compressor was not running. The peak load was also determined by observing typical measured highs in power usage typified by the condenser section being in operation. Figure 2 illustrates the cycle time, peak and base load for a typical vending machine. It should also be noted that the vending machines on campus are all located in indoor areas, which are heated and cooled, thus it was assumed that the machines will have a constant energy usage year-round.

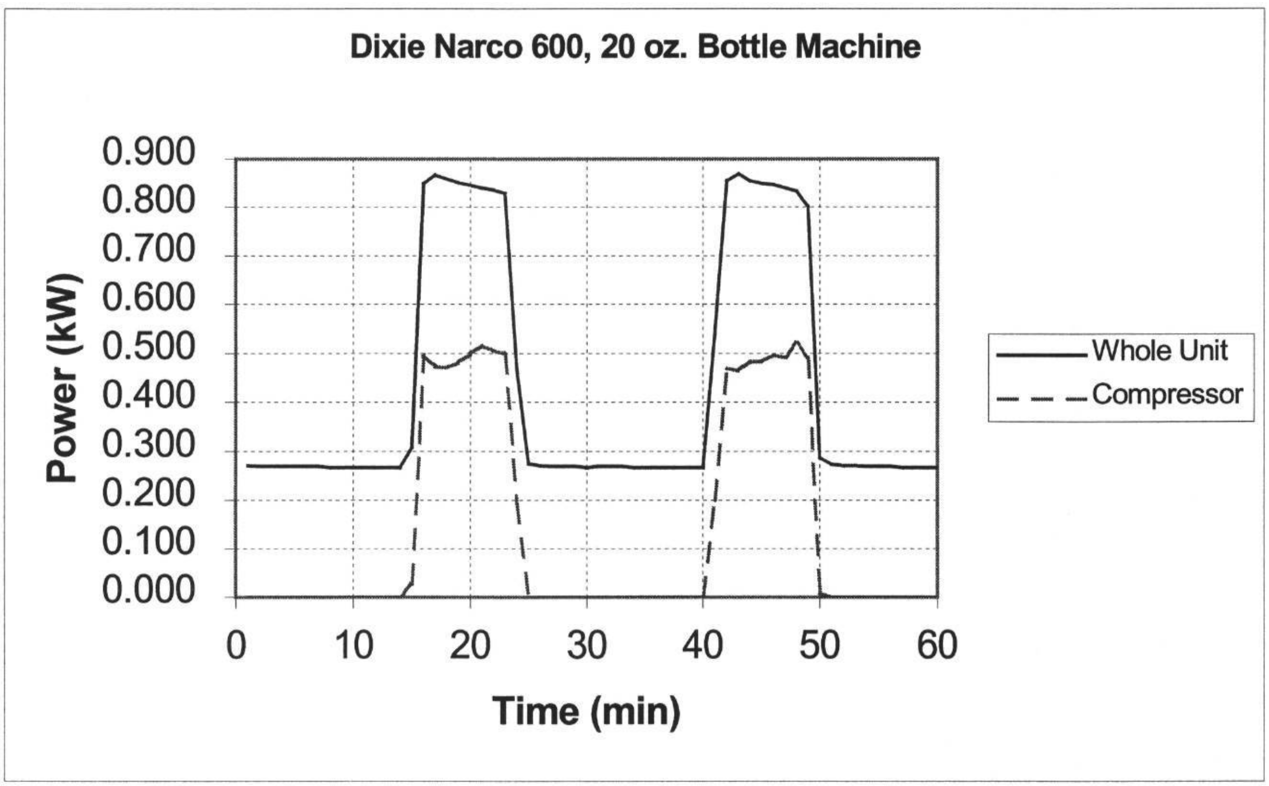


Figure 2. Typical energy profile for vending machines.

The power breakdown is a measure of the individual power consumption of the electrical components within the vending machine. The different power figures for the components were compiled and compared to the estimated base and peak loads. Figures 3 and 4 illustrate the typical power breakdown of the various machines.

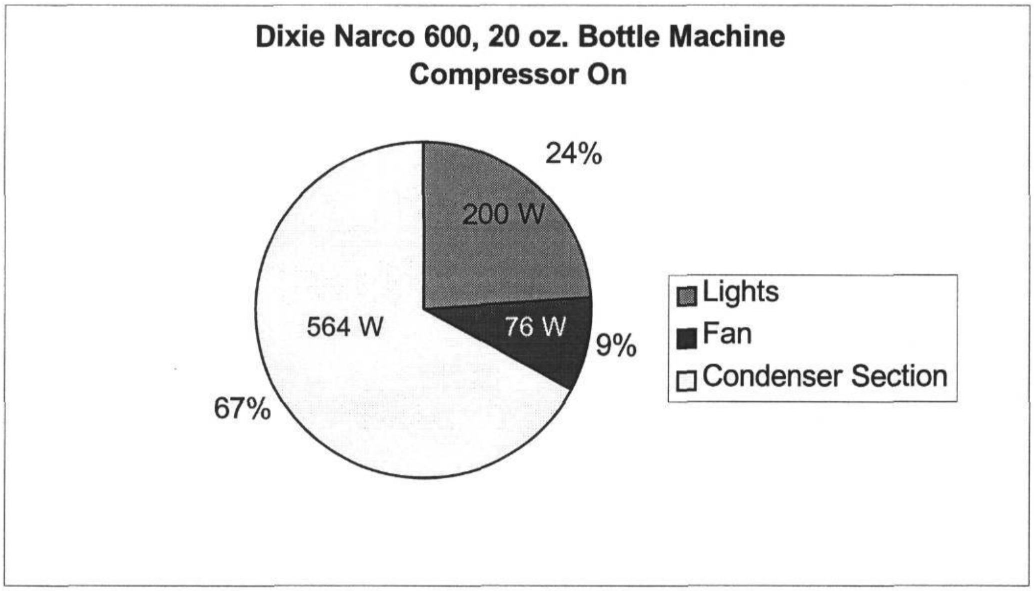


Figure 3. Power breakdown when the condenser section is running.

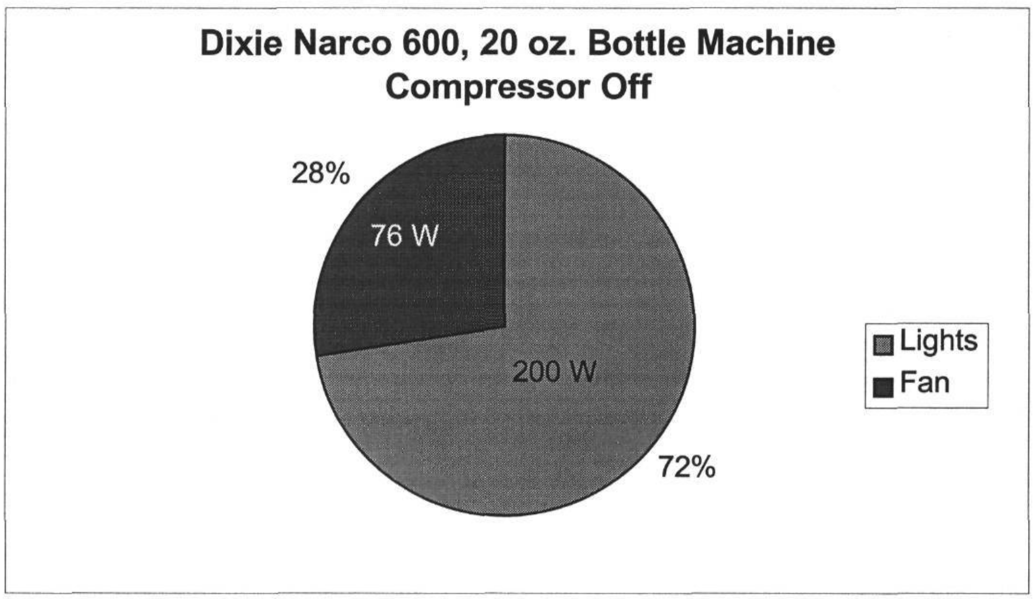


Figure 4. Power breakdown when the condenser section is not running.

For each individual machine, the condenser section, circulation fan and lighting power data were averaged using a weighted average based on the cycle times to determine the average power usage in kilowatts for the whole unit over time; this value was then converted into kilowatt-hours per day (kWh/day). This data was scaled-up to create an estimate for the entire campus. The cost estimates are based on the cost of electricity to the university, which are $0.03/kWh with a demand charge of $5.00/kW/month.

The 263 machines on campus have a combined demand of 108 kW costing $6,390/year, the power usage and cost were estimated to be 933,000 kWh/year costing more than $30,000 per year, as shown in Table 3 below.

Table 3. Vending Machine Energy Usage.

| Machine | Time On/Off (min) | Fan (kW) | Lights (kW) | Condesor Section (kW) | Total (kW) | Weighted Average (kW) | Total (kWh/year) | Cost ($/year) |
|---|---|---|---|---|---|---|---|---|
| DN 440 | 6 | 0.029 | 0.075 | 0.47 | 0.574 | 0.280 | 2,453 | $ 90.38 |
| | 10 | 0.029 | 0.075 | 0 | 0.104 | | | |
| DN 501E (new) | 5 | 0.071 | 0.139 | 0.5 | 0.71 | 0.402 | 3,522 | $ 129.77 |
| | 8 | 0.071 | 0.139 | 0 | 0.21 | | | |
| DN 600 | 8 | 0.076 | 0.2 | 0.5 | 0.776 | 0.450 | 3,942 | $ 145.26 |
| | 15 | 0.076 | 0.2 | 0 | 0.276 | | | |
| R 448 | 4 | 0.032 | 0.21 | 0.38 | 0.622 | 0.411 | 3,600 | $ 132.67 |
| | 5 | 0.032 | 0.21 | 0 | 0.242 | | | |
| R 768 | 5 | 0.091 | 0.19 | 0.48 | 0.761 | 0.481 | 4,214 | $ 155.27 |
| | 7 | 0.091 | 0.19 | 0 | 0.281 | | | |
| | | | | | **Average Total** | 0.405 | 3,546 | $ 131 |
| | | | | | **Total for 263 Machines** | 106 | 932,611 | $ 34,366 |

Based on the scaled-up data, the vending machine lighting systems consume a total of 375,000 kWh of energy annually with a demand of 43 kW, incurring a combined annual cost of $ 13,800. The lighting system cost accounts for 40% of the total electrical cost for the vending machines.

To determine the expected range of power usage, the vending machine power demand standard deviation was calculated, which was found to be 76.6 W, which translates to about ± $4,600 in the total annual cost. The variance between the various machines and the average was less than two standard deviations away, which is acceptable for the small data set, and is illustrated in Figure 5 below.

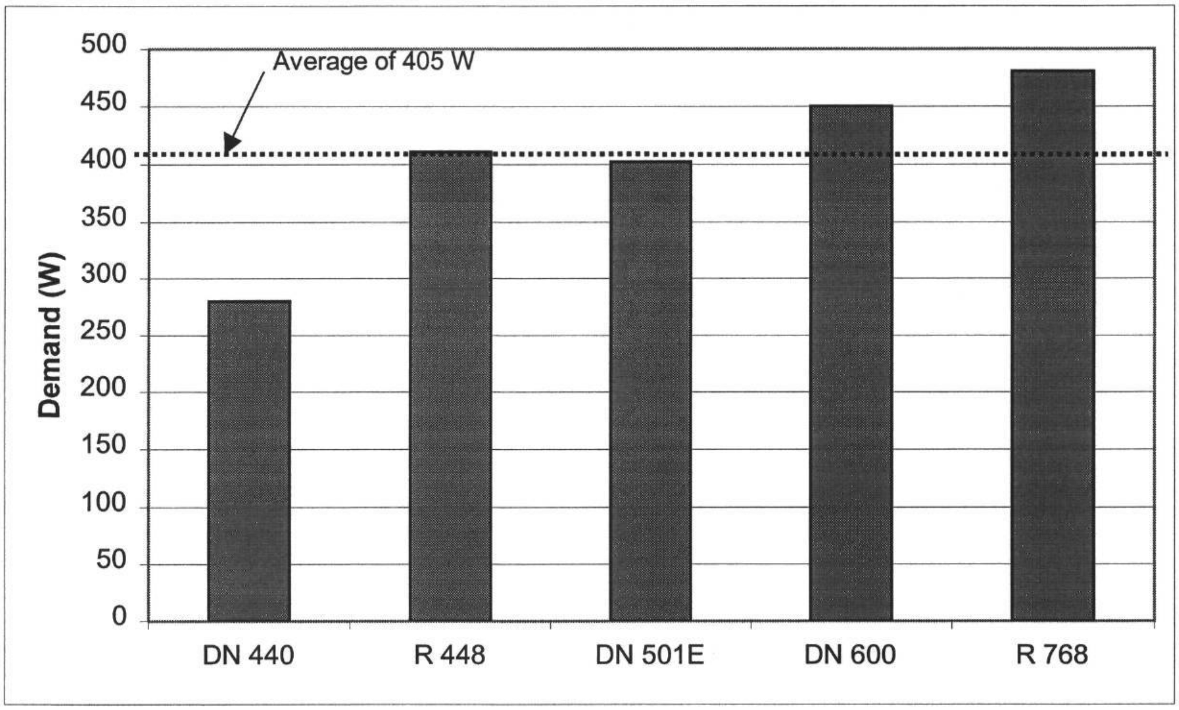


Figure 5. Vending Machine Electrical Demand.

*VendingMiser Evaluation:*

To illustrate the effects of the VendingMiser, the energy profiles for the vending machine with and without the VendingMiser are shown in Figure's 6 and 7 below.

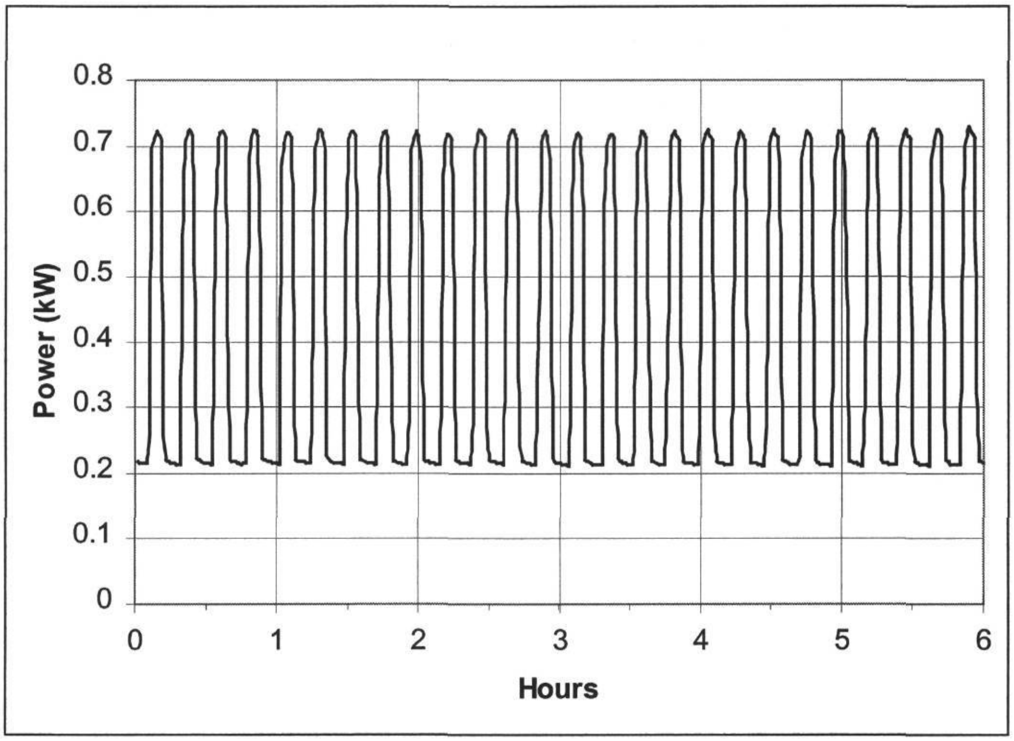


Figure 6. Energy profile for vending machine without the VendingMiser.

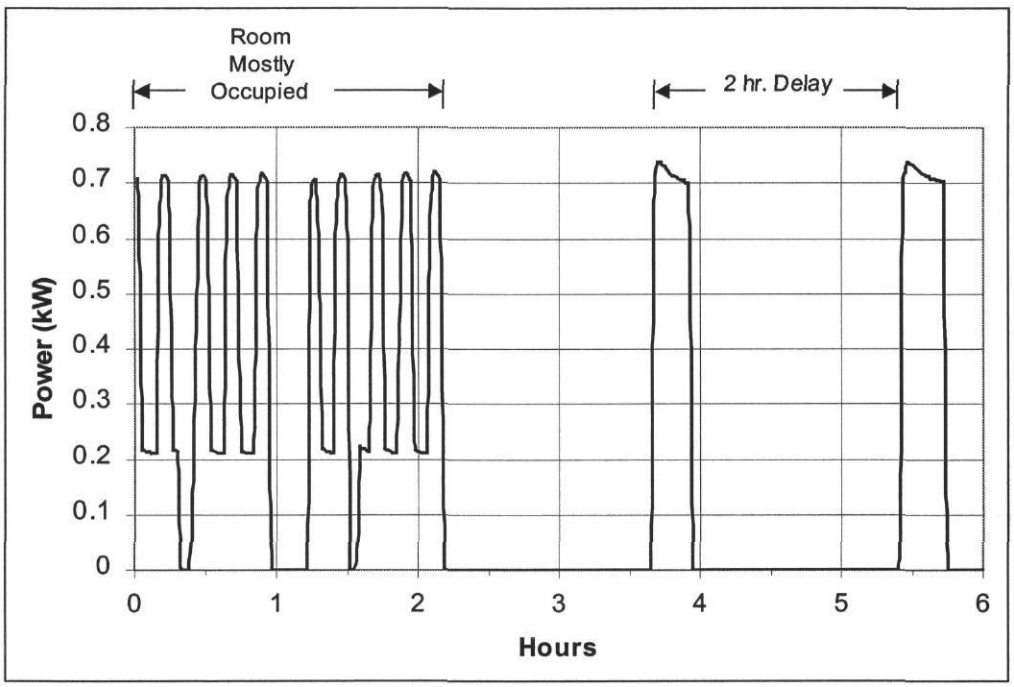


Figure 7. Energy profile for vending machine with VendingMiser set to the 2-hour delay and the 15-minute inactivity timeout settings.

The data from the various tests were analyzed to determine the average kilowatt-hour per day (kWh/d) of energy consumed by the vending machines. To obtain the energy consumption, the data for each of the test parameters listed in Table 2 were averaged for a period of 7 consecutive days. The percent reduction was then determined from the energy consumption data with the VendingMiser compared to the machine running without the device. The power consumed by the test vending machine without the VendingMiser is approximately 9.0 kWh/d. The results are summarized in Table 4 and Figure 8 below.

Table 4. Summary of test results.

| Vacancy Delay (hours) | Inactivity Timeout (minutes) | Power Used (kWh/d) | Precent Reduction |
|---|---|---|---|
| 2 | 15 Fixed | 4.28 | 52% |
| 2 | 30-90 Logic | 3.76 | 58% |
| 4 | 15 Fixed | 4.29 | 52% |
| 4 | 30-90 Logic | 4.66 | 48% |
| 8 | 15 Fixed | 3.93 | 56% |
| 12 | 15 Fixed | 3.15 | 65% |
| 12 | 30-90 Logic | 3.15 | 65% |
| | **No VendingMiser** | **9.00** | |

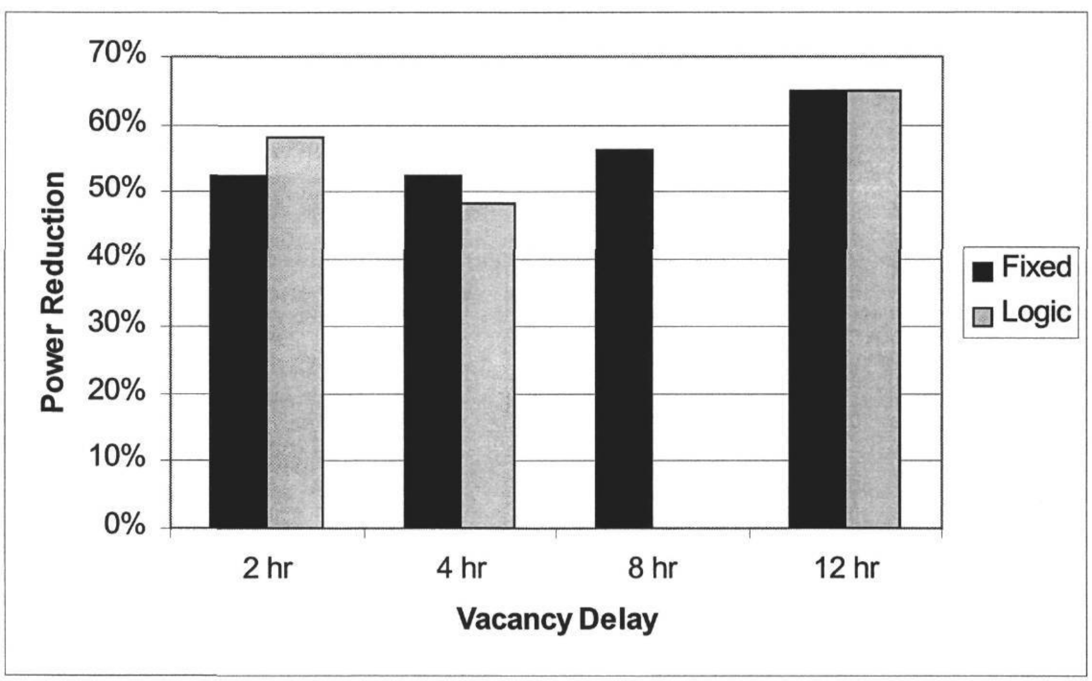


Figure 8. Comparison of the power reduction for the vacancy delay settings.

As illustrated in Figure 8, there is no clear trend in power reduction as the vacancy delay is increased as one might expect. To gain a better understanding of the data, the data analysis was narrowed down to where only the fixed 15-minute inactivity timeout data was considered. The 30-90 minute inactivity timeout logic setting data was excluded due to the wide scatter most likely occurring from the variable nature of this setting. The power reduction for the logic and fixed inactivity timeout settings are shown below in Figure's 9 and 10.

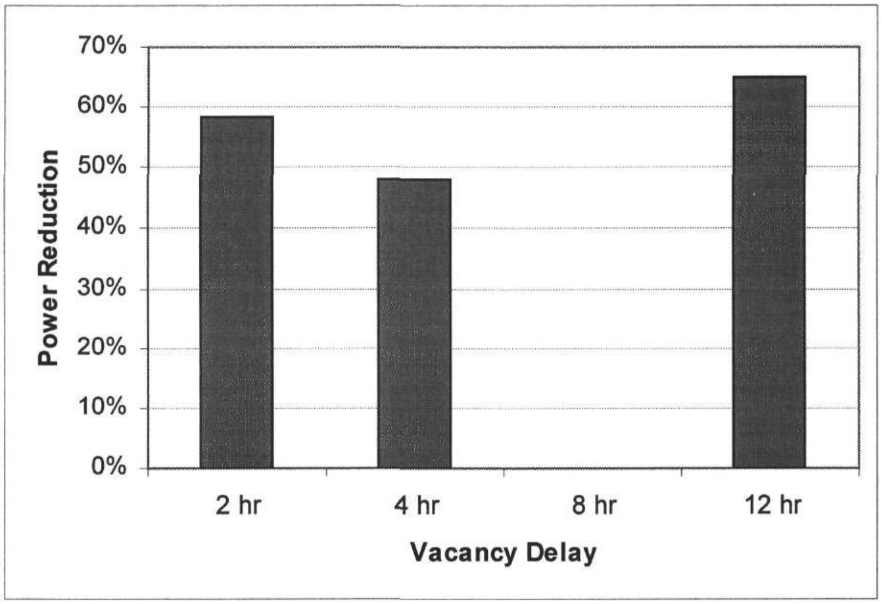


Figure 9. Power reduction for the logic inactivity timeout setting.

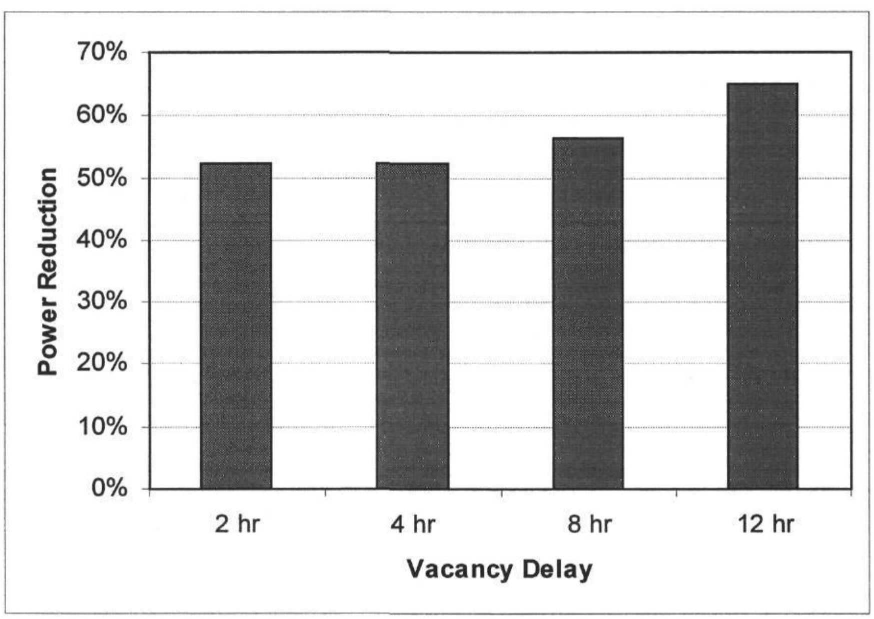


Figure 10. Power reduction for the fixed inactivity timeout setting.

The fixed inactivity timeout setting data were plotted as power consumed versus the vacancy delay, and the data points were then bounded by upper and lower linear lines, as shown in Figure 11 below.

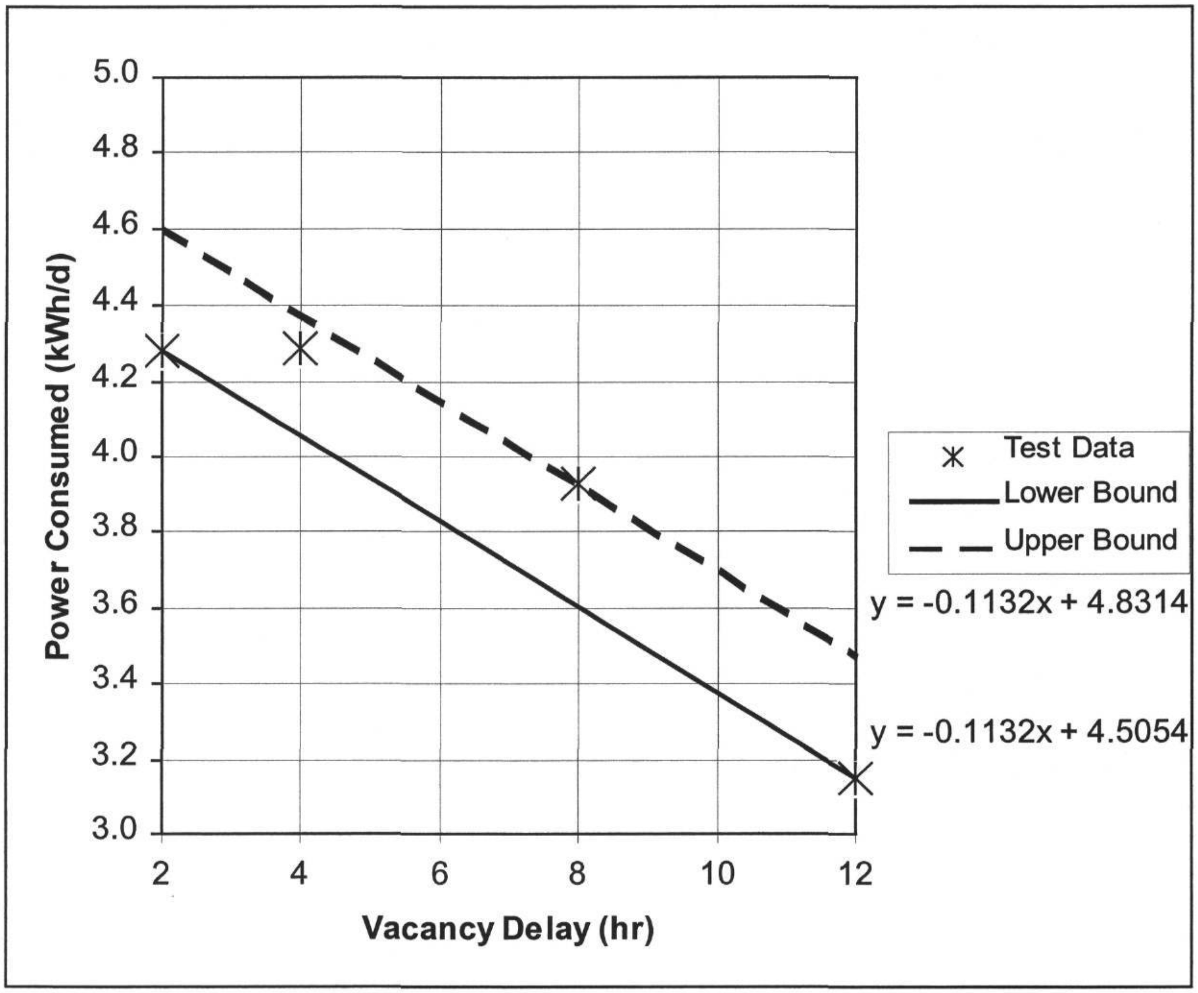


Figure 11. Linear model for power consumed for various vacancy delay settings and a fixed inactivity timeout.

The lower boundary forms a linear line connecting the two lowest values, which occur at the 2 and 12 hour vacancy delay. The upper boundary is a linear line parallel to the lower boundary and intersects the data point farthest away from the lower boundary, which is the 8 hour vacancy delay. From the linear boundary line equations, lower and upper power consumption for the various vacancy delay settings were estimated, as shown in Table 5 below.

Table 5. Estimates from the upper and lower linear boundary lines.

| Vacancy Delay (hours) | Actual (kWh/d) | Lower Estimates Power Usage (kWh/d) | Lower Estimates Percent Change From Acutal | Higher Estimates Power Usage (kWh/d) | Higher Estimates Percent Change From Acutal |
|---|---|---|---|---|---|
| 2 | 4.28 | 4.28 | 0% | 4.61 | 7% |
| 4 | 4.29 | 4.05 | -6% | 4.38 | 2% |
| 8 | 3.93 | 3.60 | -9% | 3.93 | 0% |
| 12 | 3.15 | 3.15 | 0% | 3.47 | 9% |

Also included in Table 5 is the percent change from the actual, which is percent difference between the estimated point and the actual point. The greatest value for the percent difference is 9% and combined with the small differences of the power consumption for the various vacancy delays, it is possible to have overlapping of measured power consumption. For example, the 2 hour vacancy delay has an estimated power savings of 4.28 to 4.61 kWh/d, compared to the 4 hour having an estimated savings of 4.05 to 4.38 kWh/d, where the two settings power savings overlap between 4.28 and 4.38 kWh/d.

## Conclusion and Recommendations

*Vending Machine Energy Consumption Evaluation:*

Examination of the typical energy consumption for vending machines on the Texas A&M campus shows that each machine consumes approximately 9.72 kWh per day, and the 263 machines on campus have an annual cost of more than $34,000 (± $4,600).

By disconnecting the lighting system on each vending machine on campus, it is estimated that the university may save more than $11,300 and 375,000 kWh annually. Given that all the campus vending machines are located indoors, in well-lit areas, disconnecting the lighting should not result in lowering the machines' appeal to customers. Also, the lighting system is independent of all other electrical components in the machine, and disconnecting it will not result in faulty operation. Many newer machines include internal lighting controls, which allow the lighting to be turned off completely when they are not needed.

Specifying machines with lower power consumption will also lower the power cost for the vending machines on campus, since comparable vending machines were not evaluated, savings estimates can not me made at this time.

*VendingMiser Evaluation:*

The results of the VendingMiser test indicate the potential energy savings for vending machines located in a typical business building environment using the

VendingMiser device, with building operating hours of 8 a.m. to 5 p.m. weekdays, and minimal weekend activity. The evaluation indicates that the VendingMiser could possibly reduce energy consumption ranging from 48 to 65 percent in these conditions.

However, the VendingMiser will save considerably less energy for vending machines in locations occupied mostly by students, such as a dorm, as students tend to observe sporadic working hours at all times of the day and night.

Although the cause of the variance of the power consumption for the various vacancy delay settings is not completely known, it is most likely a result of the variance of occupation of the Energy Systems Laboratory during the evaluation period. The Energy Systems Riverside lab occupation varied from high occupation when tests were being conducted, to very little occupation when the employees were in the field. Other causes may be from natural occurrences, such as birds flying through the lab, thunderstorms, and other random movements, all of which might have set off the occupancy sensor.

Based on an energy cost to the university of $0.03/kWh, the potential energy cost savings and paybacks were calculated, as shown in Table 6 below. The paybacks were based on a cost of $166 for a VendingMiser unit. No demand savings are assumed, since the unit would likely be on during the normal occupied hours in the daytime when the peak campus demand occurs.

Table 6. Energy cost savings and paybacks for the VendingMiser located in a normal 8 to 5 weekday environment.

| | **Energy Savings** kWh/d | **Precent Reduction** | **Energy Cost Savings** $/year | **Payback** Years |
|---|---|---|---|---|
| Maximum | 5.85 | 65% | 64 | 2.6 |
| Minimum | 4.32 | 48% | 47 | 3.5 |

As Table 6 illustrates, the energy cost savings for a vending machine using a VendingMiser are quite good, saving 50% of the total energy, having a payback of about 3 years. However, this is for a machine located in a typical office environment. The VendingMiser would generate far less savings for the typical vending machine on campus, as most vending machines are located in areas occupied by students, who typically observe long and sporadic working hours. If the VendingMiser device were to be used on campus, the vending machines selected to use the device should be in buildings that observe normal occupied and unoccupied periods and are normally shut down on weekends. The VendingMiser is not recommended for dorms, the MSC, or other locations where there is high student traffic throughout the day and night.