Technical Report

June 2003 • NREL/TP-550-34008

Analysis of NREL Cold-Drink Vending Machines for Energy Savings

M. Deru, P.Torcellini, K. Bottom, and R. Ault

National Renewable Energy Laboratory

1617 Cole Boulevard
Golden, Colorado 80401-3393

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TABLE OF CONTENTS

INTRODUCTION 1
ENERGY STAR® RATING 1
LOAD-MANAGING DEVICE 2
EXPERIMENTAL APPROACH 2
ANALYSIS 3
EXPECTED SAVINGS 6
CONCLUSIONS 8
REFERENCES 8
APPENDIX A: PERFORMANCE DATA 10
APPENDIX B: TESTING PROCEDURE 15

Introduction

Refrigerated vending machines consume a significant amount of energy to supply cold products. Measurements at the National Renewable Energy Laboratory (NREL) have shown that a typical machine that dispenses 500 12-oz cans with an illuminated front consumes between 7 and 11 kWh/day in an office environment. Measurements by other groups show similar results; for example, a study for the Sacramento Municipal Utility District (SMUD) reported energy consumption of 8 to 13 kWh/day [1]. For comparison, new Energy Star® certified residential refrigerators use 1-2 kWh/day [2]. One reason for the high-energy use is that the manufacturers and owners of the vending machines generally do not pay for the energy to run the machines; therefore, they have little incentive to improve the energy efficiency of the machines. The building owners, who pay the utility bills, have little choice in the type of vending machine that is deployed at their site.

As a building owner, NREL also has little control over the vending machines deployed at its site. However, NREL staff, as part of Sustainable *NREL,* an initiative to improve the overall energy and environmental performance of the lab, decided they could control how those machines were used. As part of this effort, the cold-drink vending machines across the lab were analyzed for potential energy saving opportunities. This report details the monitoring and the analysis of two energy conservation measures (ECMs) applied to the cold-drink vending machines. The first ECM was to utilize a load-managing device designed for vending machines and the second was to simply remove the advertising lights in the front of the machine. The load-managing device was also studied to determine if it had any adverse effects on the operation of the vending machines or on the temperature of the delivered product.

There are sixteen cold-drink vending machines on the NREL campus. Both ECMs were only applied to fifteen of these machines. One machine was only delamped because it is in an area that is continuously occupied and the load-managing device would produce very little savings. The details of the machines are listed in Appendix A. Measurements were only taken on ten of the machines and the savings for the others were estimated based on the measured data.

There may be a concern that delamping the advertising light fixtures might reduce the amount of product sold because people will think the machines are not in service. However, consumers in an office environment with no other beverage choices are a captive audience, and they quickly learn that the machines are always in service. In order to educate the occupants and ensure them that the machines were still in service, signs indicating that the lights were turned off to save energy were placed on the machines when they were first delamped. Additionally, the beverage vending company was consulted prior to delamping the machines.

Energy Star® Rating

An effort to create an Energy Star standard for rating vending machine energy performance [3], which is hoped to improve the average energy performance, is underway. The initial draft of this standard states that Energy Star qualifying models shall consume a quantity of energy in a 24-hr period equal to or less than the value obtained from the equation shown below:

$$Y = 0.55\ (8.66 + 0.009 \times C)$$

Where Y is the 24-hr energy consumption (kWh/day) and C is the machine product capacity expressed as the maximum number of equivalent 12 oz (355 ml) cans the machine can hold. This would require that a 500-can capacity machine consume no more than 7.2 kWh/day. A 600-can and an 800-can capacity machine may consume no more than 7.7 kWh/day and 8.7 kWh/day respectively. This draft of the standard is not very stringent and will likely be revised.

Load-Managing Device

The load-managing device tested in this study uses a passive infrared occupancy sensor to turn off the vending machine when the surrounding area is unoccupied and turn it back on when the area is reoccupied. The load manager also monitors the ambient temperature while the vending machine is off, and it powers up the machine when required to ensure that the product stays cold. In addition, the load manager monitors electrical current used by the vending machine so that it is not shut off while the compressor is running to prevent a high head pressure start from occurring. This process reduces maintenance costs and extends the life of the vending machine by significantly reducing the number of compressor cycles.

There have been numerous studies on the performance of this particular load-managing device for vending machines [4]. Most of the studies focus on simple energy savings estimations, which vary between 24% and 76%. One detailed study focused on the electrical demand savings potential of the device [1]. This study estimated a peak demand reduction of 22 W per installation in an office environment. This small reduction can be explained by the fact that the vending machines are often located in occupied areas during the peak demand periods, and therefore, there is little savings produced by the load manager. This study also estimated an average annual energy savings of 37% for applications across different building types. Finally, an independent evaluation of the load manager was completed for the manufacturer [5]. The product was found to have very good to excellent integrity, manufacturing, and serviceability. In an unoccupied 90°F test chamber, the load manager was found to reduce energy consumption by 48% and did not adversely affect the product temperature. In addition, the report concluded that the reduced cycling of the compressor and condenser fan would increase the life of the vending machine.

Experimental Approach

Two existing protocols for rating vending machine performance are ASHRAE Standard 32.1-1997 [6] and CAN/CSA-C804-96 [7]. These two methods are very similar and are designed to test the machines in tightly controlled conditions for performance rating. They are not meant for testing machines under actual operating conditions. A new method of testing the performance of the machines was devised for two levels of information. The details of the testing procedures are found in Appendix B.

The purpose of the first test was to determine the total energy consumption of the vending machines with and without applying the ECMs. This was done by measuring the energy consumption over the period of one week for each condition using a portable plug-in, watt-hour meter. Three different operating conditions were measured: without the load manager, which established a base case; with the load manager; and with the load manager and the internal advertising lights removed. The internal advertising lights consist of two T-12 50-W fluorescent bulbs. The average ambient temperature during the test periods was also recorded. In four of the vending machines, the advertising lighting had already been removed so all the measurements were conducted with the lights off. The average power consumed with the lights on was estimated based on measurements from similar machines. Machines 11 to 16 were not monitored and the results were estimated based on the measurements of similar models.

The second testing procedure was performed to gain a better understanding of how the load-managing device saves energy and affects product temperatures. This test consisted of instantaneous current readings at one-minute intervals and room air temperature and machine internal temperature measurements at 15-minute increments. This test was performed on the number one and two vending machines listed in the tables in Appendix A, which were already delamped from the first test. It is expected that the other machines will respond in a similar fashion.

Analysis

The results of the energy data taken for the three different cases are found in Figure 1 and Appendix A. Figure 1 compares the average power consumed by each machine over a one-week period under the three test conditions: baseline, load manager, and load manager plus delamping. The values for machines 11-15 are all estimated and are represented by machine 11 in Figure 1. On average, each vending machine consumes approximately 8.3 kWh/day when operating under baseline conditions, 5.6 kWh/day when operating with the load manager alone, and 3.7 kWh/day when operating with the load manager while delamped. The measured minimum, maximum, and average energy savings for the two test cases and the estimated savings for delamping alone are shown in Table 1. This first testing procedure shows that the load manager alone produced an average energy savings of 33%, and disconnecting the advertising lamps with the load manager can save approximately 56% of the energy. Assuming that the power of the advertising lamps is 100 W, the average energy savings from just delamping the machines is approximately 29%.

The energy savings achieved by the load manager in other applications will depend on the vending machine, the ambient conditions, and the occupancy patterns. The occupancy schedule for the office environment in these tests is typically 10-12 hours, five days a week plus occasional occupancy at night and on weekends by cleaning and security personnel.

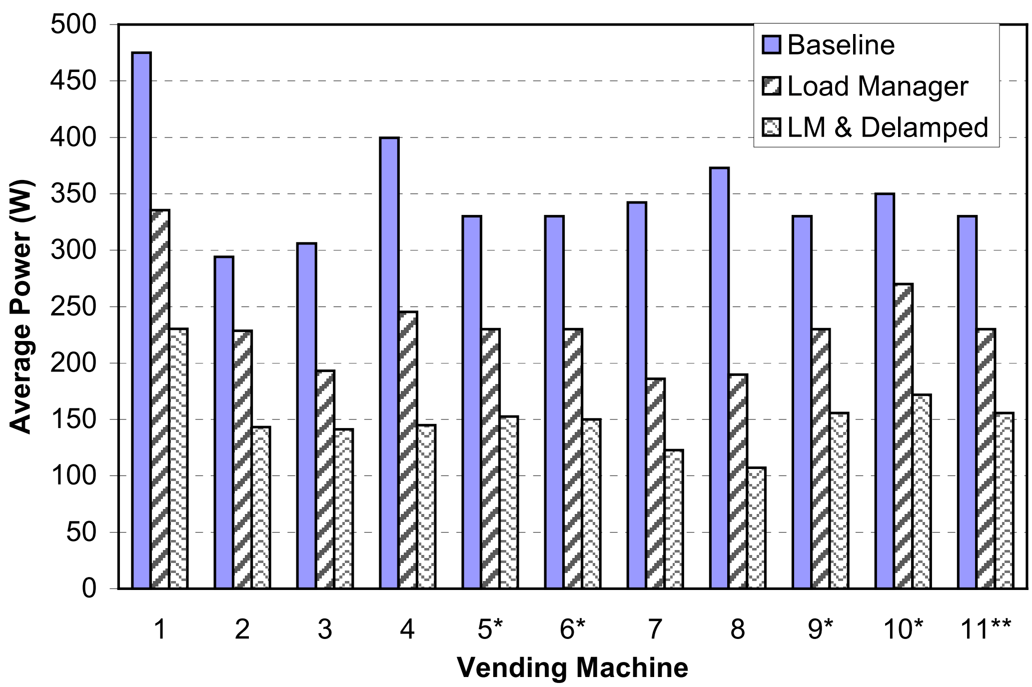

Figure 1: Average power consumption of NREL vending machines for three test cases. * Lights on values estimated **All values estimated

Table 1: Percent energy savings for energy conservation measures

Energy Conservation Measure	Min	Max	Avg
Load manager	22%	50%	33%
Load manager & delamping	51%	71%	56%
Delamping (estimated)	27%	34%	29%

The second level of testing was performed on two machines (#1 and #2 from Figure 1) with and without the load manager and no advertising lights for either test case. These machines are located side-by-side in a break room that has frequent occupation throughout the day. The test revealed some interesting information about how the load manager affects vending machine operation and product temperatures. A look at the current profiles in Figures 2 and 3 for one day during each testing period shows how the load manager affects the operation. The test conditions were not identical for each period as the quantity of the product changed slightly and the room air temperatures were slightly different. The average room temperatures for the two tests were 74.5°F for 10/23/02 and 73.0°F for 10/30/02. The temperature variation represents about 4% of the temperature difference from the room air to the product.

The top graph of Figure 2 shows that vending machine #1 never shuts off completely without the load manager. It draws a 1 A current between compressor cycles, probably for condenser fan operation. The load manager turns the machine off during unoccupied periods as shown in the bottom graph in Figure 2. This represents about an 8% energy savings. The load manager also reduces the frequency of the compressor cycles during unoccupied periods, which produces a 21% energy savings.

Figure 2: Current profile for vending machine #1 with and without the load manager

Figure 3 shows the current profile for vending machine #2 with and without the use of the load-managing device. This machine uses less energy than #1 (as shown in Figure 1) and has more frequent and shorter compressor cycles. There is also no current draw between compressor cycles. The use of the load manager produces fewer and longer compressor on cycles at night. The savings for the one-day shown in Figure 3 is approximately 8%. The savings measured by the plug in watt-hour meter during a different test period was approximately 14%.

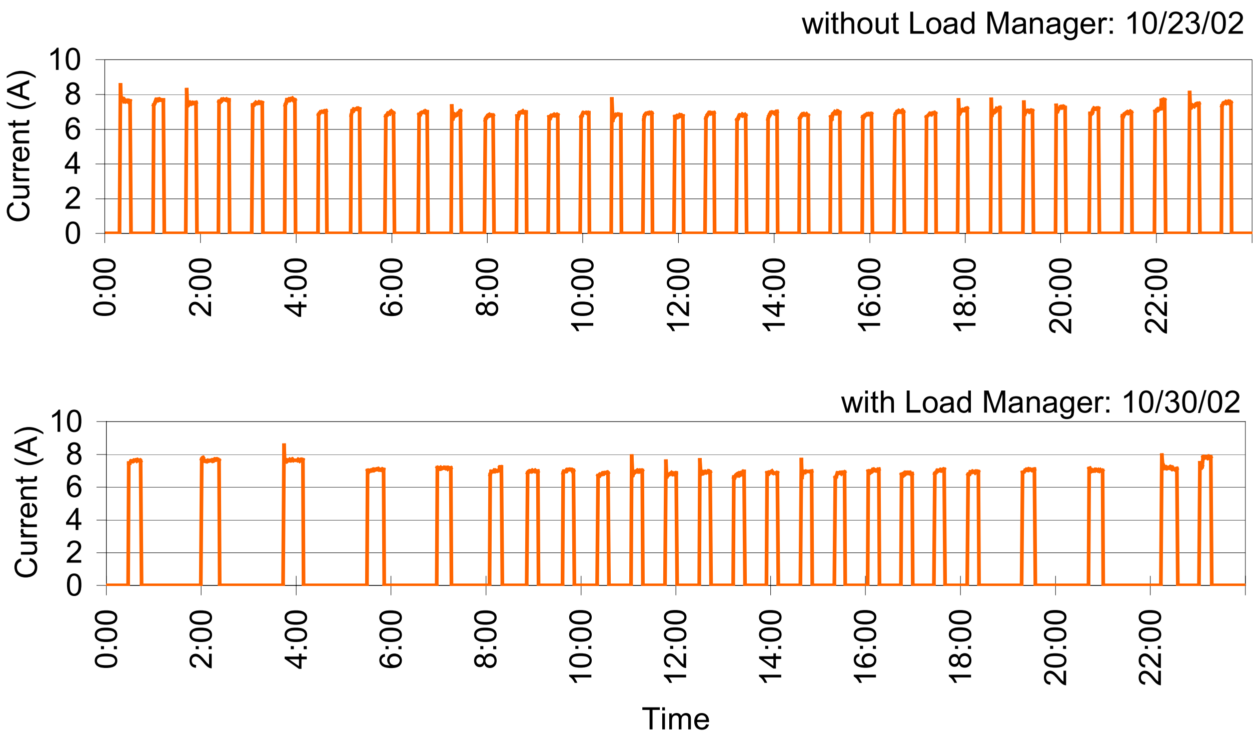

Figure 3: Current profile for vending machine #2 with and without the load manager

A temperature sensor was placed inside the vending machines in the center next to the product to obtain temperature readings from within the machine. Table 2 shows the maximum, minimum, and average internal temperature for vending machine #1 during the weeklong testing periods.

Table 2: Vending Machine #1 Internal Temperature Data (°F)

Case	Average	Maximum	Minimum	Avg. Room
With load manager	35.5	43.0	32.8	76.0
Without load manager	36.6	40.2	32.8	77.6

The use of the load manager has a negligible effect on the product temperature. In fact, the average internal temperature with the load manager was slightly lower than without the load manager; however, the average room temperature was also slightly cooler during the period with the load manager. For a closer look at the load manager's effect on product temperature, an interior temperature profile for vending machine #1 over one full weekday was recorded as seen in Figure 4. The temperature profiles were taken during a different testing period than the current profiles shown in Figure 2. The decrease in the frequency of temperature fluctuations with the use of the load manager was caused by fewer and longer compressor cycles with the load manager.

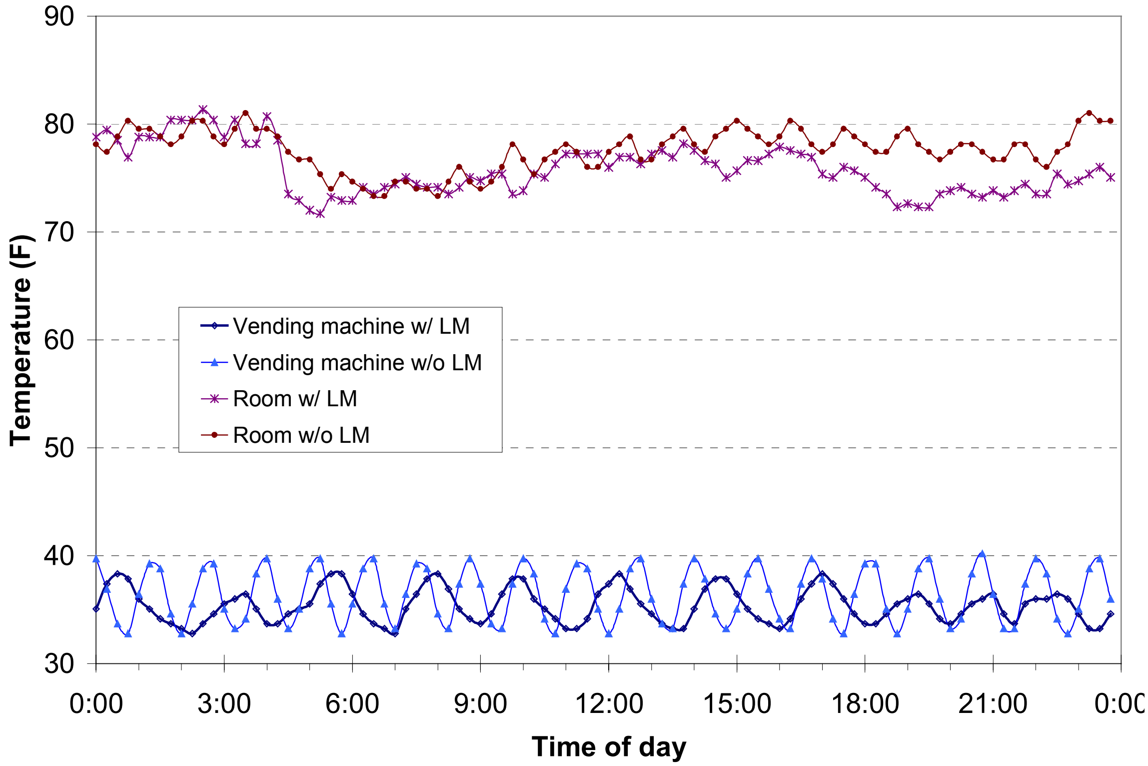

Figure 4: Room and vending machine #1 internal temperature profiles for the tests with and without the load manager

Expected Savings

For the vending machines tested in this study, the load manager reduced the energy consumption by an average of 33%. Disconnecting the advertising lamps along with the load manager reduced the energy consumption by 55%. The estimated annual energy savings of the three ECMs applied to the 15 machines at NREL are 14.8 MWh for the load manager, 13.2 MWh for delamping, and 25.2 MWh for the load manager and delamping. The actual energy savings is the latter number because all the machines have a load manager and are delamped.

The energy cost savings is more difficult to determine because it is related to the reduction in the energy used and the reduction in the electrical demand. All of the vending machine studies, except one reviewed by the authors that included cost savings analysis, used a fixed energy cost rate for the cost savings estimates. Most commercial buildings have a utility rate structure based on a demand charge and a low energy cost rate. The reduction in the peak demand is very difficult to determine because it depends on the coincidence of the electrical loads. The areas of the vending machines are normally occupied during business hours; therefore, very little, if any, demand reduction will be attributed to the load managers. The SMUD study reported only a 22 W demand savings per machine with the load manager during normal business hours for offices; however, there were significant demand savings during nonoccupied hours [1]. One of the 17 machines in this study was delamped, which represents about one fourth of the 22 W demand savings.

NREL has buildings at two different sites with different electrical rate structures. For 2002, the South Table Mountain (STM) site has an energy charge of $0.01612/kWh and demand charges of $7.71/kW for 8 a.m.–10 p.m. and $5.36/kW for 10 p.m. to 8 a.m. The National Wind Technology Center (NWTC) has an energy charge of $0.01612/kWh and a demand charge of $12.8/kW.

The following assumptions were made to estimate the energy cost savings:

1. Vending machines with no ECMs applied contribute 2/3 of the average power consumption per machine to the building peak demand. This is estimated from the SMUD study for vending machines in offices.
2. Load managers on vending machines in areas that are normally occupied during business hours do not contribute to building peak demand reduction during this time period (i.e., the demand charge is calculated as in assumption #1). This applies to all vending machines.
3. Load managers reduce the building peak demand calculated under assumption #1 in half during unoccupied times (i.e., the peak demand is 1/3 of the average power consumption). This reduction is only relevant to the machines at the STM site, which has a nighttime demand charge.
4. Delamping a vending machine provides a constant 100 W reduction in power consumption compared to the baseline case.
5. The average power consumption of the vending machines was taken as that measured over a one-week period with the plug-in watt-hour meter.

The annual energy cost savings by kWh, demand, and total for each of the ECMs is shown in Table 3 for all the vending machines. The use of the load manager and delamping saves approximately $635 per year. Delamping the machines saves more money than using the load manager alone because of the savings in the demand charges. These savings are due to the assumption that the load manager will not reduce the daytime demand charges. The demand cost savings for the load manager are only due to the reduction of the nighttime demand charge for the STM site. A simple payback analysis of the load managers is shown in Figure 5. This graph uses only the initial purchase cost of the load managers and not the installation costs. In addition, no inflation of the energy cost or discount rate was taken into account. This analysis estimates that it will take approximately six years for the load managers to pay for themselves if they are used with no delamping. This payback period is longer than reported in other studies of this load manager due to the relatively low electrical energy costs.

Another method of calculating the energy cost savings is to use the virtual rate, which is equal to the total electric charge divided by the total kWh's used. The virtual rate for the STM site is $0.045/kWh and the NWTC site is $0.051/kWh. Using the virtual rate, the load managers would produce about a $600/year savings with a simple payback of less than four years.

Table 3: Total annual energy and demand cost savings

Case	kWh cost savings	Demand Cost Savings	Total Energy Cost Savings
Load manager	$239	$99	$338
Load manager & Lights off	$407	$228	$635
Lights off	$212	$157	$369

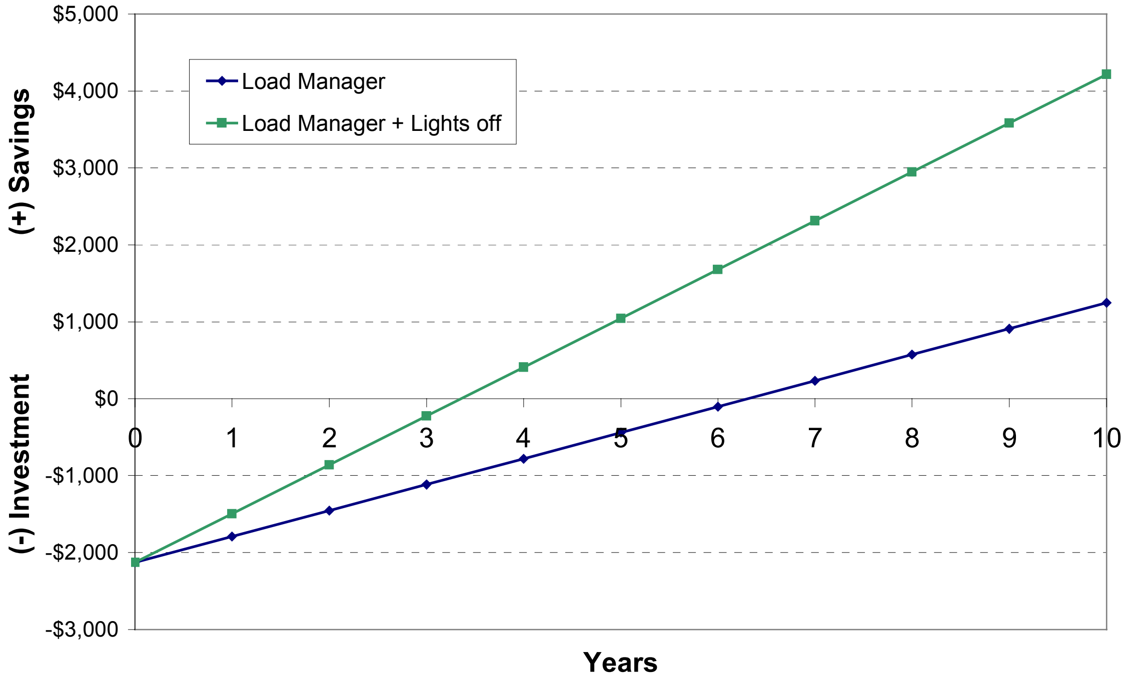

Figure 5: Projected energy cost savings for the ECMs assuming no inflation of energy costs.

Conclusions

Based on the tests performed on the various NREL cold-drink machines the following general conclusions were made:

- Typical illuminated-front cold-drink vending machines consume 7-11 kWh/day.
- Over half of the energy consumed can be saved by using the load manager and delamping the advertising lights.
- The advertising lighting uses old technology, which is very inefficient, and it should be disabled where appropriate or replaced with more efficient lighting.

The tests performed on the NREL vending machines shows that a significant amount of energy can be saved by implementing conservation techniques such as delamping and using vending machine load managers. These two methods combined can save NREL over 25 MWh of electricity and approximately 56% in cold-drink machine operating costs. In the long run, these techniques will save money spent on electricity and aid in the sustainability of NREL.

References

[1] Chappell, C., Hanzawi, E., Bos, W., Brost, M., and Peet, R. (2002). "Does It Keep the Drinks Cold and Reduce Peak Demand? An Evaluation of a Vending Machine Control Program," *2002 ACEEE Summer Study on Energy Efficiency in Buildings Proceedings,* pp. 10.47-10.56.

[2] ACEEE. (2001). *The Most Energy Efficient Appliances 2001,* American Council for an Energy Efficient Economy, Washington D.C.

[3] EPA. (2003) Energy Star Labeled Vending Machines. http://134.67.99.43/Estar/consumers.nsf/content/vending_machines.htm, Last accessed April 1, 2003.

[4] Bayview Technology Group LLC. (2003). Save Money and Energy with the Vending Miser. http://www.bayviewtech.com, last accessed April 7, 2003.

[5] Foster-Miller, Inc. (2000). *Vending Machine Energy Efficiency Device Engineering Evaluation and Test Report* BAY-00159. BayView Technology Group LLC, San Carlos, California.

[6] ASHRAE Standard (1997). Methods of Testing for Rating Bottled and Canned Beverage Vending Machines. 32.1-1997

[7] Canadian Standards Association. CAN/CSA-C804-96 Energy Performance of Vending Machines. September 1998. http://www.csa.ca/language/default.asp?thisUrl=%2FDefault%2Easp

APPENDIX A: Performance Data

Table A.1: Vending machine locations and descriptions

Tier I Data

No	Building	Location	Avg. Temp at Location (F)	Container Type	Oz.	Capacity	Total Oz.	Manufacturer	Model #	Serial #
1	Bldg 27	230-C	78.4	Bottles	20	278	5560	Dixie-Narco	DN501E MC/SII-9	2651 6488BW
2	Bldg 27	230-C	78.4	Cans	12	475	5700	Vendo	S10427013 960506	422051
3	Bldg 17	2nd Floor Left	70.1	Cans	12	471	5652	Dixie-Narco	DN501E MC/SII-9	2383 6560CX
4	Bldg 17	2nd Floor Right	70.1	Cans	12	368	4416	Dixie-Narco	DNCB 368CC/216-7	1184 3116BN
5	Bldg 16	2nd Floor Hall	69.8	Bottles	20	278	5560	Dixie-Narco	DN501E MC/SII-9	1475 6577CX
6	Bldg 16	2nd Floor	69.8	Cans	12	471	5652	Dixie-Narco	DN501E MC/SII-9	2402 6560CX
7	SERF	1st floor	63.9	Cans	12	471	5652	Dixie-Narco	DN501E MC/SII-9	2339 6560CX
8	SERF	2nd floor	69.2	Cans	12	368	4416	Dixie-Narco	DNCB 368CC/216-7	1039 3116BN
9	FTLB	Main Hall N.	71.2	Bottles	20	278	5560	Dixie-Narco	DN501E MC/SII-9	1139 6551BX
10	FTLB	Main Hall S.	71.2	Cans	12	471	5652	Dixie-Narco	DN501E MC/SII-9	2406 6560CX
11	OTF	Break Room		Cans	12	471	5652	Dixie-Narco	DN501E MC/SII-9	12516584DX
12	AFUF	1st Floor		Cans	12	471	5652	Dixie-Narco	DN501E MC/SII-9	12346584DX
13	NWTC	Break Room								
14	NWTC	Break Room								
15	Ship & Rec									
16	SEB	Entrance								

APPENDIX A (contd.)

Table A.2: Vending machine monitoring results for the baseline case

Tier I Data

No	Building	Location	Dates	Total kWh	Total Hrs.	Avg. W	Vac. kWh	Vac. Hrs.	Vac. Avg W	Peak W	Air T (F)
			Baseline Test								
1	Bldg 27	230-C	9/13/01 - 9/18/01	56.4	118.75	475					
2	Bldg 27	230-C	9/13/01 - 9/18/01	36.13	123	294					
3	Bldg 17	2nd Floor L	1/9/02 12:30 PM -1/16/02 12:30 PM	51.142	167.167	306	29.291	94.917	309	2290	
4	Bldg 17	2nd Floor R	1/9/02 12:30 PM -1/16/02 12:30 PM	66.812	167.2	400	26.712	65.9	405	2182	
5	Bldg 16	2nd Floor Hall	1/23/02 1:00 PM-1/30/02 1:00 PM	42.577	167.15	255	17.399	67.7	257	2188	70.7
6	Bldg 16	2nd Floor	1/23/02 1:00 PM-1/30/02 1:00 PM	38.816	167.117	232	15.877	68.2	233	2116	
7	SERF	1st floor	1/8/02 1:00 PM -1/15/02 1:00 PM	57.499	168.017	342	23.990	72.217	332	2152	
8	SERF	2nd floor	1/8/02 1:45 PM -1/15/02 1:45 PM	62.625	167.917	373	27.924	75.233	371	1925	
9	FTLB	Main Hall N.	1/8/02 2:00 PM -1/15/02 2:00 PM	41.797	167.867	249	26.621	107.417	248	2236	
10	FTLB	Main Hall S.	1/8/02 2:00 PM -1/15/02 2:00 PM	42.944	167.667	256	23.132	90.95	254	2439	
11	OTF	Top Floor									
12	AFUF	1st Floor									
13	NWTC										
14	NWTC										
15	Ship & Rec										
16	SEB										

Notes:
1 – The advertising lights for machines 5, 6, 9, & 10 were off during this test
2 – The vacant kWh & hrs may be inflated due to motion sensor not being taped "on." It is more likely 60-70 hours.

APPENDIX A (contd.)

Table A.3: Vending machine monitoring results for the load manager only case

Tier I Data

			Load Manager Only								
No	Building	Location	Dates	Total kWh	Total Hrs.	Avg W	Vac. kWh	Vac. Hrs.	Vac.Avg W	Peak kW	Air T (F)
1	Bldg 27	230-C	9/18/01 - 9/25/01	54.7	163	336					
2	Bldg 27	230-C	9/25/01 - 10/02/01	38.18	167	229					
3	Bldg 17	2nd Floor L	1/21/02 7:00 AM -1/28/02 7:00 AM	32.461	168.117	193	13.824	104.217	133	2265	70.9
4	Bldg 17	2nd Floor R	1/21/02 7:00 AM -1/28/02 7:00 AM	41.214	167.983	245	5.124	74.3	69	2180	70.9
5	Bldg 16	2nd Floor Hall									
6	Bldg 16	2nd Floor									
7	SERF	1st floor	1/22/02 1:30 PM - 1/29/02 9:00 AM	30.408	163.367	186	2.351	70.7	33	2145	65.4
8	SERF	2nd floor	1/22/02 1:30 PM - 1/29/02 9:00 AM	30.988	163.25	190	3.814	77.967	49	1912	70.0
9	FTLB	Main Hall N.									
10	FTLB	Main Hall S.									
11	OTF	Top Floor									
12	AFUF	1st Floor									
13	NWTC										
14	NWTC										
15	Ship & Rec										
16	SEB										

Notes:
1 – The advertising lights for machines 5, 6, 9, & 10 were off during this test

APPENDIX A (contd.)

Table A.4: Vending machine monitoring results for the load manager and delamped case

Tier I Data

			Load Manager & Lights Off								
No	Building	Location	Dates	Total kWh	Total Hrs.	Avg W	Vac. kWh	Vac. Hrs.	Vac.Avg W	Peak kW	Air T (F)
1	Bldg 27	230-C	10/17/01 - 10/24/01	37.786	164	230	17.15	93.533	183		
2	Bldg 27	230-C	10/02/01 - 10/09/01	23.93	167	143					
3	Bldg 17	2nd Floor L	1/30/02 1:00 PM -2/6/02 1:00 PM	23.847	168.95	141	9.334	102.967	91	2271	69.3
4	Bldg 17	2nd Floor R	1/30/02 1:00 PM -2/6/02 1:00 PM	24.503	168.95	145	4.722	73.817	64	2123	69.3
5	Bldg 16	2nd Floor Hall	1/30/02 1:00 PM -2/6/02 1:00 PM	25.777	168.933	153	1.709	71.05	24	2121	69.0
6	Bldg 16	2nd Floor	1/30/02 1:00 PM -2/6/02 1:00 PM	25.359	168.95	150	3.530	70.517	50	2169	69.0
7	SERF	1st floor	1/29/02 10:00 AM - 2/5/02 10:00 AM	20.575	167.7	123	1.637	71.467	23	2119	62.9
8	SERF	2nd floor	1/29/02 10:00 AM - 2/5/02 10:00 AM	18.02	167.917	107	1.687	76.733	22	1839	62.9
9	FTLB	Main Hall N.	1/15/02 2:00 PM -1/22/02 2:00 PM	26.156	167.967	156	3.541	62.783	56	2247	71.2
10	FTLB	Main Hall S.	1/15/02 2:00 PM -1/22/02 2:00 PM	28.863	167.95	172	4.621	62.917	73	2431	71.2
11	OTF	Top Floor									
12	AFUF	1st Floor									
13	NWTC										
14	NWTC										
15	Ship & Rec										
16	SEB										

APPENDIX A (contd.)

Table A.5: Vending machine energy savings for energy conservation measures

Tier I Data

No	Building	Location	Savings VM	Savings VM & Lights
1	Bldg 27	230-C	29%	52%
2	Bldg 27	230-C	22%	51%
3	Bldg 17	2nd Floor Left	37%	54%
4	Bldg 17	2nd Floor Right	39%	64%
5	Bldg 16	2nd Floor Hall	40%	*
6	Bldg 16	2nd Floor	35%	*
7	SERF	1st floor	46%	64%
8	SERF	2nd floor	50%	71%
9	FTLB	Main Hall N.	37%	*
10	FTLB	Main Hall S.	33%	*
11	OTF	Top Floor		
12	AFUF	1st Floor		
13	NWTC			
14	NWTC			
15	Ship & Rec			
16	SEB			

* These machines already had the lights turned off

APPENDIX B: Testing Procedure

The following information should be reported for Vending Machine Performance:

Test 1

- Machine type.
- Machine capacity
- Description of energy conservation measures applied to equipment (i.e. load managers, time clocks, lamp removal, etc.)
- Manufacturer, Product model number, Product serial number
- Average ambient air temperature where machine is located during each test period
- Average daily energy consumption for each test iteration
- Maximum peak power demand for each test iteration
- Characterize use patterns (standard working hours, 24 hr/day, occasional use, etc.)

Test 2

- All of Test 1 data
- One minute current profile (Amps vs. time)
- Fifteen minute product and room air temperatures

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13. ABSTRACT *(Maximum 200 words)* NREL Staff, as part of Sustainable NREL, an initiative to improve the overall energy and environmental performance of the lab, decided to control how its vending machines used energy. The cold-drink vending machines across the lab were analyzed for potential energy savings opportunities. This report gives the monitoring and the analysis of two energy conservation measures applied to the cold-drink vending machines at NREL.

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