A Roadmap for Simultaneously Developing the Supply and Demand for Energy Efficient Beverage Vending Machines

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ABSTRACT

Refrigerated beverage vending machines ("vending machines") present a previously untapped opportunity for significant energy savings. In the U.S. there are about 2.5 million vending machines in the field and new machine sales exceed 250,000/year. Existing vending machines consume approximately 7.5 billion kWh/year and cost $600 million/year to power. Initial estimates suggest that approximately 3.5 kWh/day can be saved per machine through refrigeration and lighting energy efficiency improvements alone, most of which have already proven successful in other applications. Over the ten year machine life, the approximate per machine savings are 13,000 kWh, electric bill savings of $910, and carbon dioxide savings of almost 10 tons. Additional energy savings are achievable through energy management features that enable the lights to be turned off during off-peak times and the refrigeration system to cycle down when the machine is idle for extended periods.

A coalition of interested parties formed to research this market and to develop a plan that would lead to the manufacture and sale of more energy efficient vending machines. A strategy to overcome market barriers and work with the four major stakeholders has been developed. This includes working with vending machine manufacturers to develop a performance based energy consumption specification compatible with the EPA/DOE Energy Star labeling efforts, and stimulating and demonstrating end-user demand by obtaining letters of support from high visibility institutions with a large number of vendors. This paper reports on our progress to date.

Introduction

Refrigerated beverage vending machines ("vending machines") present a previously untapped opportunity for significant energy savings. In the U.S. there are about 2.5 million vending machines in the field and new machine sales exceed 250,000/year. Existing vending machines consume approximately 7.5 billion kWh/yr. and cost $600 million/yr. to power. (Arthur D. Little, 1996). Initial estimates suggest that approximately 1,000 kWh/yr. per new vending machine can be saved through adoption of more efficient, low cost refrigeration and lighting technologies, most of which have already proven successful in other applications.

Despite the magnitude of these potential savings, efforts to capture these savings have been very limited to date. This can be attributed to two factors: 1) the vending machine purchaser is not the one who pays the electric bill, and 2) the end user (e.g. hotel, office building, gas station, university, etc.) who pays the electric bill is often unaware of the cost to power these machines -- roughly $350/yr/machine -- and has not demanded more efficient models.

In order to further pursue this energy savings opportunity, a coalition of interested parties was organized by the Natural Resources Defense Council (NRDC) in 1997. This coalition, the Energy Efficient

Vending Machine Working Group, consists of representatives from the NRDC, Environmental Protection Agency (EPA), Department of Energy (DOE) and its national laboratories, American Council for an Energy Efficient Economy (ACEEE), California Energy Commission (CEC), and Consortium for Energy Efficiency (CEE). In this paper, we provide an overview of the vending machine market, the strategy developed to intervene in this market, a report of progress made to date, and suggestions for future work.

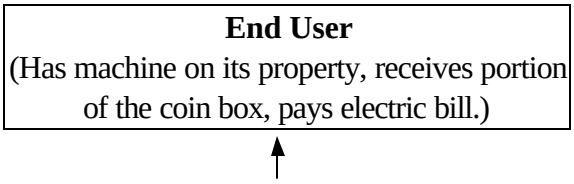
Background

Market Overview

The scope of this initiative was limited to vending machines selling canned or bottled refrigerated beverages (e.g. soda, water, juices, sports drinks, etc.). Other beverage distribution methods such as fountain serve, refrigerated coolers, or vending machines dispensing beverages in cups were not covered by this work.

A schematic outlining the vending machine market is shown in Figure 1. Some key points relative to this market are:

- Bottling and distribution companies ("bottlers" and "distributors") purchase vending machines directly from the machine manufacturer. In most cases, they place the machine at an end-user's site for free in exchange for the exclusive right to service the machine and to split the coin-box revenues.
- Often a written contract covering the key terms of the agreement is signed. This contract may apply to a single machine or building, or to all of the machines located at a company's or organization's sites across the country.
- In almost all cases, the end user and not the machine owner (the bottler/distributor), pays the electric bill.
- The beverage companies such as the Coca-Cola Company, PepsiCo Inc., and Dr. Pepper/Seven-Up Company do not typically purchase the vending machines. In many cases, however, the beverage company may have a financial interest in the bottler or distributor. In addition, the beverage companies have a strong financial interest in expanded sales of their products through the vending machine channel.
- The most critical issue, from the beverage company's perspective relative to vending machine performance, is ensuring that the customer receives a cold product.
- The vending machine manufacturing market is controlled by three manufacturers who collectively make up roughly 85% of the market.
- With the exception of the front panel design, the vending machine manufacturer designs the machine, selects and purchases the components, and assembles the machine. While the beverage companies do not specify the design of the machine, they often have written specifications and test procedures regarding light output, product temperature, etc. that the vending machine manufacturers must adhere to.



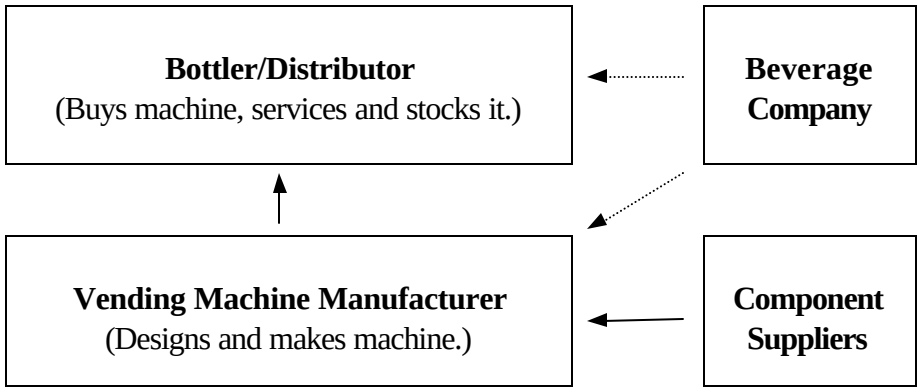


Figure 1. Beverage Vending Machine Market Actor Diagram

Vending machines come in various dimensions and capacities range from around 200 cans to over 800 cans. The average life for a vending machine is 10 years. With rare exceptions, the manufacturers produce a single line of products assuming the unit may be placed indoors or outdoors. Even though the industry is rapidly shifting from 12 oz metal cans to 20 oz plastic bottles, the energy consumption literature data is all expressed on a per can basis.

Technical Background

Machine Performance and Test Procedures. The literature on vending machine energy consumption is very limited and somewhat incomplete. The two best studies are: 1) a 1996 DOE funded study by Arthur D. Little (Arthur D. Little, 1996) which proposes component substitutions and provides estimates for the resultant energy and cost impacts, and 2) an E-Source report (E Source, 1996) which summarizes various reported daily energy consumption levels based on field and laboratory measurements.

The American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) recently published a laboratory test procedure for measuring daily energy consumption by vending machines. In brief, the proposed ASHRAE test method (ASHRAE, 1997) is a 24 hour test performed in a controlled laboratory chamber at 90 F, 65 % relative humidity. The ASHRAE test procedure is based upon the Canadian Standards Association's standard (Canadian Standards Assoc., 1996). Unlike the ASHRAE test procedure, the CSA standard also contains an equation which specifies the allowable maximum daily energy consumption (kWh/day) as a function of machine capacity (number of 12 oz. cans).

The ASHRAE test procedure has been widely accepted and is currently being utilized by the vending machine manufacturers. This test procedure provides a mechanism for interested parties to reliably compare the energy performance of the various vending machines.

The actual daily energy consumed by a vending machine is dependent upon the machine capacity (expressed as the number of vendable 12 oz. cans), the machine manufacturer, the machine location, and its usage. For example, a machine that is located in an unshaded area in a warm climate will use significantly more energy than a machine in a climate controlled office building. Given these various factors, care must be taken when using laboratory test data to predict the actual energy and electricity bill savings that will accrue in the field by converting to more efficient vending machine.

Potential Efficiency Improvements. The two major energy consuming systems in beverage vending machines are the lighting and refrigeration systems. Lighting accounts for roughly one third of machine energy use and typically consists of two T-12 fluorescent lamps and a magnetic ballast. The lamps used are either hi-output or slim-line depending on the beverage company's light output requirements. The lamp technology currently employed does not take advantage of widely available, more efficient technology such as T-8 lamps and electronic ballasts.

The lights contained within existing machines are generally left on continuously, even in spaces that are unoccupied for extended periods of time such as office buildings during nights and weekends. Numerous low cost technologies such as programmable timers or motion detectors could easily be employed to reduce the time that the lights are on and consuming energy. During discussions with vending machine manufacturers, we learned that the next generation machines will likely contain energy management features that enable the machine to be programmed to automatically turn the lights off during off-peak hours, and a way to turn off or greatly reduce the energy consumed by the refrigeration system during extended periods of non-operation.

Vending machine manufacturers design and assemble their own refrigeration systems. Key opportunities for reducing energy consumed by the refrigeration system are more efficient compressors and fan motors, and system optimization. For more detailed discussion of the machine components and their energy usage, the reader is referred to the aforementioned ADL report.

Intervention Strategy

In order to encourage development and adoption of more energy efficient models, the coalition recognized the need for a two pronged strategy:

a. Supply-side - Work with machine manufacturers to design and produce more energy efficient models.

b. Demand-side - Educate end users on the energy usage and operational costs of vending machines, and the potential energy and cost savings that more efficient models could provide. Communicate the newly created demand-side interest for more efficient models to the key stakeholders.

Supply-side

Historically none of the supply chain stakeholders -- the vending machine manufacturer, beverage company, or bottler/distributor -- have given much consideration to the energy consumption of vending machines. Although the beverage companies have a formal testing procedure to certify manufacturers' products, there are no specified limitations on energy consumption.

To fill this void, the Energy Efficient Vending Machine Working Group decided to develop an energy consumption specification for vending machines. Early in the process, the group decided to center its efforts around the development and roll-out of an Energy Star™ specification for vending machines. The Energy Star specification would establish an energy consumption target for vending machine manufacturers to aim for.

Energy Star is a voluntary EPA/DOE energy efficiency labeling program. Manufacturers can use the Energy Star label to help promote products that meet the specification requirements. The Energy Star label is an easy to understand indicator that a particular unit is energy efficient. The key challenges identified by the team were: 1. What energy levels to use in the specification?, and 2. How to create demand for qualifying Energy Star vending machines?

Relying on information available from the CSA Standard, the ADL report and researchers at the DOE's Lawrence Berkeley National and Oak Ridge National Laboratories, the coalition formed a sub-group to begin writing a draft Energy Star specification. The sub-group appointed Noah Horowitz of NRDC to serve as its point person for communications and negotiations with the vending machine manufacturers. During initial conversations with the manufacturers, we learned that a small but growing number of end users were beginning to ask questions about the energy consumption of their machines and, in some cases, were seeking more efficient models. A handful of bottlers/distributors, the actual machine purchasers, were also making similar inquiries.

Given these developments, the vending machine manufacturers were supportive of our efforts to develop an Energy Star specification and for the potential opportunity to utilize the Energy Star label for qualifying models. The label was seen by them as an effective vehicle for communicating to their customers that a particular model is energy efficient.

Demand-side

In evaluating possible intervention strategies, the team focused on the motivations of each of the key stakeholders (see Table below). Since the bottlers/distributors do not pay the machine's electric bill and are the ones who buy the machine, they were viewed as not likely to have an interest in purchasing more efficient machines, especially if the initial cost was higher.

Table 1. Stakeholder Motivations and Influence Strategies

STAKEHOLDER	MOTIVATION	STRATEGY
Beverage Company	Seeks to increase market share; wants to increase number of machines containing their products; interested in brand and company image as good corporate citizen.	Seek their support, offer media opportunities to demonstrate environmental commitment. Have them influence their bottler/distributor network.
Machine Manufacturers	Wants to maintain/expand market share; can offer a machine that meets needs of customers seeking efficient models.	Offer them Energy Star label for complying machines. Have them actively participate in specification development.
End-User	Wants to reduce energy costs, demonstrate environmental commitment to internal and external constituents.	Educate them on machine energy usage and the potential for move efficient machines. Solicit their support and document demand for more efficient machines (market pull).
Bottler/distributor	Get as many accounts as possible;	Have a machine available for those

have favorable contract terms; buy reliable, low cost vending machines.	customers that demand an energy efficient model.

Based on our knowledge of the market, we decided to focus our efforts around educating end users about the energy consumption and electricity costs of vending machines and converting that knowledge into demand for more efficient models. Large, high visibility organizations having a large number of vending machines on their properties would be targeted and asked to sign a letter stating their interest in reducing the energy consumed by vending machines and their intention to request Energy Star compliant machines in their future contracts.

These letters of support will then be taken to the vending machine manufacturers and the beverage companies. This effort can be classified as a "market pull" strategy. Dialogue with the beverage companies will center around how to gain their support and the role they can play in persuading their bottlers/distributors to switch to Energy Star models. Per the beverage companies' advice, we will then work with the bottler/distributor community. Unlike the small number of beverage companies and vending machine manufacturers, there are hundreds of bottler/distributors across the country and these networks are complex, vary by beverage company, and decision making is often decentralized.

Progress To Date

Specification Development

Early in the process, the group committed to actively seek input from the vending machine manufacturers. To that end, initial visits were made to key manufacturers to learn more about their processes, how machine components are selected, the energy usage of current and planned machines, etc. A lot of important information was learned during these visits and a sound foundation was laid for future communications including feedback and hopefully support of the resultant Energy Star specification.

After these visits and follow-up phone conversations, the group began to write a draft Energy Star specification based on the following key principles:

1. The specification will be performance based, not technology specific.
2. The specification should set a maximum 24 hr energy consumption level based on continuous machine operation.
3. The specification will include an energy consumed vs. machine capacity equation.
4. The testing will be done in a laboratory according to the ASHRAE 32.1P test method.
5. Some language related to energy management features will also be included in the specification.
6. Encourage changes that can be made by simple component changes and little to no manufacturing line retooling.

In developing the specification, the group opted to not only to select a fairly aggressive steady state energy consumption equation but to also ensure that the machine was equipped with a sleep mode feature that can easily be programmed by the site owner. This language allows for each machine to be programmed to site specific conditions. For example, a machine placed in an office building may not have any transactions

between 7 p.m. and 7 a.m. each day, and perhaps no transactions on weekends and holidays. Another site may have a totally different operating schedule.

By a few simple to input entries, the site owner is able to set the hours of non-activity. The sleep mode, when activated, results in the lights going off and the refrigeration system being powered down. Separate time set points can be entered for the lighting and refrigeration modes. This is important because an outdoor machine in a warm climate, may not need its lights on during the day but will definitely need the refrigeration system to be operating. The group considered it essential that the site owner be able to set or program the time set points themselves as they have the best knowledge of their property's operation and as the payer of the electric bill, are the most motivated to make sure the system is enabled and operating properly.

The sub-group developed a draft Energy Star specification and sent it to the manufacturers for their review. This draft specification led at least one manufacturer to perform testing on its machines and to begin to explore options for reducing their machine's energy consumption. Once we receive the results of additional prototype testing data supplied by the manufacturers, we will finalize the Energy Star specification.

As the specification has not yet been finalized, we are unable to provide a copy in this paper. This Phase 1 specification is likely to go into effect the fall of 1998 and will be effective for two years. A Phase 2 specification will then be introduced. Given the dynamic state of the refrigeration and lighting industries, more efficient, yet cost-effective components are likely to emerge between now and finalization of the Phase 2 specification.

Energy Savings and Other Benefits

The Phase 1 Energy Star specification is likely to be at least 25 % more stringent than the current CSA standard . For a 450 can capacity machine, this translates to savings of approximately 3.5 kWh/day. Additional savings of approximately 1.5 kWh/day will be obtained if the sleep mode feature is enabled and the lights are not operated for twelve hours per day (eg. lights are off from 6 pm to 6 am).

Table 2 demonstrates the magnitude of these savings over the ten year machine lifetime. (These estimates are based on manufacturer test data derived per the ASHRAE test procedure. Actual savings will depend on the model selected and field conditions.)

Table 2. Projected Savings Over Machine Life[1]

A. For 24 hr/day Machine Operation:

	Number of Machines within the Organization		
Savings	**100**	**1,000**	**10,000**
Energy (kWh)	1,300,000	13,000,000	130,000,000
Electricity ($)	91,000	910,000	9,100,000
Carbon Dioxide (Tons CO_2)	975	9,750	97,500

[1] Calculations assume 10 year machine life time, electricity cost of $0.07/kWh, and conversion rate of 1.5 lbs. CO_2/kWh. Actual savings will vary depending on model selected, location, and usage.

B. If Sleep Mode Enabled with Lights Off 12 hrs/day:

	Number of Machines within the Organization		
Savings	**100**	**1,000**	**10,000**
Energy (kWh)	1,825,000	18,250,000	182,500,000
Electricity ($)	127,750	1,277,500	12,775,000
Carbon Dioxide (Tons CO_2)	1,370	13,700	137,000

Demand Side Recruiting

The core of the demand-side efforts is obtaining institutional letters of support indicating an institutions intent to purchase Energy Star compliant vending machines, once available. In selecting candidate institutions, the following criteria were sought: large number of vending machines, has sound environmental track record and/or is current Energy Star partner for other technologies, high visibility/name recognition, motivated by resultant positive, i.e. green, publicity or ability to demonstrate environmental commitment to key stakeholders (employees, media, stockholders, students, etc.). Some of the types of institutions that rose to the top of our list included universities, hotel chains, companies with a lot of manufacturing and office sites, military and other large governmental agencies, large office building management firms, etc.

From this process a list of thirty priority candidates emerged. The EPA, based on its Green Lights work, provided suggested contacts for many of the institutions. The demand-side sub-group then contacted each of the organizations by phone and provided written follow-up material to interested individuals. Many of those contacted were unsure how many vending machines were present within their organizations nor what the process was for contracting for these machines. They were, however, willing to get this information and agreed to work with us on this project.

Some of the larger institutions had already begun exploring various ways to reduce the energy consumption of the vending machines, including delamping and simply unplugging the entire machine at night and on weekends, prior to our inquiry. Their feedback was very favorable concerning the Energy Star label and the sleep mode component of the specification.

Future Work

Program Roll-out

The path of simultaneously developing a performance specification and creating demand for Energy Star compliant machines has been successful. We are very close to finalizing the Phase 1 specification and are in the process of receiving signed letters of intent from end users that represent roughly 50,000 machines. Once we complete these two tasks, we will begin our outreach to the beverage companies and the bottler/distributor community.

The Energy Star program will officially announce the Energy Star specification and label for vending machines in the fall of 1998. The Energy Efficient Vending Machine Working Group is exploring various methods for providing recognition and publicity for participating beverage companies, vending machine manufacturers, large bottlers, and institutions that requested Energy Star compliant models.

Specification Revision and DOE Testing Program

Given the rapid advances in lighting and refrigeration technologies, a revised Tier 2 spec will be developed that incorporates the additional available energy savings. In anticipation of the Tier 2 spec, a three phased research program, possibly funded by the DOE, is proposed :

Phase 1 - Perform baseline laboratory energy consumption testing on Phase 1 Energy Star machines
Phase 2 - Develop prototype Phase 2 machines and perform follow-up laboratory energy consumption testing
Phase 3 - Perform field testing on existing and prototype machines.

Phases 1 and 2 work will be done at DOE laboratory facilities on machines provided by the vending machine manufacturers. Field sites with varying environmental conditions -- i.e. indoor, outdoor, warm climate, cool climate, in sunshine, etc. -- will be selected for Phase 3 and other partners including interested end users and utilities will be recruited to assist in the data collection effort.

The field measurement data will provide valuable "real life" data for manufacturers and bottler/distributors to provide to their clients regarding anticipated energy use and cost of operation.

Retrofits

In order to remain focused, the group delayed work on the lighting retrofit opportunity till a later date. Further exploration of this opportunity should be explored with the beverage companies, bottler/distributors, and utilities who might be able to offer logistical support and financial incentives. Given the existing base of roughly 2.5 million machines in the US, this savings may be quite substantial and relatively easy to attain.

Conclusions

Prior to the inception of this project: a) most end users were unaware of the energy consumption or cost of operating vending machines, and b) no standard or industry specification existed for vending machine energy consumption. In order to motivate the vending machine manufacturers, bottler/distributors, and beverage companies, the Energy Efficient Vending Machine Working Group communicated its intention to develop a voluntary energy consumption specification for vending machines for subsequent incorporation by the EPA/DOE Energy Star labeling program. Simultaneously we began to develop and demonstrate demand from end users for efficient, Energy Star compliant models. These efforts caused vending machine manufacturers to respond. Several manufacturers began to test the energy performance of their machines and actively pursue development of more efficient models.

Key learnings from this effort include:

- The vending machine manufacturers were very willing to work with our group to share test data and appreciated the opportunity to provide input on the Energy Star specification. They recognized the marketing value of the Energy Star label.

- The multi-disciplinary skills of the working group were essential to the program's success. The demonstrated depth of the group's knowledge provided credibility in negotiations with the machine manufacturers.

- The demand-side market pull effort of collecting letters of intent from institutions having a large amount of machines on-site was an effective way to solve the split incentives barrier (eg. the end user pays the bill and a different party buys the machine) and may be transferable to other efforts.

- The existence of a credible energy measurement test method and an up to date baseline of machine energy consumption are critical components for the inception of any program intended to reduce an appliance or technology's energy consumption.

- Additional outreach work is needed to educate end users about the energy consumption of vending machines and the potential savings provided by Energy Star models.

- Training and follow-up will be needed to ensure that the energy management features are being enabled and providing the forecasted energy savings.

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